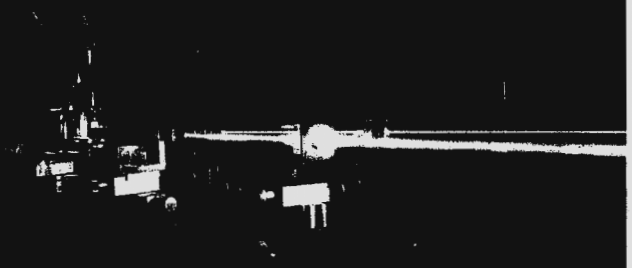

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THE LABORATORY TODAY

Flashback

THE BIRTH OF THE LABORATORY

In March 1943 a small group of scientists came to a remote mesa high above the Rio Grande, northwest of Santa Fe. Their mission was to design and build the world's first nuclear weapon. This effort, called Project Y, was part of the U.S. Army's secret World War II crash program, named the Manhattan Engineer District, to develop and produce a weapon that would unleash the huge amounts of energy produced during nuclear fission.

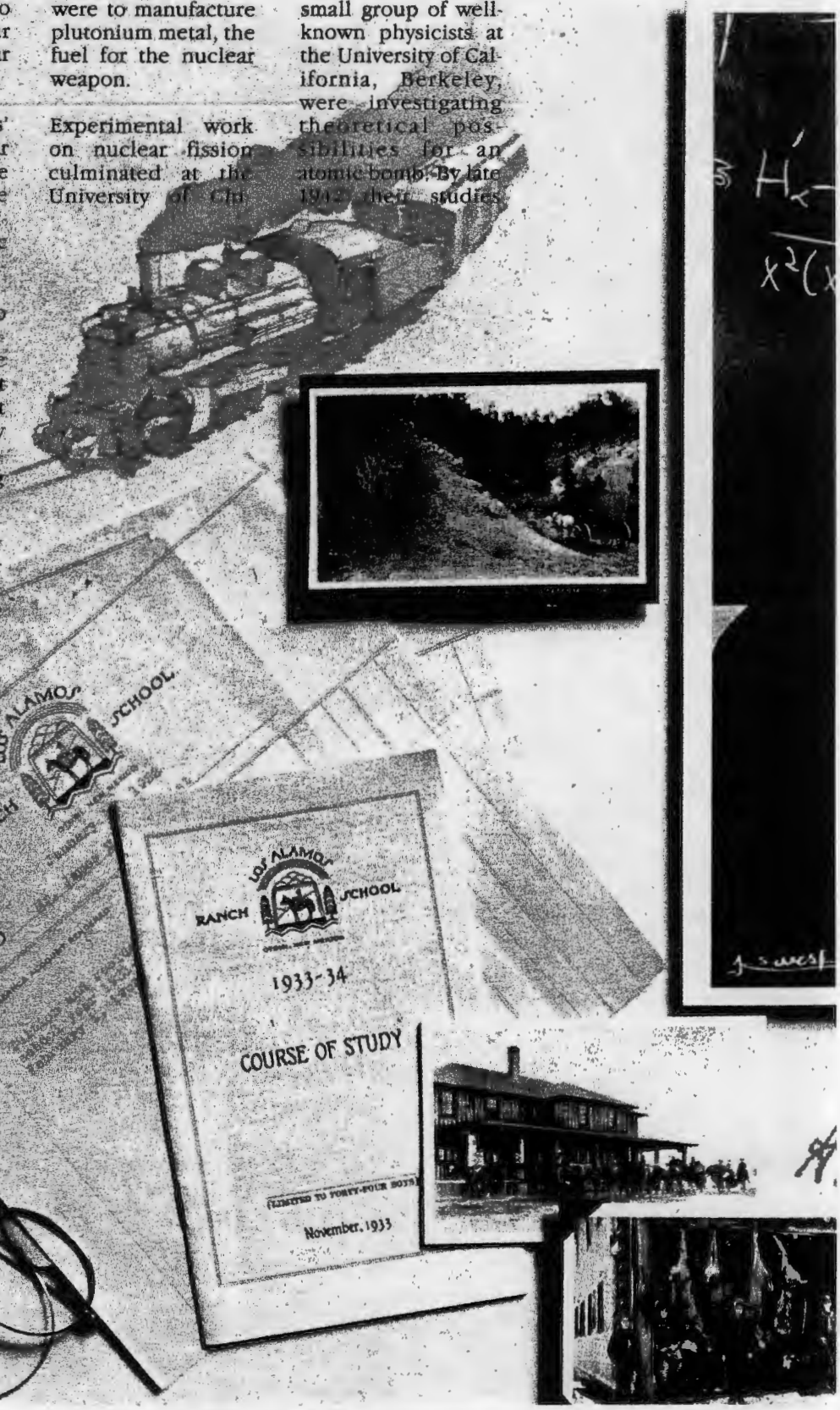
Although radioactivity had been known since 1896, nuclear fission was not discovered until 1938. Immediately thereafter, scientists all over the world began investigating fission and the possibility of a chain reaction that would release useful amounts of nuclear energy.

The results of these first investigations and the early recognition that uranium fission had military applications led a group of American scientists, including several refugees from Nazi Germany, to write to President Franklin Roosevelt. They persuaded him to support a uranium research program to investigate nuclear power and nuclear weapons.

The United States' entry into World War II in 1941 and the belief that the Germans were working on an atomic bomb spurred the expansion of this research program into the massive Manhattan Project, a wartime effort carried out with the utmost secrecy and urgency by the finest scientific and engineering talent available.

This vast effort included research laboratories at Columbia University, the University of California, and the University of Chicago. The enormous separation and production plants at Oak Ridge, Tennessee, and Hanford, Washington, were to manufacture plutonium metal, the fuel for the nuclear weapon.

Experimental work on nuclear fission culminated at the University of Chicago on December 2, 1942, when Enrico Fermi and his coworkers achieved the world's first nuclear chain reaction. Meanwhile, J. Robert Oppenheimer and a small group of well-known physicists at the University of California, Berkeley, were investigating theoretical possibilities for an atomic bomb. By late 1942 their studies had progressed so that experimentation was necessary to substantiate their hypotheses.



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MAPPING ROOM

Foreword

At the Otowi Building in the administrative complex of the Laboratory, prospective employees receive information on advertised positions, and new employees learn about benefits and services.

Scientists at Los Alamos National Laboratory investigate an astounding range of phenomena that extend from the earth's interior through its atmosphere and magnetosphere into outer space, from subnuclear particles to galaxies, from events occurring in trillionths of a second to those that take thousands of centuries, from temperatures near absolute zero to those measured in tens of millions of degrees, and from the energy of a single photon to that of a supernova.

Combining basic sciences with engineering disciplines and technological advances has made Los Alamos National Laboratory an innovative institution on the frontiers of science.

Its mission is to apply science and technology to problems of national security, ranging from defense to energy research. To fulfill this mission, Los Alamos focuses on defense and weapon systems, arms control programs, and energy research and development. The Laboratory also conducts a vigorous basic research program to support national security and energy needs.

Los Alamos scientists work on hundreds of research programs. They collaborate with fellow employees in other disciplines and with university scientists across the country. They take part in cooperative international research. They perform joint research with private industry and assist in technology transfers.

In staff and technical capabilities, Los Alamos is one of the largest multidisciplinary, multiprogram national laboratories in the United States. It is also internationally recognized as one of the most prestigious scientific institutions in the world.

The Laboratory is managed by the University of California for the United States Department of Energy. In fact, all the national laboratories are managed for the government by universities or private industry. Laboratory employees are employees of the University and consequently share in many benefits that are available to faculty members. Full-time research schedules combined with substantial individual freedom encourage first-rate contributions in basic and applied sciences.

In addition, the Laboratory is a good neighbor in northern New Mexico. For four decades it has positively influenced the local community by offering steady employment, by creating a market for goods and services, and by providing use of Laboratory resources to local educators.

For those of us who live and work here, Los Alamos is a place of challenge and discovery in a setting of great natural beauty. We welcome you to Los Alamos.

and military personnel were working at Los Alamos in July 1945, when the first nuclear test was successfully performed at Trinity Site in southern New Mexico.

After the end of World War II, the future of the Laboratory that had been born of expediency and operated under military control was suddenly in doubt. A number of people strongly urged that the Los Alamos site be abandoned and a laboratory established in southern California. But General Leslie R. Groves, who was in charge of the Manhattan Project, believed Los Alamos Laboratory should continue so that the nucleus of a staff for future weapon development would always be available.

Los Alamos was not abandoned. Instead, it became a permanent institution that has achieved recognition as one of the finest scientific research laboratories in the world. Today the Laboratory is a multiprogram national laboratory of the United States Department of Energy, still operated by the University of California; the original contractor to the wartime Manhattan Engineer District.

PROGRAMS

The Laboratory's mission is to apply science and technology to solve national problems, both in nuclear weapon development and in energy supply and conservation programs. Basic and applied scientific and engineering research complements and strengthens the fundamental technical capabilities of the Laboratory.

National security programs account for nearly 70 percent of the Laboratory's operating budget. Most programs are nuclear related. Nonnuclear programs (such as fossil and geothermal energy, electricity transmission and storage, and regional energy assessment and policy analysis) account for much of the remainder. Most of the recent growth in nonweapon work has been in nuclear-related energy research in such programs as magnetic confinement fusion, laser isotope separation, nuclear safeguards, and other research programs conducted for the Nuclear Regulatory Commission. Research teams in weapon and energy programs share nuclear materials and buildings in cost-effective and staff-efficient ways.

National Security

National security programs include the design, development, and testing of nuclear weapons; research into defenses against ballistic missiles; research and development of advanced conventional weapons and the control and accountability of nuclear materials; development of means to detect clandestine nuclear explosions; and research on inertial confinement fusion for military and commercial applications.

Weapons

The world's first atomic weapons were produced at Los Alamos, and Los Alamos scientists conducted the first detonations of a fission weapon (atomic bomb) and a thermonuclear, or fusion, weapon (hydrogen bomb). Since the early 1940s, the Laboratory has concentrated on designing and developing nuclear devices. Today the Laboratory shares that responsibility with Lawrence Livermore National Laboratory in California.

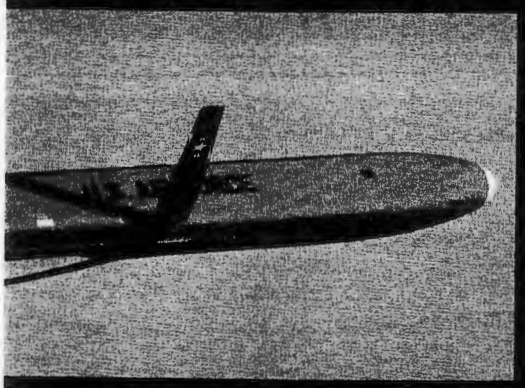
Developing nuclear weapons is a complex technical challenge because the physical conditions generated in a nuclear explosion are beyond ordinary experimental means and involve temperatures typical of stars. The Laboratory maintains a highly qualified staff and specialized buildings and resources to conduct broad-based research unique to the weapon program. Engineers, scientists, and others at Los Alamos participate in research, development, and testing of nuclear weapons. Continuing research, both theoretical and experimental, enhances the weapon program by focusing on mathematics, nuclear physics, nuclear chemistry, metallurgy, computer science, fluid dynamics, and fabrication methods.

Los Alamos has designed about two-thirds of the weapons in the national stockpile. Major recent contributions include the W85 warhead for the U.S. Army's Pershing II missile, the W80 warhead that will be carried by both the air-launched and submarine-launched cruise missiles, the W78 warhead for the Minuteman III intercontinental ballistic missile, the W76 warhead for Trident and Poseidon submarine-launched missiles, and the B61, a multipurpose aircraft-carried bomb used by all the services. Weapons currently under development include the W81 warhead for the U.S. Navy's SM-2 missile, the W88 warhead for its Trident II submarine-launched ballistic missile, and warheads for future use in the U.S. Air Force's advanced cruise missiles and in naval antisubmarine missions.

The evolution of a nuclear weapon typically involves seven phases that span about twenty-five years: (1) conception, (2) feasibility determination, (3) development engineering, (4) production and engineering, (5) first production, (6) quantity production, and (7) retirement.

The air-launched cruise missile is equipped with the W80 warhead, developed at Los Alamos and designed for common application in the U.S. Navy's Tomahawk cruise missile.

Submarine-launched ballistic missiles are the most survivable arm of the strategic triad. The W88 warhead is being developed for new missions for the Trident submarine.



The W85 warhead, used in the Pershing II missile, was developed by Los Alamos for the U.S. Army.

The Department of Defense generally initiates the first phase with a request to the weapon laboratories for conceptual studies. These studies may result in a recommendation to modify a current weapon or to develop a new system.

In the second phase, the two competing design teams, Los Alamos National Laboratory (with Sandia National Laboratories, Albuquerque) and Lawrence Livermore National Laboratory (with Sandia National Laboratories, Livermore), conduct studies to determine the feasibility of the proposed warhead and associated system. The design teams identify tradeoffs regarding size, weight, cost, nuclear yield, and packaging and then submit proposals for weapon development.

Before the third phase, one design team is selected to carry the remaining responsibilities for developing the nuclear warhead. The team evaluates and tests the weapon design frequently, using computer calculations and hydrodynamic experiments with mockups containing nonnuclear components. Making the experimental components may involve developing new fabrication processes and measurement methods. The entire process usually culminates in underground nuclear tests.

Weapons for the national nuclear stockpile are produced and assembled at U.S. government weapon production plants. Engineers from the design team supply technical expertise during the production phases. Throughout the life of a weapon, the laboratory that developed it ensures its integrity and provides advice regarding maintenance.

Benefits of the weapon program extend beyond national defense. This program provides knowledgeable personnel and specialized resources for other national programs, such as space reactor propulsion, nuclear safeguards, inertial fusion, and reactor safety.

Testing and Verification

Nuclear testing has been, and continues to be, an essential part of nuclear weapon development. The Laboratory conducted atmospheric nuclear tests at locations in the Pacific, beginning in 1946 and continuing until 1963. In 1951 the Laboratory began testing at the Nevada Test Site, about 65 miles northwest of Las Vegas, Nevada. During the past thirty years several hundred nuclear tests have been conducted, but all testing since 1963 has been underground, in accordance with the Limited Test Ban Treaty. Since 1976 the Laboratory has also limited all testing to a maximum yield of 150 kilotons, in accordance with the Threshold Test Ban Treaty. The testing program provides most of the nation's data on weapon effects. Knowledge gained from underground testing is applicable also to nuclear waste storage, fossil fuels, and hot, dry rock geothermal energy programs.

To verify that other countries are abiding by treaty regulations, Los Alamos developed sensing instruments carried aboard Vela satellites and their successors. It is investigating other means of detecting clandestine nuclear explosions as well, such as the propagation of earth motion waves into both the atmosphere and the ionosphere. The Laboratory also responds to special requests for technical advice regarding arms control efforts; for example, Los Alamos advisors participate on the United States' negotiating teams for Strategic Arms Limitation Talks (SALT) and test ban and nonproliferation treaties.

Safeguards and Security

Safeguards work at Los Alamos is concerned with developing equipment, automated instrumentation, and techniques for detecting and measuring nuclear materials in many physical and chemical forms; with developing accounting systems to monitor nuclear materials; and with providing expertise to the nuclear industry, the government, and other research organizations.

Diagnostic cables allow researchers to obtain detailed information on the performance of a nuclear test device.

The Nevada Test Site is pocked with subsidence craters that form over the site of an underground nuclear explosion.

The nuclear industry is implementing nondestructive technology, originated at Los Alamos, for both active and passive assay. In active assay, external sources produce radioactivity in samples, which are then analyzed to determine the amount of fissionable material present. In passive assay, the fissionable material in a sample is determined by detecting the radiation it emits.

The Laboratory's MASS (for material accountability and safeguard system) is the most sophisticated, comprehensive, and adaptable accounting system developed thus far for monitoring nuclear materials. Used Laboratorywide, MASS determines the location, quantity, and chemical nature of all radioactive materials on a near real-time basis. MASS registers statistical deviations and automatically computes discrepancies if there is a material imbalance.

The Laboratory transfers techniques, concepts, and designs for safeguards and security to the nuclear industry to protect fuel fabrication plants, strategic nuclear materials storage sites, nuclear power plants, fuel reprocessing plants, and waste disposal sites. As part of this transfer, the Laboratory offers special training courses and workshops and provides staff to consult with and participate in international advisory groups.

The Laboratory also supplies trained personnel and equipment to the national Nuclear Emergency Search Team (NEST). This team offers scientific and technical assistance to federal, state, and local authorities faced with a nuclear emergency. For example, NEST helped track down and retrieve parts of the nuclear-reactor-powered Soviet satellite that fell in Canada in 1978.

Los Alamos and U.S. military experts examine a simulated damaged weapon in a nuclear weapon accident exercise at the Nevada Test Site.

Department of Defense Programs

The Department of Defense uses the Laboratory's experience with hydrodynamic calculations, accelerators, lasers, high explosives, and materials science for research on advanced conventional (nonnuclear) weapon systems. Research accelerators at Los Alamos spawned Department of Defense programs on directed-energy, neutral-particle beams. The goal is to develop a powerful radio-frequency linear accelerator as an orbiting defense system. Another program involves possible application of free-electron lasers for satellite or ballistic missile defense.

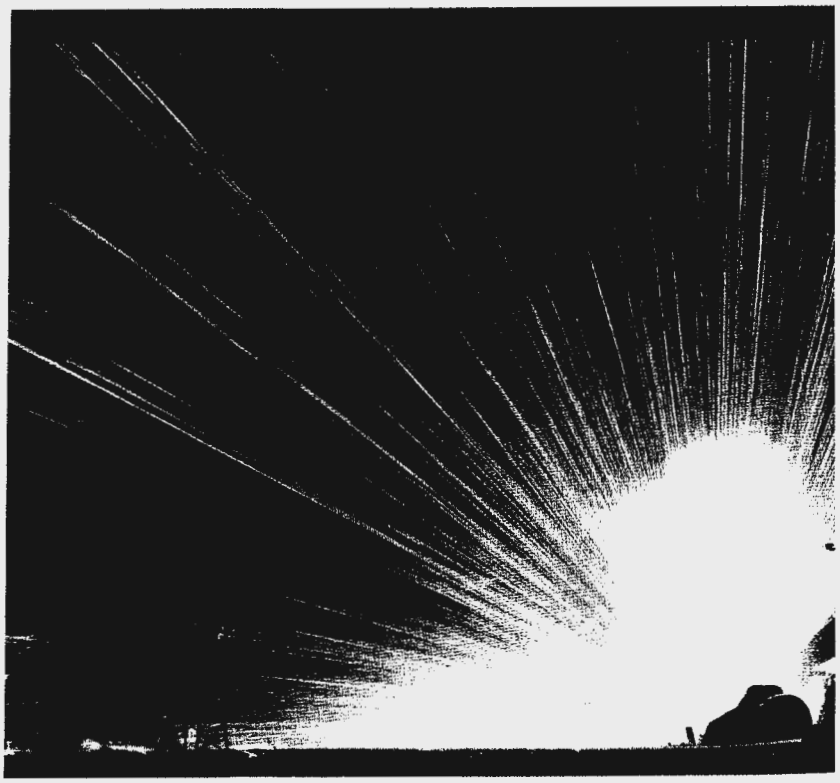
A number of Department of Defense programs apply the Laboratory's expertise in high explosives: nonnuclear warheads for defense against ballistic missiles; nonnuclear warheads for cruise missiles; rail guns, which are electromagnetic projectile launchers driven by explosives; nonnuclear warheads for antisubmarine and antiarmor applications; kinetic-energy armor penetrators; and special armor to protect tanks from antitank missiles.

Los Alamos work in laser isotope separation led to military applications, such as the use of lasers to detect chemical warfare agents. Laser-based detectors developed here can detect nerve gases more sensitively than any other means, and various laser techniques have the potential for remotely sensing chemical clouds. Lasers can be tuned so that specific substances will fluoresce when the laser light strikes them, facilitating cleanup of contaminated surfaces.

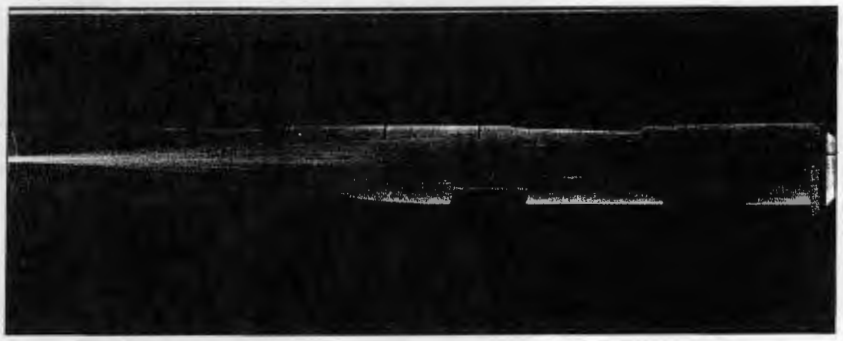
Ultrasensitive analysis with lasers has improved the identification and measurement of isotopes from soil samples collected after underground nuclear weapon tests at the Nevada Test Site. With these improved measurements, scientists can more accurately assess a weapon's performance. Los Alamos also developed unique solid-state lasers that are compact and have high power output, high efficiency, and the potential for tactical military applications.

Materials scientists at Los Alamos developed erosion-resistant materials that may be used for nose tips on missiles intended to reenter the atmosphere. Because of the speeds at which these missiles travel, special high-temperature materials (even more resistant than the heat shields used on space vehicles) are necessary to prevent the missile from overheating.

In addition to these research programs, the Laboratory conducts special studies for the Department of Defense and other government agencies. An energy options study assesses the military's energy requirements to identify possible solutions that could also help in commercializing new energy technologies. A tactical battlefield study uses the Laboratory's expertise in conventional explosive weapons and nuclear explosives to evaluate tradeoffs for the use of such weapons in tactical or theater warfare.



A directed-energy experiment conducted at PHERMEX shows instabilities in the propagation of an electron beam in helium.



A flash x-ray machine at PHERMEX is used for pulsed high-energy experiments.

The free-electron laser is a prototype research device for the strategic defense initiative.

Inertial Confinement Fusion

The goal of the inertial confinement fusion program at Los Alamos is to produce small and controlled thermonuclear reactions similar to the large-scale and unmanageable fusion manifested in thermonuclear weapons.

Accomplishing inertial confinement fusion in the laboratory requires large, high-energy lasers. Since 1969 Los Alamos has developed a series of carbon dioxide lasers with the potential for attaining the necessary energies and efficiencies. These gas lasers are also capable of the repetitive operation required for generating electricity. Antares, the fourth in the series, can produce 40 kilojoules of energy in a billionth of a second, an output sufficient to allow fusion experiments that can provide basic information on the complex interaction of light and matter.

Developing a powerful laser was only the first step, however. The next challenge is to understand how laser light is absorbed by the target and how this light is converted into energy that can efficiently compress and heat fusion fuel. Because laser light penetrates a target to a depth that varies inversely with the wavelength (the shorter the wavelength, the deeper the penetration), energy conversion is not highly effective with the long-wavelength carbon dioxide laser; most energy from its light is absorbed at the outer surface of the target.

The Laboratory is therefore developing an excimer gas laser with a wavelength almost forty times shorter than carbon dioxide. The shorter wavelength will alleviate many problems of energy transport. Aurora, a short-wavelength laser, will allow scientists to address laser technology issues and costs. Outputs in the 10-kilojoule range have been produced with this laser, and prospects for acceptable efficiency and costs are encouraging. Many engineering challenges must be overcome, however, before laser-driven fusion reactions will be commercially attractive.

For use in laser fusion experiments, glass microballoons (shown here on a U.S. quarter) are coated with gold by a unique electrodeposition process.

A blue glow from Cerenkov radiation is emitted by the core of the Laboratory's Omega West research reactor.

Laser-produced plasma is generated when the Antares beam strikes a gold microsphere mounted in the center of the evacuated target chamber.

Energy

Los Alamos is engaged in research and development to expand options for energy supply and for power and propulsion concepts. Goals for energy-related programs are to provide solutions to meet national needs, to maintain a base of research excellence, and to use this scientific expertise to develop effective methods for the generation, recovery, conversion, storage, and transport of energy.

The objectives of each energy program are the same—to determine its technical and economic potential and to develop that potential, if warranted by projected commercial applications. Whether pursuing long-range approaches to fusion energy or near-term technologies for fossil fuel recovery, the Laboratory works closely with industry so that, as new technologies are developed, they can be expeditiously transferred and applied to meet the nation's needs.

Nuclear Programs

The Laboratory's programs in nuclear fission energy encompass the breadth of the nuclear fuel cycle, as well as reactor design and development. Major initiatives are under way to develop and deploy reactor systems as secure sources of primary power for strategic defense sites and equipment. The Laboratory is originating or evaluating innovative reactor designs for these applications. Materials and component development projects enable these designs to come to fruition. Advanced physics and thermal/hydraulic and mechanical design tools are being developed to facilitate this work. The Laboratory's advanced computing capabilities make it possible to use these sophisticated tools.

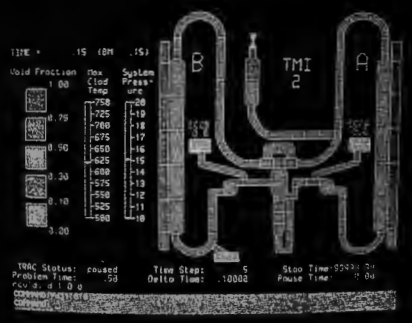
The Laboratory's extensive computing capabilities also help safety specialists explore major areas of uncertainty in reactor operation during hypothetical accidents. These uncertainties are impossible to investigate experimentally. Accordingly, large multicomponent, multiphase computer simulations examine the complex,

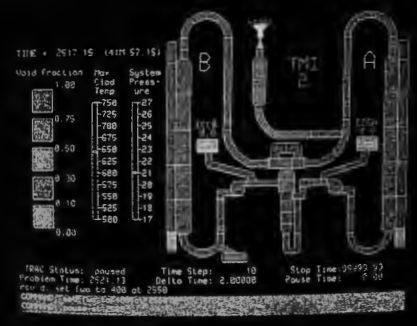
interrelated physical processes that would probably occur in these accidents. The results of this work contributed to understanding the events and circumstances surrounding the Three Mile Island accident. This understanding, in turn, has suggested design modifications and revisions to operating procedures that could improve the safety of nuclear reactors.

The Laboratory's efforts in fuel-cycle-related technologies concentrate on waste management and safeguards. Additional work addresses several issues related to enriching the special nuclear materials used as fuel and to reprocessing spent fuels. Laboratory resources are applied to studying geochemical and mineralogical characteristics of areas in which nuclear wastes might be isolated. In particular, Los Alamos contributes to the Nevada Nuclear Waste Storage Investigations, which are evaluating a region of the Nevada Test Site for commercial waste storage. Los Alamos also is responsible for the design and construction of an exploratory shaft that will allow experiments to be conducted in the region of this proposed repository. Data from the experiments will allow comparison of this site with other proposed repository locations.

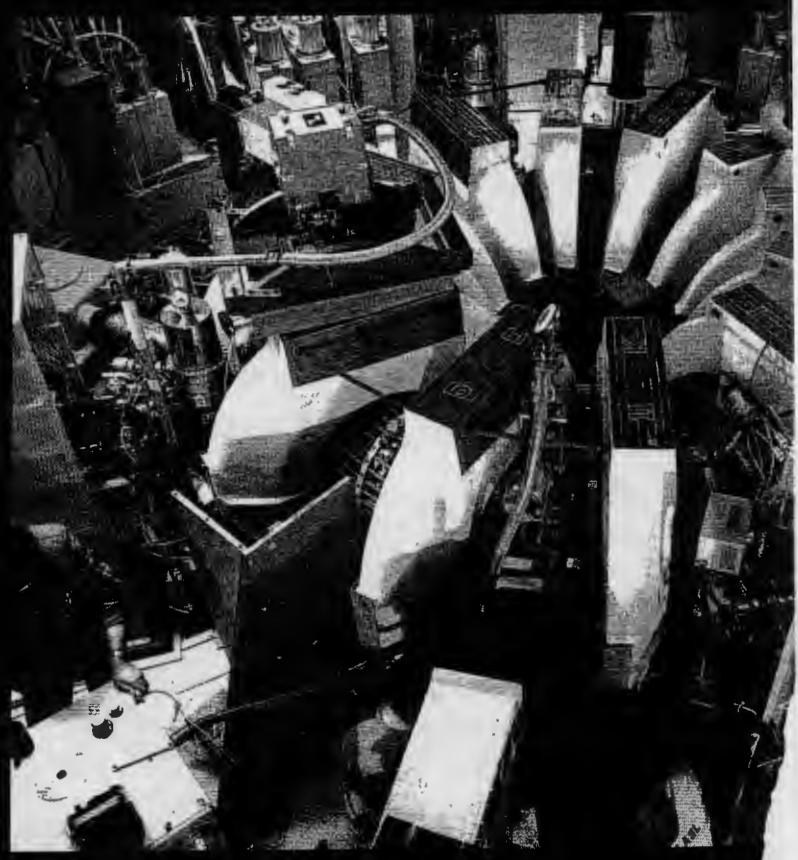
Safer methods for shallow land burial of low-level wastes are the objective of other waste management projects. Los Alamos operates an engineering test site for shallow land burial, which allows scientists to evaluate trench caps, various lining materials, and surface-water control techniques that would help isolate low-level wastes.

Instruments and systems developed at the Laboratory are becoming international standards for safeguarding special nuclear materials. An integrated data system (IDS) is being developed to acquire, reduce, and store experimental data. The IDS will sample about five thousand different data channels from tests (some of which continue for several years), store the data, and





The Nuclear Plant Analyzer displays a scenario similar to the 1979 Three Mile Island accident caused when a valve jammed in the open position.



transfer them to principal investigators for analysis. The system is being built to a stringent reliability requirement within a quality-assurance program that will support licensing of the Nuclear Waste Repository.

Magnetic Fusion Energy

The magnetic fusion project Sherwood, established at Los Alamos in 1952, was the nation's first program in controlled thermonuclear research. In 1957 the first laboratory thermonuclear plasma (at a temperature of about 10,000,000 degrees Celsius) was achieved at Los Alamos. Since then the Laboratory has investigated nearly all aspects of the production, heating, and magnetic confinement of plasma.

Los Alamos research on magnetic confinement fusion focuses largely on concepts of high power density, which show the possibility of scaling to compact, relatively simple reactor systems. The reversed-field pinch and two compact toroid concepts are being studied. The largest reversed-field pinch device is the ZT-40M, a toroidal machine that uses strong electrical currents (up to 600,000 amperes) flowing in the plasma to heat it to millions of degrees and provide the major magnetic field for confining the plasma. Experiments with the ZT-40M contribute toward the data base needed to develop this approach for confining the hot plasma fusion fuel. Plasma has been heated to 6,000,000 degrees Celsius in plasma discharges, which have been sustained for up to 27 milliseconds, one thousand times longer than previous Los Alamos reversed-field pinch experiments.

The compact toroid experiments (the CTX spheromak and the FRX-C field-reversed experiment) produce doughnut-shaped plasmas with confining magnetic fields generated principally by electric currents flowing within the plasmas. The hole in the torus shrinks to produce a compact toroidal shape without vacuum walls and magnetic coils passing through the center of the torus. CTX has produced hot plasmas with temperatures between one and two million degrees Celsius, in pulses lasting up to 8 milliseconds. Plasma temperatures as high as 7,000,000 degrees Celsius have been achieved in FRX-C.

In a related program, the Laboratory is developing technology for safely handling large quantities of tritium. The Tritium Systems Test Assembly, which began operating with tritium in 1984, is helping to develop, evaluate, and demonstrate the tritium technology required for next-generation fusion experiments and for fusion reactors.

Experiments with the ZT-40M are providing important data on the reversed-field pinch approach to magnetic confinement fusion.

Alternative Energy Sources

The Los Alamos Energy Security Program provides a coherent approach to the energy research and development needs of the military, but its efforts benefit civilian concerns as well. Scientists have identified research required to provide secure energy supplies for both the near and distant future.

Los Alamos researchers believe that fuel-cell technology will have both a civilian and a military role. To date, the effort has concentrated on identifying and performing research for transportation applications. In addition to systems analyses, work has focused on electrochemistry, alternative catalysts and electrolytes, and uses of unique resources, such as the 6-million-electron-volt ion-beam facility for *in situ* electrochemical measurements. The research is complemented by analytical computer modeling of reactions. The program also includes design and development of the fuel processor that extracts hydrogen from a hydrocarbon fuel for the fuel cell.

Fuel cells, currently used for space applications and under development for utility applications, could be used as part of a propulsion system for city buses, military vehicles, submarines, and, ultimately, private automobiles. The Laboratory also performs systems studies that examine other fuel-cell applications, such as transportable power plants for military purposes.

In an effort to increase fuel efficiency, Laboratory hydrodynamists model the processes that occur in internal combustion engines. To determine combustion patterns in cylinders, these computer programs model in three dimensions material flow, thermochemistry, and heat transfer. Such codes are being extended to model the combustion of coal and water mixtures.

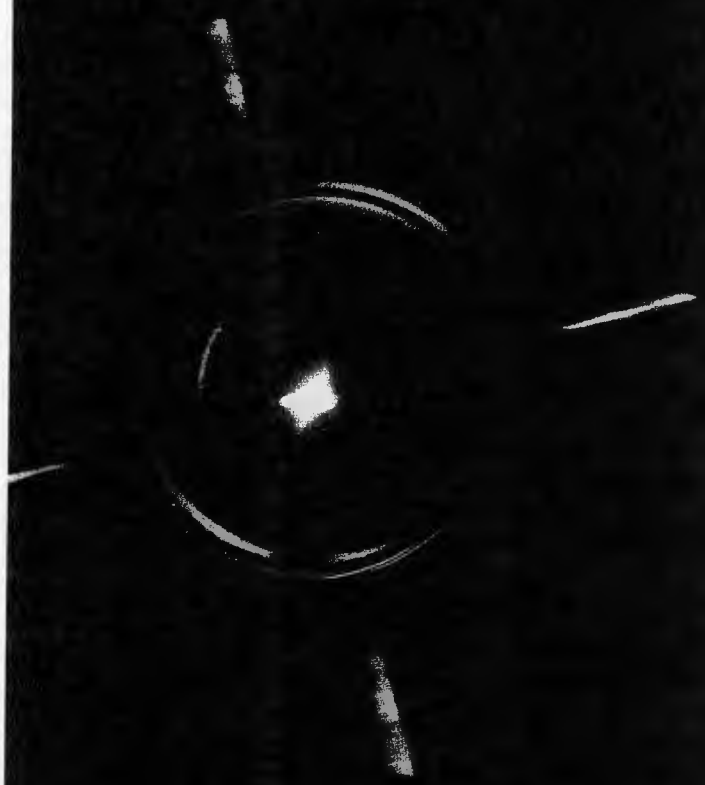
Los Alamos is continuing to develop state-of-the-art, nonintrusive diagnostic techniques for *in situ* measurements in coal gasification streams. Lasers of different wavelengths excite molecules in the gas to determine the degree of combustion, impurities present, and remaining mineral matter. Several field tests have been completed using gasifiers of the Morgantown Energy Technology Center.

In oil shale research, the Laboratory has major responsibility for studies on siting methodology. It will initially concentrate on atmospheric dispersion modeling and environmental concerns associated with the potential siting of oil shale plants.

The hot, dry rock geothermal energy program is developing the technology required to produce energy from the natural heat stored in rock at accessible depths in the earth's crust. The world's first hot, dry rock geothermal energy system was developed near Los Alamos using fluid pressure (hydraulic fracturing) to create cracks in hot granitic rock at depths of about 8,500 feet. The fractures connected two inclined wells through which water was circulated, extracting heat from the hot rock. The system was a closed loop that produced 60 kilowatts of electricity and proved to be environmentally benign.

A larger, deeper, hotter system is now being developed at the same site. Two wells have been drilled to about 15,000 feet. Again, using hydraulic fracturing, a large reservoir capable of producing up to 60 thermal megawatts was formed. Research is directed toward connecting the wells to the reservoir and subsequently circulating water through the system to determine the reservoir performance and lifetime. Upon successful completion of the research, the site is potentially capable of supporting a small commercial power plant.

The science and technology base supporting the hot, dry rock program has produced remarkable achievements in new, high-temperature equipment and instrumentation and in seismic analysis, as well as a better understanding of the earth's geology. Because hot rock exists everywhere beneath the earth's surface, hot, dry rock systems are of great international interest. The United States government and agencies of the governments of the German Federal Republic and Japan jointly support the Los Alamos program.



Laser-induced breakdown spectroscopy allows researchers to measure the concentration of elements in the product stream of a coal gasifier. When a laser spark is viewed through crossed lenses, atomic emission lines are superimposed on the background continuum.

The world's largest hydraulic fracture operation at Fenton Hill created a reservoir for the hot, dry rock geothermal energy program.

Western pioneers learned from the Indians of "the rock that burns." Today Los Alamos geoscientists are studying in situ *rubblization and retorting of oil shale.*

Flags of the United States, Japan, and the German Federal Republic fly at Fenton Hill to symbolize international collaboration in the hot, dry rock geothermal energy program.

Basic Research

The search for new knowledge—basic research—leads to fuller understanding of the nature of the world and the universe. In addition, discoveries and advances in basic research often lead to new ideas or applications—the practical but unpredictable consequences of fundamental inquiries.

J. Robert Oppenheimer, the first director of the Laboratory, said of basic research: "If the inquiry is well conceived it will not merely come up with a new answer, it will come up with something far more valuable, which is a new question, one which had not been thought of before. Out of such questions, and their progeny, the growth of science and the growth of practice both arise." Indeed, the Laboratory's basic and applied research programs have a synergistic effect on each other, an effect that helps keep Los Alamos in the forefront of scientific and technological discoveries.

Basic research provides support and guidance for national security and energy programs, while advancing the endless frontier of science. The Laboratory's programs cover every major branch of science—physics, chemistry, mathematics, biology, geosciences, engineering, materials science—and almost all subdisciplines: astrophysics, geochemistry, and biophysics, to mention only a few.

Physics

Physics, both theoretical and experimental, is a major research area at the Laboratory. Included are nuclear physics; plasma physics; condensed matter physics; astrophysics; atomic and molecular physics; space physics; and nonlinear, nonequilibrium phenomena.

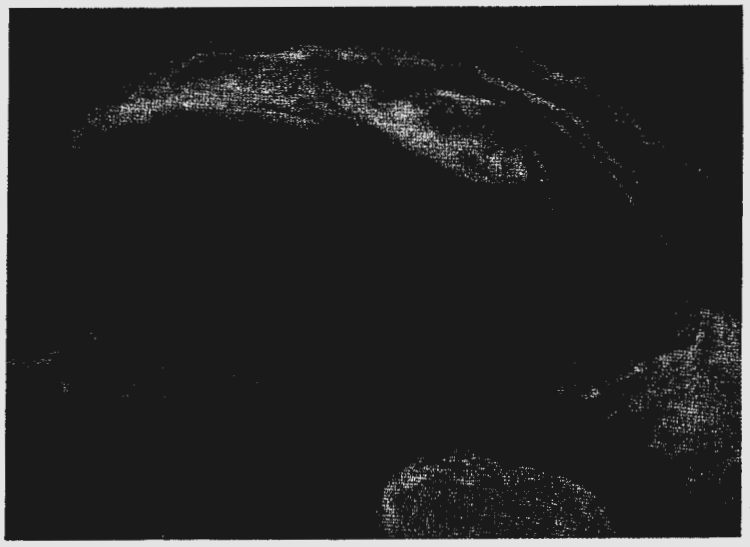
Los Alamos researchers invented methods for predicting the motion of free neutrons (neutron transport) and developed data bases of important nuclear and material properties, namely, nuclear cross sections, equations of state, and opacity. Reactor physicists and weapon designers routinely use these data in their calculations. Basic numerical methods for studying time-dependent compressible and incompressible flows in three dimensions and with large material distortions are Laboratory contributions.

The Clinton P. Anderson Meson Physics Facility (LAMPF) provides the world's most intense proton beams for nuclear science research. The heart of the resource is a linear accelerator designed to provide beams of protons with variable energies up to 800 million electron volts and a current of 1 milliampere. The accelerator is designed to bridge the gap between nuclear and subnuclear physics, as well as to be used for practical applications.

A successor to the present accelerator is currently being planned. This upgraded accelerator will provide proton beams with energies up to several billion electron volts and will open new frontiers of research in high-energy and particle physics.

The Laboratory conducts basic research in space physics and astrophysics to support such defense efforts as the interagency verification program. This program provides the United States with satellite systems for worldwide surveillance of nuclear explosions conducted in the atmosphere or in space. Research is also

The red spot on Jupiter is a striking example of natural structures that originate from nonlinear fluid dynamics, a subject actively studied by Los Alamos scientists.



carried out to assess the chemical and plasma effects of detonating nuclear weapons within and above the atmosphere.

In the quest to unravel the complexities of black holes, white dwarfs, and neutron stars, Los Alamos astrophysicists probe the nature and origin of cosmic gamma-ray bursts, supernovae, transient x-ray sources, and the astrophysical processes that occur near strong gravitational fields. One research project investigates the hypothesis that the observed periodic extinctions of terrestrial species are the result of comet showers caused by Nemesis, a hypothetical companion star to the sun. According to this theory, the comets' impact on the earth produces a new outer atmosphere of hot gas and dust that blocks sunlight and causes the death of plant and animal life.

Mathematics and Computational Physics

Los Alamos mathematicians concentrate for the most part on two general areas of research in their attempt to describe and understand complex phenomena relevant to Laboratory programs. The first concerns the effect of nonlinearities (processes characterized by irregular or unstable motion), which pervade the models associated with complex physical phenomena.

The second area is numerical analysis, that is, more efficient and effective ways to represent and calculate approximate solutions to complex problems. An important application is numerical fluid dynamics, which the Laboratory helped develop into a powerful research tool.

Other areas explored mathematically at Los Alamos include the application of group theoretic techniques to molecular and atomic spectroscopy, as well as the behavior of models of biological systems. In addition to studying specific problem areas, Los Alamos leads in developing computational techniques for ordinary and partial differential equations, integral equations, and approximation theory.

High-voltage Cockcroft-Walton generators supply particles for LAMPF's experimental beams.

Los Alamos has one of the major computing centers in the world. Within tens of seconds the common file system, which offers large-capacity online storage, can retrieve cartridges from a honeycomb of cells.

Chemistry is fundamental to the success of many Laboratory technical and scientific programs.

Chemistry

Chemical research unites classical test-tube chemistry with advanced techniques using molecular jets, lasers, and ultrafast diagnostics to prove the nature of chemical structures and reactions. Activities range from analytical chemistry and its uses in environmental research to physical chemistry and nuclear chemistry research to the development and application of lasers for basic research, national defense, energy, and industrial uses.

Some analytical chemistry research aims to develop robotic systems for routine sample preparation; these systems will provide more accurate analysis, increased productivity, and reduced human exposure to hazardous materials. Chemists are analyzing a variety of substances containing plutonium, uranium, and americium. These materials include actinide metals analyzed for trace impurities, state-of-the-art alloys used in prototype nuclear weapons, and chemical solutions related to processing, recovering, and recycling scrap plutonium and uranium.

In laser photochemistry, researchers examine fundamental molecular interactions in an attempt to understand and control chemical reactions that are important to the synthesis of materials and to energy production. Using advanced laser diagnostic techniques, scientists investigate the detailed chemistry and reaction rates of highly reactive, transient species that otherwise would be difficult or impossible to study.

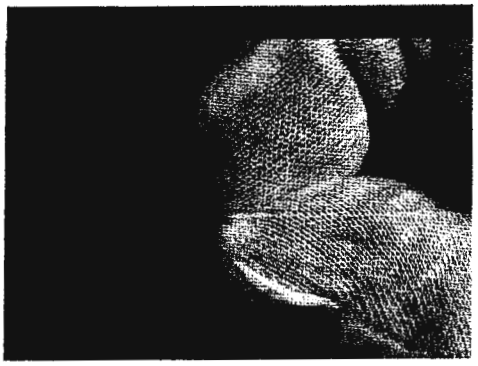
Surface scientists study chemical reactions that occur in such complex events as catalysis and corrosion. An important goal is selectively modifying the surface reactivity of materials by using additives or altering microscopic surface structure. These studies have practical applications for improving catalysts and fuel cells. Los Alamos scientists also are developing theoretical techniques for understanding the dynamic aspects of materials.

Materials Science

Understanding the relationship between the composition, structure, and properties of materials and their response to external environments represents a continuing challenge to Los Alamos scientists. Research on mechanical behavior of materials emphasizes the response to multiaxial and high-rate loading. Analytical models are being developed that relate microstructural features, such as texture and preferred crystal orientations, to macroscopic behavior. Scientists examine microstructures with metallography, electron microscopy, and x-ray diffraction. Research on the behavior of materials under severe environments, such as high pressure, high temperature, and high strain rates, includes experiments with the diamond anvil cell and dynamic flier plates. A major effort in materials science is the increasing use of ion beams to analyze surface structure and composition and to modify surfaces for improved electronic or mechanical properties.

Much of the Laboratory's materials research concerns the behavior and properties of actinides, especially the role played by their unique electronic structure. The study of superconductivity and magnetism in actinide compounds has uncovered a class of heavy fermion (electron) materials, some of which exhibit a mechanism for superconductivity. This research offers new insights into the electronic behavior of materials.

Materials synthesis and processing represent significant efforts at the Laboratory, ranging from structural ceramics to electrically conducting polymers and novel metals and alloys. Silicon carbide "whiskers" are the strongest materials known. When they are incorporated into another material, they make it stronger and stiffer but add little to its weight. Structures made from materials reinforced with silicon carbide whiskers can withstand extremely high temperatures and severe shocks before failure. In heat exchangers or turbines, the whiskers significantly increase thermal efficiency.



Silicon carbide whiskers are single-crystal fibers, one of the smallest forms a substance can take, yet they are stronger than any other form of material known.

The Proton Storage Ring (PSR) is a major addition to LAMPF; this newly operational driver for a high-intensity pulsed-neutron source will expand research strength in materials science and nuclear physics. The picture shows the beam injection and extraction region of the PSR.

Earth Sciences

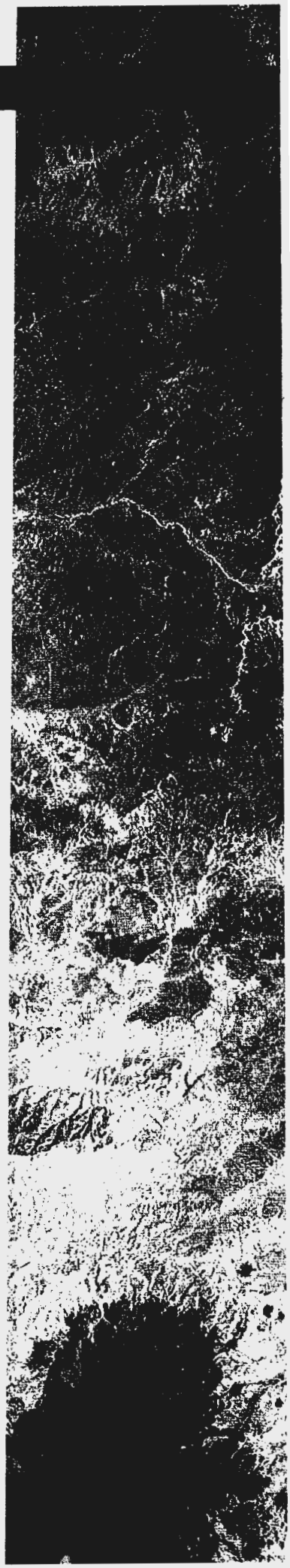
Earth sciences research contributes to several Laboratory programs: underground nuclear testing; hot, dry rock geothermal energy; and radioactive waste management. In addition, Los Alamos earth scientists study continental geodynamics, physical processes that govern variations in winds and turbulence, and selected geologies from prospective waste storage sites.

Studies of wind turbulence contribute to a variety of earth sciences programs.

Research efforts in field geology and geophysics, rock physics, seismology, petrology, mineralogy, geochemistry, numerical simulations, and technology development are dedicated to the fundamental goal of understanding continental geodynamics, such as continental rifts. Currently, scientists are investigating hydrothermal systems through the Continental Scientific Drilling Program.

Los Alamos research attempts to understand the physical processes that govern important variations in wind and turbulence. A better understanding of these processes is essential to siting and developing energy production operations in an environmentally responsible manner. Processes studied include nighttime cold-air drainage down hillsides and along valleys, channeling of winds parallel to ridges and valleys, air stagnation in basins, and mountain-induced waves of air. Using the combined techniques of experiment and numerical modeling, scientists can describe quantitatively the region of influence and strength of wind circulation and turbulence, estimating the effect of these factors on the distribution of released tracer gases. Local research efforts are combined in a multilaboratory program called Atmospheric Studies in Complex Terrain (ASCOT), which Los Alamos will manage from 1985 to 1990.

Radiochemists and geologists are investigating the migration and fixation of elements under various geologic conditions. The goal is to determine the effectiveness of certain geologic formations as barriers to radionuclide migration under diverse hydrologic conditions. Uranium ore deposits, the natural reactor in Gabon, and nuclear explosion cavities at the Nevada Test Site serve as areas for field experiments. The results of these studies can provide information not only applicable to determining safe, permanent storage for nuclear wastes, but also relevant to understanding natural geochemical processes such as ore formation.



The photograph on the right, taken from a satellite 1,000 kilometers above the earth, shows an area of the Rio Grande Rift approximately 100 kilometers square. The river, which appears as a blue line descending from the upper right, is the Rio Grande, and the crater in the center is the Valle Grande. Vegetation photographed on infrared film appears red.

Life and Environmental Sciences

Basic research in the life sciences addresses the most fundamental molecular functions of living systems. It also supports the Laboratory's responsibility to identify and minimize potential problems associated with its energy and defense programs.

New ways of measuring biochemical events permit experiments never before possible. Such experiments have contributed to understanding cancer induction and progression, as well as to studies of the mechanisms underlying gene expression and function. These studies address the fascinating problem of how a living cell can select only that portion of the genetic information required for its own function. They also address the relationship of chromosome instability to tumor growth and the molecular mechanisms of cellular defense and DNA repair that have evolved in humans and other mammals. Collaborations among theoretical, computational, physical, and biological scientists have advanced studies of neurobiology, the analysis of complex protein mixtures, the use of neutrons to study the structures of large proteins and cell nuclei, and the development of techniques for imaging metabolic processes.

In collaboration with Lawrence Livermore National Laboratory, Los Alamos scientists have developed a national resource to produce chromosome-specific, human recombinant DNA libraries. Studies of repetitive DNA sequences provide new, sensitive tools for detecting DNA damage and new insights into the relationship between DNA structure and function. Theorists in cell biology, immunology, and genetics are the architects and builders of GenBank, the national computer library for storing and studying nucleic acid sequences, the components of RNA and DNA.

Instruments developed at Los Alamos use laser-induced fluorescence to analyze and sort individual cells for anomalies (a technique called flow cytometry). After fifteen years of pioneering developments, the Laboratory was designated by the National Institutes of Health and the Department of Energy as the National Flow Cytometry Resource. The Laboratory provides the worldwide biomedical community with access to state-of-the-art flow cytometry technology.

Los Alamos scientists also produce stable and radioactive isotopes for medical researchers to image organs, diagnose diseases, and monitor physiological processes. In addition, they are developing clinical laboratory instruments for the rapid identification of viruses and bacteria. Because the instruments require only minutes, rather than hours or days, to identify viruses and bacteria, treatment of life-threatening diseases can begin promptly.

Argon-ion and krypton-ion laser beams focus on the flow chamber of the flow cytometer where a thousand cells are analyzed per second.

Cells exit the flow chamber of the flow cytometer in a stream of tiny droplets, which can be charged and deflected by an electric field to allow researchers to isolate single cells.

Los Alamos researchers are investigating the potential of nuclear magnetic resonance as a tool for diagnosing metabolic disorders.

Engineering

Virtually every major research and development activity at the Laboratory involves engineering. Engineering research often combines with scientific research to achieve an overall objective. For example, a multidisciplinary team of scientists and engineers, combining experimental and theoretical techniques, is working to develop a more fundamental and detailed understanding of how explosives behave. The knowledge gained could lead to practical new explosives for use in the Laboratory's weapon programs.

In addition, many projects are specifically designed to advance engineering disciplines. For example, extensive research is under way to develop advanced computer techniques for engineering analysis. This work advances the Laboratory's ability to model accurately complex fluid flows, heat transfer processes, and the response of materials and structures to a range of driving forces. Another important area of research is advanced electronics, which includes circuits that are highly resistant to heat and radiation, as well as photoconductive switches capable of operating in picoseconds and at high power levels. Additional research areas include advanced computer networks, development and implementation of CAD/CAM systems (computer-aided design/manufacture), development of new materials and composites and determination of their properties, and development of electromechanical devices for application in weapon and energy programs. These and many other projects provide the Laboratory with the state-of-the-art engineering capability needed to perform its mission.

Institute of Geophysics and Planetary Physics

In 1950 the University of California formed the Institute of Geophysics and Planetary Physics (IGPP) at its Los Angeles campus to serve as a center for scientists working in the many specialties relevant to the Earth and other planets. The success of this first endeavor led to additional branches on other campuses of the University, and in 1980 a branch was established at Los Alamos National Laboratory.

A special purpose of the Los Alamos branch is to develop stronger ties between researchers at the Laboratory and those on the University campuses. Consequently, the branch funds collaborative teams, whose broadly based research encompasses such disciplines as geology, geochemistry, geophysics, atmospheric sciences, space sciences, and astrophysics. The Los Alamos branch fosters exchanges of information and ideas in workshops and seminars and, in addition, promotes the sharing of equipment and resources in collaborative research. It also conducts a six-week summer field camp in the geophysical sciences.

For computer-aided inspection, a researcher uses a ruby-tipped probe to compare the dimensions of a machined part to a mathematical model.

Center for Materials Science

High-performance materials play a large and growing role in the Laboratory's defense and energy programs. These programs often subject materials to extreme conditions involving heat, pressure, and corrosion, which require materials scientists to work at the frontiers of the discipline and its technology. Virtually every experiment or design that Los Alamos undertakes is limited by the understanding or availability of materials to do the job.

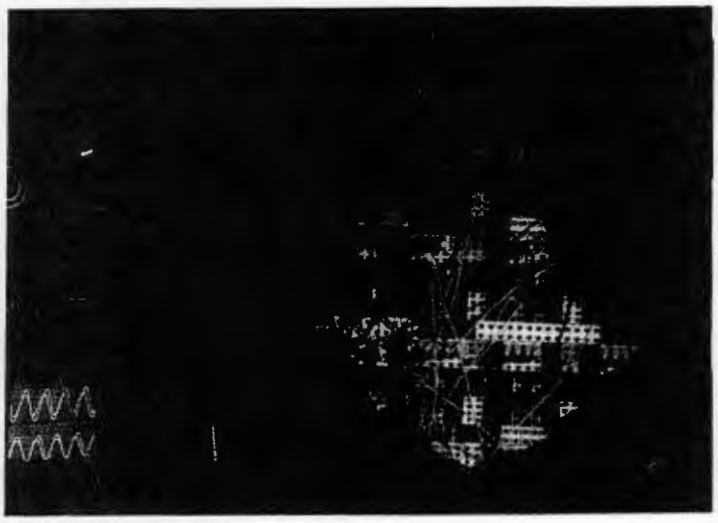
The Center for Materials Science was founded in 1981 to focus materials research and development activities within the Laboratory and to strengthen the interactions of researchers at Los Alamos with the national materials science community. The Center supports workshops, visitors, and collaborations with university researchers. An important venture, started in 1984, was the establishment of summer research groups, involving scientists from universities or industries and Los Alamos. One group focuses on mechanical properties of materials, particularly large-strain plasticity, and the other group on the electronic structure of actinide metals, particularly heavy fermion conductors.

Center for Nonlinear Studies

The Laboratory established the Center for Nonlinear Studies in 1980 to conduct scientific research on nonlinear problems, to encourage interdisciplinary research, and to increase interaction between Laboratory and university mathematicians and scientists. Nonlinear processes are typically characterized by irregular or unstable motion and by unexpected responses to small changes. Because many of the Laboratory's energy and defense programs involve complex nonlinear phenomena, developing analytical methods for nonlinear systems has broad applications.

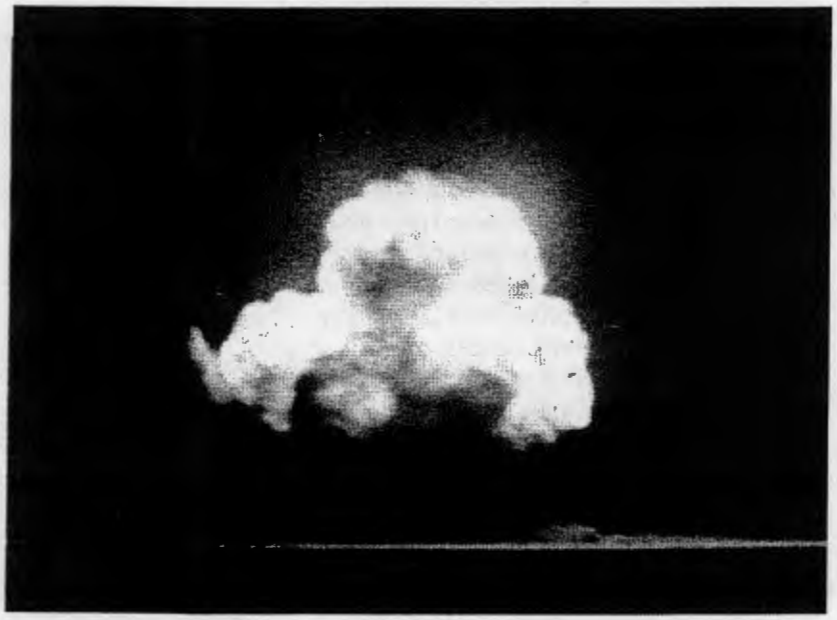
The Center coordinates the study of selected, basic nonlinear problems and stimulates interdisciplinary dialogue through international conferences and local workshops and colloquia. A number of these meetings led to published proceedings that have received considerable recognition for their value to researchers in several fields. The Center links Laboratory scientists with academic centers of excellence in nonlinear research and introduces young scientists to important nonlinear issues. Topics of research include the interplay of organized structures and chaos in physical systems such as turbulent fluids and plasmas, the mechanisms of energy transport in synthetic and biological polymers, and the development of advanced numerical methods for computer simulations of nonlinear problems.

Left: ***By diffusing plastic film with a cesium compound, scientists alter the film's structure so that it conducts electricity. This conductor can replace metal when light weight is important. The electronic structure of the plastic makes the film purple.*** **Right:** ***In a research project at the Center for Nonlinear Studies, a scientist investigates strange attractors by solving nonlinear differential equations on an analog computer.***



Some Los Alamos Firsts

As an innovative laboratory pursuing research on the frontiers of science, Los Alamos has produced many firsts. The best known is the development of the first atomic and thermonuclear weapons. Some other noteworthy contributions to the history of science and technology include the following.



The world's first plutonium bomb, code named Trinity, was detonated at Alamogordo Bombing Range on August 16, 1945. The blast created thunder audible for 50 miles and a flash visible 250 miles away.

National Security

Development of insensitive high explosives.

Development of many new special metal alloys, including several plutonium alloys.

Development of equipment and systems for safeguarding nuclear materials.

Use of carbon dioxide lasers to produce thermonuclear reactions from deuterium-tritium mixtures in fusion fuel pellets.

Development of the krypton fluoride laser.

Demonstration of uniformly frozen cryogenic laser fusion targets.

Development of technology for improved verification and arms control.

Energy

Development of the highest temperature, highest power-density nuclear reactor (Rover).

Development of a unique isotope separation process using lasers.

Laboratory demonstration of controlled thermonuclear reactions.

Production of geothermal energy from hot, dry rock at commercially useful temperatures and rates from naturally heated rock in the earth's crust.

Large-scale handling and use of liquid hydrogen, leading to much of the technology used in the space program and in the nation's cryogenic engineering industry.

Construction of the first fast reactor (Clementine), a plutonium-core reactor that demonstrated the characteristics of a fast neutron reactor.

Development of the first homogeneous fueled reactor.

Basic Research

Development of Monte Carlo computational techniques for neutral particle transport and other applications.
Direct detection of the neutrino (electrically neutral, stable, subatomic particle).
Construction of an 800-million-electron-volt linear accelerator, one of the world's largest, most powerful, medium-energy research accelerators.
Development of the particle-in-cell method for numerical calculations of fluid flows, now used extensively worldwide.
Discovery of cosmic gamma-ray bursts.
Discovery of heavy fermion metallic superconductors.

Environment and Biosciences

Production of nitrogen-, carbon-, and oxygen-enriched isotopes by cryogenic distillation.
Development and application of flow cytometry for use in biological research, bacterial and viral identification, disease diagnosis, and therapy monitoring.
Use of pion irradiation therapy for treatment of cancer.
Development of enzyme-labeled antibody tests that permit rapid, automated, mass screening for diseases.
Development of ultrasensitive analytical techniques for detecting biological molecules at extremely low concentrations.
Discovery of evidence of an iridium anomaly at the Cretaceous-Tertiary boundary in freshwater continental deposits.

Theoretical and Computational Physics

Construction of numerical models of high-explosive burn.
Construction of mathematical models of allergic response (with Johns Hopkins University).
Development of the theory of plasma turbulence.
Construction of computer models for highly distorted flows.

In the drift-tube section of the LAMPF accelerator, particles are accelerated to energies of millions of electron volts.

ORGANIZATION OF THE LABORATORY

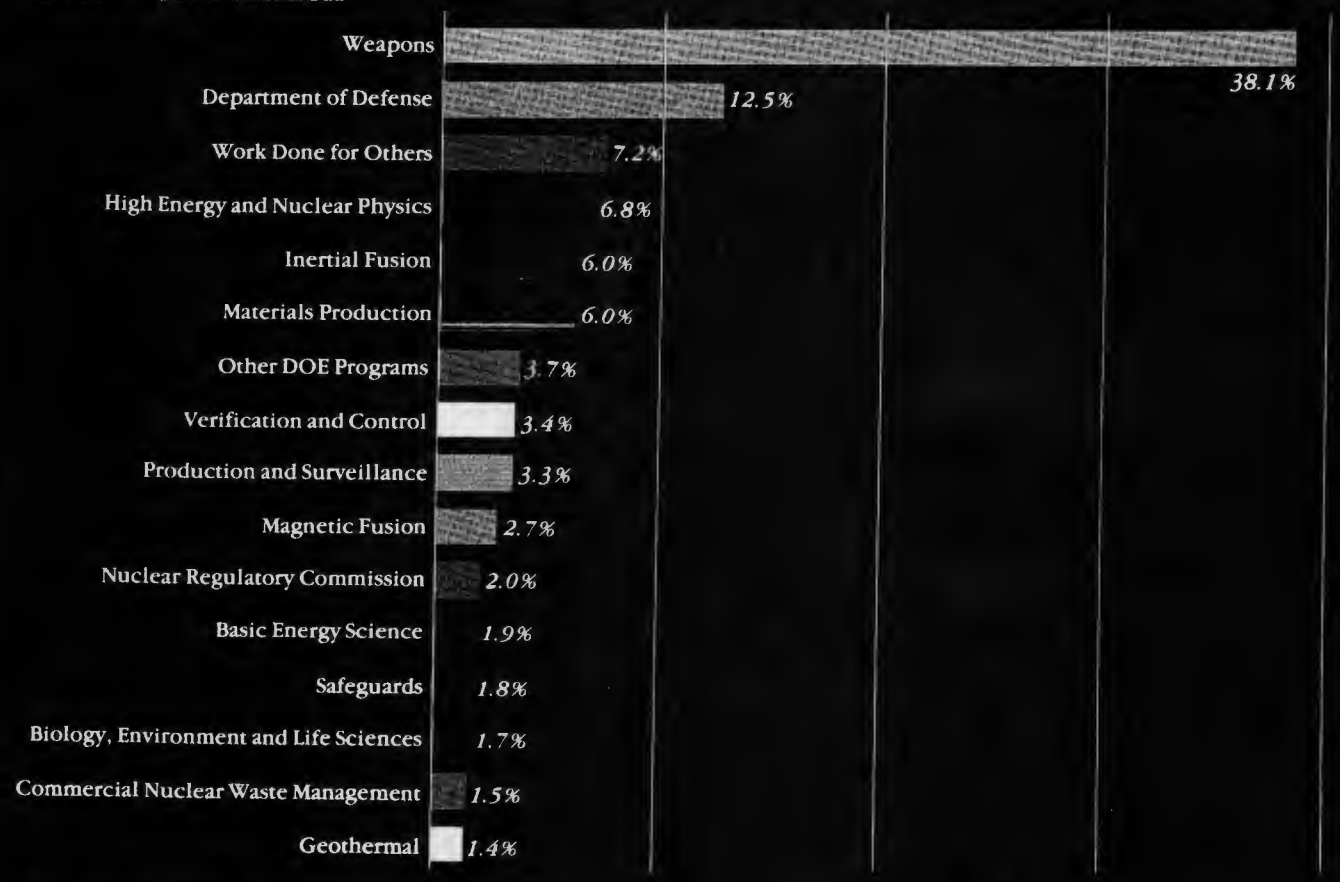
The Laboratory's land, buildings, and resources are owned by the Department of Energy and operated under contract by the University of California. The Albuquerque Operations Office of the Department of Energy oversees the administrative and budgetary aspects of the contract, assisted by its branch, the Los Alamos Area Office. Laboratory staff are employees of the University of California and benefit from the association in several ways, including participation in University retirement programs.

Discussions on programmatic work involve the Laboratory, the Albuquerque office, and Department of Energy headquarters in Washington, D. C. In the headquarters organizational structure, the Laboratory falls under the managerial purview of the assistant secretary for defense programs, along with the other weapon laboratories, Sandia National Laboratories and Lawrence Livermore National Laboratory.

The organization chart (see insert preceding back cover) presents the Laboratory's basic operational structure. Programmatic and functional management is the responsibility of the associate directors. Associate directors guide scientific and technical programs and provide services and administrative support. Division leaders are responsible for the capabilities necessary to carry out the Laboratory's research programs.

The Visitor Reception Center, which enhances security in front of the Administration Building, provides information to the public and badges to authorized visitors.

FY 85 Operating Funds
Total ~ $688 million

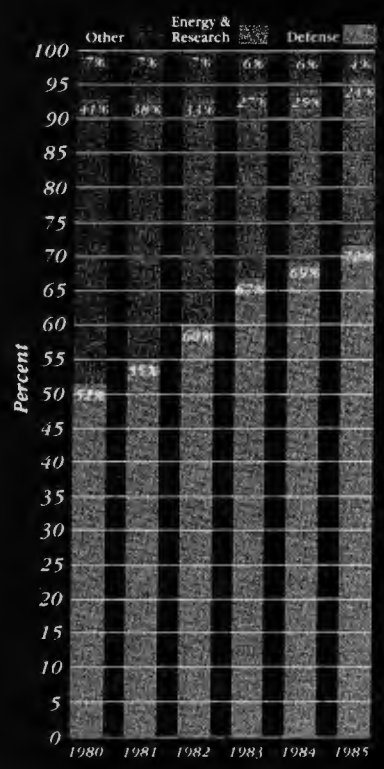


BUILDINGS, RESOURCES, AND BUDGET

The Laboratory consists of thirty-two technical areas (sites) distributed over about 43 square miles of the Pajarito Plateau. More than 125 principal buildings provide nearly 6,000,000 square feet of floor space and would cost more than a billion dollars to replace.

Of the Laboratory's many unique resources, visitors and new employees often inquire about the J. Robert Oppenheimer Study Center and the Central Computing Facility. Two of the newer complexes are the Detonation Systems Laboratory and the Target Fabrication Facility. Visitors may begin their tours of the Laboratory at the Visitor Reception Center in front of the Administration Building.

Funding Mix



The Otowi Building houses the main cafeteria, personnel services, and other Laboratory offices.

Visitor Reception Center

The Visitor Reception Center, a small building located in front of the Administration Building, provides a place for official visitors to meet their hosts and guides. Authorized visitors need badges to enter many parts of the Laboratory, and they receive these at the Center. Any visitor may obtain information there. The receptionist can answer questions about the Laboratory and the community, provide maps and brochures, and give directions to places of general interest.

The J. Robert Oppenheimer Study Center is conveniently located near the Visitor Reception Center and the Administration Building.

The J. Robert Oppenheimer Study Center

The 70,000-square-foot J. Robert Oppenheimer Study Center is generally open to the public and is built on three levels, with the main library on the first and second floors, and conference and workshop areas on the upper level.

The Study Center houses an extensive technical library, including some three hundred thousand bound volumes, more than six hundred thousand classified and unclassified reports, and current subscriptions to about four thousand journals. Foreign publications make up a significant part of the total collection. Films produced at the Laboratory, as well as audio-visual materials from other sources, are also available.

The J. Robert Oppenheimer Study Center houses the Laboratory's extensive technical library and offers space for meetings.

The J. Robert Oppenheimer Study Center offers a place where employees of the Laboratory can meet with colleagues from industry, government, universities, and other laboratories. The building lends itself easily to the needs of different visitors—from symposia to technical workshops to international groups requiring simultaneous translation capabilities. Laboratory press conferences and briefings are held here, as well as special functions for visiting dignitaries. The Study Center also

provides audio-visual equipment, seminar rooms, conference areas, and individual study desks.

The Study Center features a heating, cooling, and ventilating system developed by the Laboratory's solar energy research group. The solar system provides 97 percent of the energy needed to air-condition the building and 76 percent of its heat. Total useful solar heat energy collected by the building averages 370,000 kilowatt-hours yearly.

Central Computing Facility

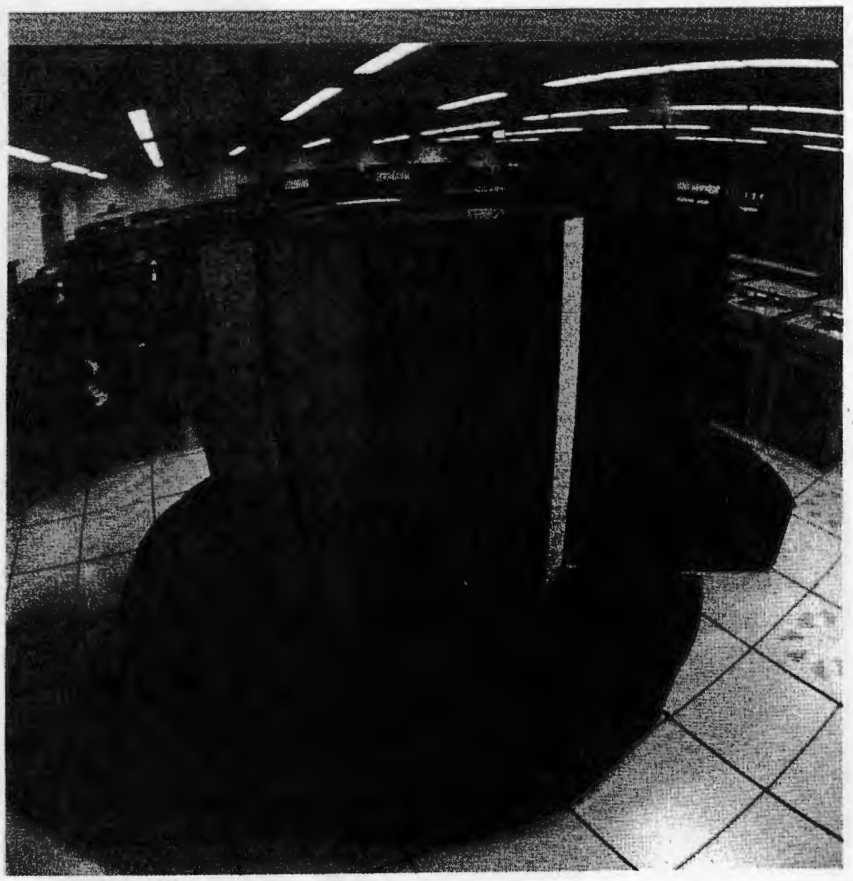
Since the early days of the Manhattan Project, Los Alamos has been at the leading edge of scientific computing. Today the Laboratory's computing capabilities equal or exceed those of any other computing center in the world. The Integrated Computing Network (ICN) links user terminals, communication computers, worker computers (large scientific computers), large-capacity storage banks, and output devices to serve more than six thousand users throughout the Laboratory and across the country twenty-four hours a day.

The ICN now consists of fourteen major computers—two Cray X-MPs, four Cray 1s, four CDC 7600s, a CDC Cyber 170/855, and three Cyber 170/825s—linked together in an integrated network. The Crays and 7600s are used primarily for scientific computing. The Cybers are used mainly for general-purpose computing and for computer-aided design and engineering applications. In addition to the large central machines, the network includes smaller computers distributed throughout the Laboratory. These computers are used for real-time data acquisition and control systems, processing of scientific data, and other related support activities.

Detonation Systems Laboratory

The Detonation Systems Laboratory, a 44,000-square-foot complex, provides office and fabrication areas. Its primary tasks are to control the processing environment, specifically temperature, humidity, and dust, and to meet current fire and safety standards for handling explosives. Clean, efficient fabrication areas contribute to product quality and lower the rejection rate for the detonators produced here.

The Cray X-MP dual processor supercomputer is the newest and most powerful addition to the Laboratory's integrated computing network.



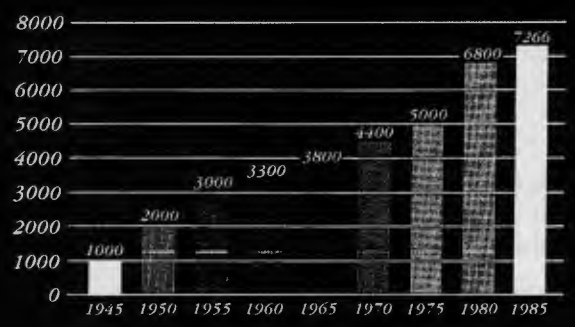
Target Fabrication Facility

The Target Fabrication Facility, built in 1983, provides necessary technical support to the national program of fabricating targets for inertial confinement fusion and weapon physics research. As inertial confinement fusion and other program experiments become more diverse and complex, so, too, do the components and targets required to conduct the experiments. The Target Fabrication Facility, with its comprehensive fabrication and assembly capabilities, range of flexible assembly techniques, and large inventory of materials, enables researchers to respond rapidly to requests for new experimental targets and components.

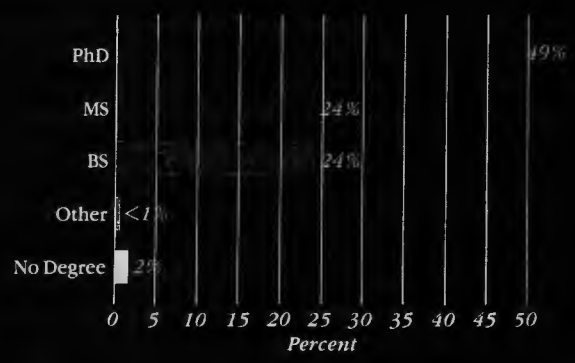
The Target Fabrication Facility also offers Los Alamos and other government installations a unique environment for conducting basic and applied research in materials science, for both classified and unclassified programs. Because the Laboratory's materials development program is interdisciplinary, the plant was designed to promote unified research and development in physical metallurgy, polymer technology, materials chemistry, electrochemistry, coatings, microfabrication and assembly, and process metallurgy.

Materials scientists use a high-powered neodymium yttrium aluminum garnet laser to drill tiny holes in metal.

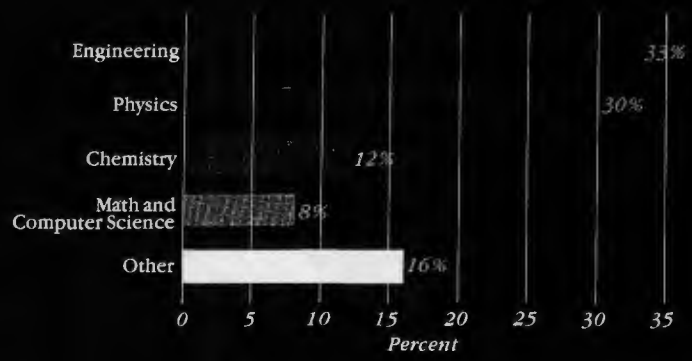
Full-Time Regular Employees



Technical Staff by Degree



Technical Staff by Discipline



Numbers do not add to 100% because of rounding.

EMPLOYMENT AND EDUCATIONAL OPPORTUNITIES

The Laboratory employs more than seventy-six hundred people, including almost seventy-three hundred regular, full-time employees.

Almost 50 percent of the technical staff members hold doctors' degrees, whereas 24 percent hold masters'degrees and 24 percent have bachelors' degrees. About 33 percent of these technical staff members hold degrees in the engineering field, 30 percent in physics, 12 percent in chemistry, 8 percent in mathematics and computer science, and about 16 percent in such disciplines as the geosciences, biosciences, and economics. Some staff members hold degrees in more than one field.

Besides these technical staff members—over three thousand people making up about 40 percent of the total Laboratory personnel—the Laboratory employs administrative staff members (10 percent), technicians (33 percent), and general series employees (17 percent). Technicians include machinists, biological and chemical technicians, and other materials and mechanical technicians.

Many opportunities for training and professional development, both formal and informal, exist at the Laboratory. Some of these special programs provide tuition assistance for career development, graduate thesis support, and self-study programs through the Learning Resources Center. The Laboratory also offers nearly three hundred courses each year in technical, management, communication, and office administration fields to enhance and upgrade employee skills and to provide opportunities for professional development.

Regular full-time employees are eligible for a comprehensive benefits program that includes a variety of health and life insurance plans, a retirement program, and a liberal sick leave and vacation policy. Regular full-time employees earn one and one-half days of sick leave and two days of vacation each month, in addition to receiving eleven paid holidays yearly.

The Laboratory's Wellness Center offers employees a variety of health and fitness programs. The Center includes a weight room with Universal equipment, an aerobic exercise room with a wide selection of equipment, and a private testing room. The Center staff provides nutrition profiles, fitness evaluations, aerobic exercise classes, and instruction in the use of equipment.

The Wellness Center offers a variety of health and fitness programs for Laboratory employees.

The Laboratory staff includes specialists in most major scientific and technical fields.

Interdisciplinary Nature of Laboratory Programs

Most Laboratory research is essentially interdisciplinary. Biochemical research, for example, requires the collaboration of biologists, chemists, physicists, nonlinear scientists, computer experts, and laser scientists. This constant mix of academic disciplines stimulates creative thinking to meet the challenge of the Laboratory's mission.

Special Employment Opportunities

The Laboratory offers several special employment programs to meet specific Laboratory needs and goals. Individual programs focus on undergraduates, graduate students and faculty, service academy cadets and officers, military researchers, recent recipients of doctoral degrees in science, and scientists who have achieved stature in their fields. Some of these special employment opportunities are:

* *Undergraduate Summer Employment.* This program provides relevant summer work experience to full-time undergraduates and high-school seniors who plan to enter college in the fall.

* *Associated Western Universities.* The Laboratory hosts appointments of graduate students and faculty, made through Associated Western Universities, by providing research opportunities at the Laboratory.

* *Historically Black Colleges and Universities Program.* Through this program the Laboratory encourages faculty and students from historically black schools to participate in research areas related to weapon programs.

* *Military Research Associate Program.* With the assignment of career scientific officers to staff member positions, this program improves interagency communication and gives the military a better understanding of work at a national weapons laboratory.

* *Service Academy Research Associate Program.* A limited number of service academy faculty members and cadets receive summer appointments to work with Laboratory employees in various programs.

* *Graduate Research Assistant Program.* The Laboratory provides jobs that contribute to students' graduate studies in science and engineering.

* *Summer Teacher Program.* Teachers participate in state-of-the-art research activities to help them keep abreast of technological developments they can share with their students.

Information on the above and other special programs may be obtained from:
Special Employment and Services Group (PA-13)
Mail Stop P290
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

Four additional programs offer special employment opportunities:

* *Bernd T. Matthias Research Fellowships* foster continuing interaction between the Laboratory and recent recipients of doctoral degrees who show promise of becoming outstanding leaders in materials science research.

* *J. Robert Oppenheimer Research Fellowships* offer research opportunities to new Ph.D.s who show promise of becoming outstanding scientific researchers.

* *Postdoctoral Research Appointments in Science and Engineering* provide work to deepen and broaden the research experience of recent Ph.D. recipients.

* *Long-Term Visiting Staff Members,* scientists who have attained stature in their fields, enhance the Laboratory's ability to meet its research and development goals.

Information on these programs may be obtained from:
Personnel Services Group (PA-13)
Mail Stop P290
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

Other employment opportunities enhance the Laboratory's interaction with industry and the academic community. Participants in these programs are affiliates rather than Laboratory employees:

* *Visiting Staff Members* come to the Laboratory for a specific assignment, on short-term appointments.

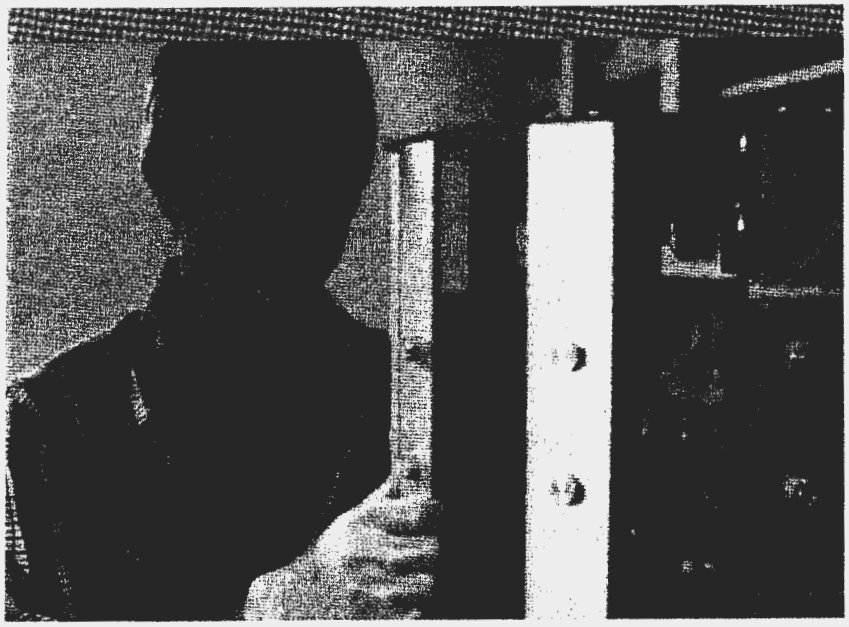
* *Industrial Staff Members* are private sector employees who receive a one- or two-year appointment to pursue collaborative technical research at the Laboratory.

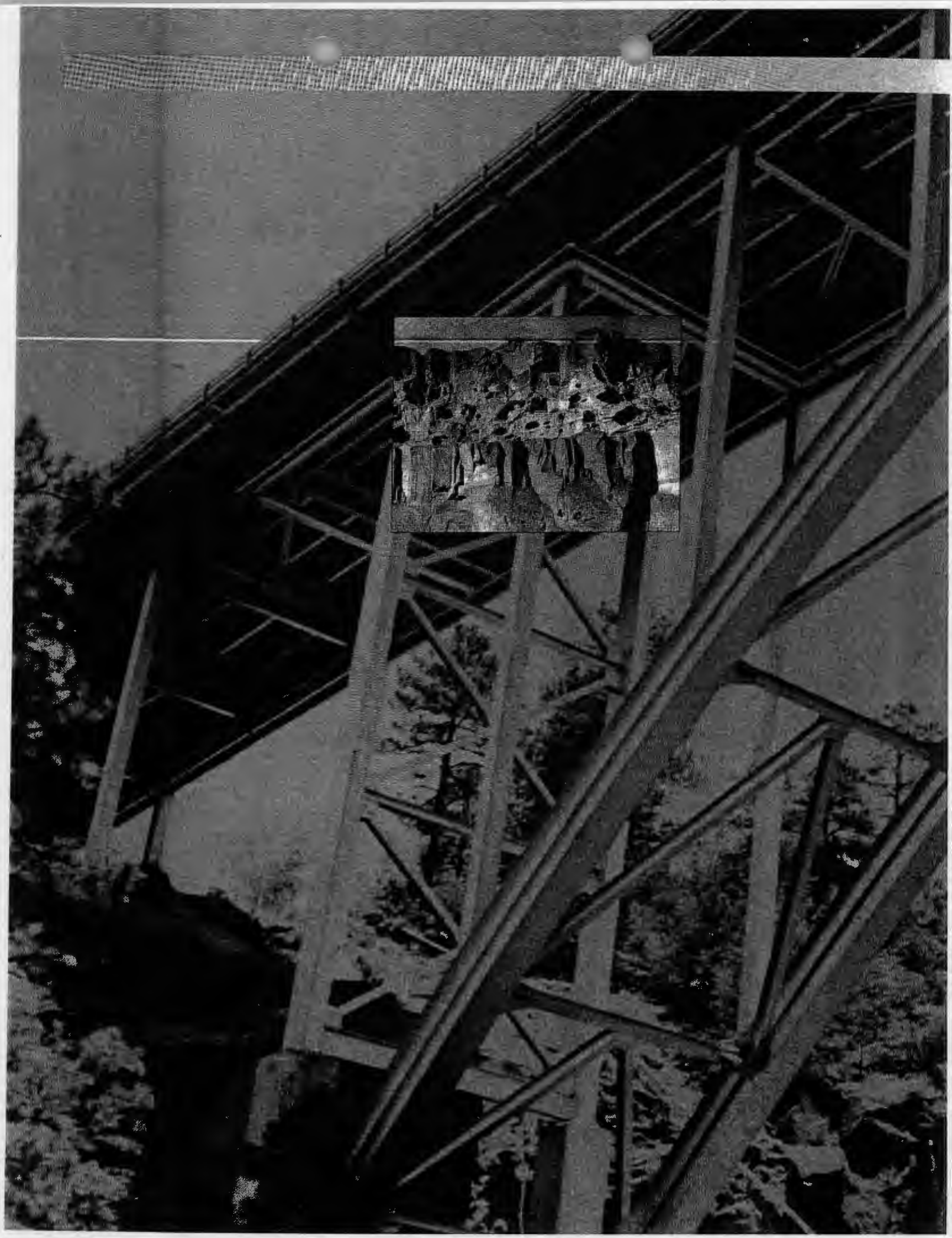
* *Guest Scientists* have the opportunity to do specific research using unique Laboratory resources, such as the Van de Graaff accelerator, Omega research reactor, and the meson physics facility.

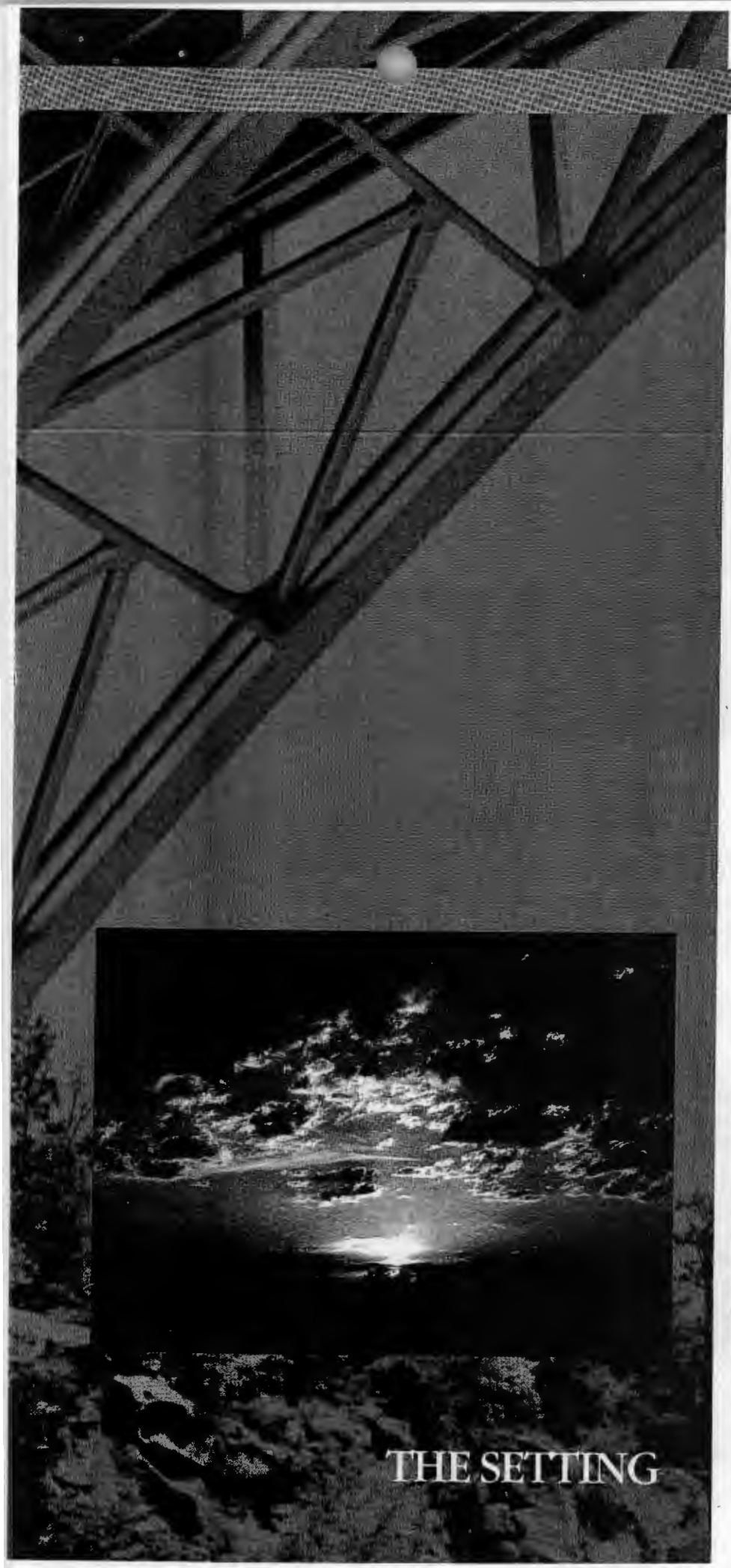
* *Consultants* help promote an exchange of information between the Laboratory and the international scientific community.

Information on the above programs may be obtained from:
Consultant and Affiliate Services (PA-13)
Mail Stop P290
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

During the summer the Laboratory hires qualified undergraduate and graduate students to work in physics, engineering, mathematics, chemistry, biology, computer science, computer graphics, and materials science.



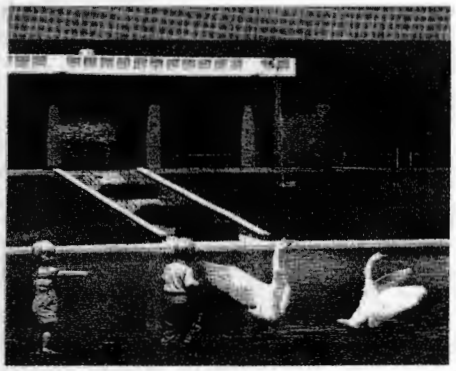




Los Alamos National Laboratory and the community of Los Alamos are connected by a bridge that spans the canyon between them. Most of the eighteen thousand community members came from other cities and states to make their homes in Los Alamos. There are two distinct areas of Los Alamos: the townsite, or "The Hill," and White Rock, a satellite community located 12 miles off the mesa. The Hill, at an elevation of 7,300 feet, has eleven thousand residents. White Rock, at 6,900 feet, has about seven thousand residents.

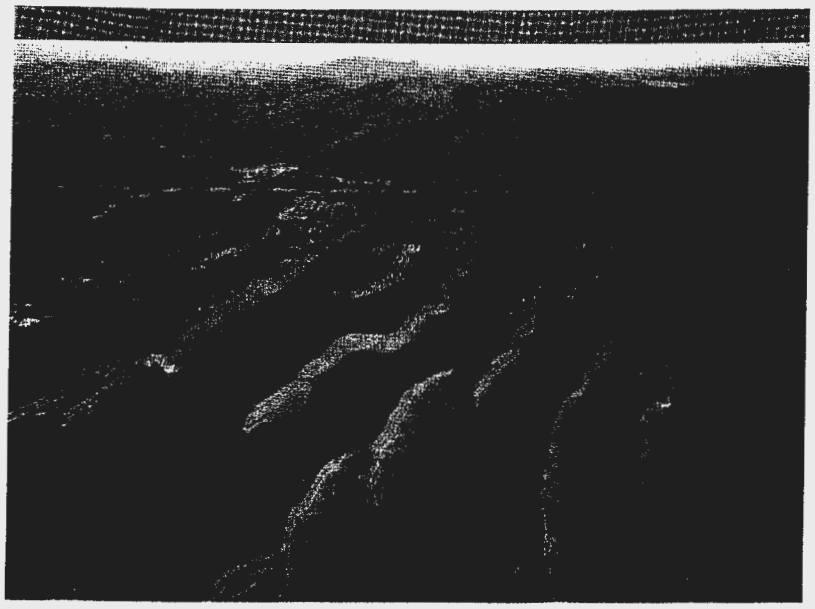
Until 1957 Los Alamos was a closed community with strict security controls on residents and visitors. Everything was federally owned, from houses to utilities, but now all residential property is privately owned, and Los Alamos County owns and operates most of the community services and assets.

Most Los Alamos residents are Laboratory or contractor employees and their families. About 60 percent of the total Laboratory work force lives in the community. The rest commute from Española, 20 miles north of Los Alamos; Santa Fe, 34 miles southeast; and other communities within a 100-mile radius of the Laboratory.



Ashley Pond in downtown Los Alamos commemorates Mr. Ashley Pond, founder of Los Alamos Ranch School.

Flashback



The Jemez Mountains and their finger plateaus were sculpted by volcanic eruptions, winds, and erosion.

THE HISTORY AND CULTURE OF THE PAJARITO PLATEAU

Twelve million years ago a series of volcanic eruptions west of Los Alamos began building the Jemez Mountains. This activity climaxed more than a million years ago with two gigantic explosions that deposited 100 cubic miles of tuff (welded ash) and pumice around the mountain flanks.

The center of the highlands collapsed to form a caldera, a basin-shaped depression, 12 to 20 miles across and from 500 to 3,000 feet deep. Then, except for the secondary volcanic upthrusts that built the cone-shaped peaks within the caldera, the volcanoes became dormant, as they are today. Wind, water, heat, and cold shaped and changed what the volcanoes so magnificently created. The central caldera, once a lake, is now covered with lush grasses for grazing cattle.

The Pajarito (Little Bird) Plateau, where Los Alamos and the Laboratory sites are located, is capped by a pocked and jointed layer of Bandelier tuff. The plateau has been dissected by erosion into fifteen or more finger mesas separated by steep-sided canyons that run southeast to the Rio Grande. Deer, elk, bear, small mammals, birds, fish, and reptiles thrive in the forests and streams of these mountains, mesas, and canyons.

People came at least eight thousand years ago (and perhaps much earlier) to hunt the abundant wildlife. Artifacts and petroglyphs show that they continued to hunt here for thousands of years. Eventually, Indians built houses and dry-farmed on the mesas. Villages evolved by A.D. 1100.

For the next four hundred years, many thousands of Indians lived on the plateau, cultivating squash, beans, and corn in the valleys by day and retreating to their cliff dwellings by night. About A. D. 1300 the Anasazi people of Chaco Canyon, Mesa Verde, and Kayenta in the Four Corners area left their great cities and moved farther south into Arizona and New Mexico. They may have joined the expanding populations already resident along the Rio Grande. The ruins of several hundred of their settlements sprinkle the mesa tops around Los Alamos.

The Indians gradually abandoned the high mesa tops and built large villages in canyons and on low mesas nearby at Otowi, Tyuonyi, Tsankawi (now in Bandelier National Monument), and Tshirege (near White Rock). They farmed near permanent water sources and supplemented their diet by hunting and gathering. Turkeys were their only domesticated animals. By the end of the sixteenth century the Indians had left the Pajarito Plateau, probably driven out by drought, overpopulation, and ecological imbalance.

Legends say they moved to the Tewa village of San Ildefonso, although many moved to other villages along the Rio Grande, such as the pueblos at Santa Clara, Cochiti, San Felipe, and Santo Domingo. Today about thirty-one thousand Pueblo Indians, including some descendants of the early Pajarito Plateau culture, live in the nineteen Pueblo groups in New Mexico.

The first Europeans to explore New Mexico came with Francisco Vasquez de Coronado in 1540, seeking the gold and silver of the fabled Seven Cities of Cíbola. Part of the expedition passed near Los Alamos, as did another expedition led by Antonio de Espejo in 1582. In 1598, eight years after an unsuccessful attempt to colonize New Mexico, Don Juan de Oñate and 140 settlers established the Spanish capital where the Rio Chama and the Rio Grande meet, at what is now known as San Juan Pueblo. The capital was moved across the Rio Grande the following year and named San Gabriel del Yunque.

The Spanish moved their capital to Santa Fe in 1610, only three years after the English settled Jamestown, Virginia. The Spanish continued colonization efforts, despite a Pueblo revolt in 1680 that drove them out of the area for a dozen years. A gradual influx of people from Spain and Mexico after 1692 eventually established a permanent Hispanic population in New Mexico. Some of these settlers farmed and raised livestock in the vicinity of Los Alamos.

The United States acquired New Mexico as a territory in 1848, and the first Anglo-Americans arrived to homestead the Pajarito Plateau in the late 1880s. They started cattle ranches, farmed, mined, and logged. During this time, Adolph Bandelier's excavations of prehistoric Indian ruins in Frijoles Canyon generated national interest. In 1916 Bandelier National Monument was established, four years after New Mexico, the tricultural "Land of Enchantment," became a state. Los Alamos Ranch, started in 1911 near the present Fuller Lodge site, raised beans and wheat and served as a convalescent camp for tubercular patients. Ashley Pond bought the ranch and in 1918 opened Los Alamos Ranch School for boys. It flourished for nearly a quarter of a century before its buildings were appropriated and expanded in 1943 to accommodate scientists who came to build the first atomic bomb.

Santa Clara Pueblo owns and administers the ruins of Puyé, one of the Pueblo communities abandoned by the end of the sixteenth century.

Santa Clara Indians perform the rain dance at San Ildefonso Pueblo as part of the eight northern pueblos' summer festival.

Bishop Lamy imported French architects and Italian artisans to design and build the stone Romanesque Cathedral of St. Francis in Santa Fe.

SCHOOLS

The Los Alamos school system has a nationwide reputation for excellence. Each year an average of fifteen Los Alamos High School students become National Merit Finalists—from a school population that could be expected to have two or three finalists. The strength of the schools' academic program is also demonstrated in standardized test results; each year Los Alamos students score well above national and state averages. The high school offers numerous advanced courses in English, mathematics, science, and history. Graduates qualify for many academic scholarships at major universities throughout the United States. About 69 percent go to college.

Nearly four thousand students are in the public school system, the pupil/teacher ratio for all grades is about twenty to one, and the county spends nearly four thousand dollars annually per pupil. With an average of almost sixteen years of schooling, Los Alamos residents have the highest education level in the nation, according to the U. S. Census Bureau.

Chamisa Elementary School in White Rock is one of seven schools in the county.

As part of the Educational Outreach effort, Laboratory volunteers take special programs to area schools.

University of New Mexico—Los Alamos

A two-year branch college of the University of New Mexico is located in Los Alamos (UNM-LA). The college is rapidly growing to meet the needs of the community and Laboratory. Besides the first two years of undergraduate studies, UNM-LA offers several technical programs in such areas as computer graphics, hazardous materials handling, and electronic technology. It grants a variety of associate degrees, such as business administration, preengineering, and computer science. UNM-LA also administers the Los Alamos Center for Graduate Studies.

Through its branch campus and Center for Graduate Studies, the University of New Mexico brings a variety of educational opportunities to Los Alamos.

Both cross-country and downhill skiing are within easy reach of Los Alamos.

The county's golf course is one of many outdoor recreation spots in Los Alamos.

Santa Fe Baldy in the Pecos Wilderness is a challenging peak for hikers and backpackers.

CLIMATE AND OUTDOOR OPPORTUNITIES

The natural beauty of Los Alamos includes snow-capped mountains, piñon and ponderosa pine, blue skies, and sweeping vistas. The climate offers cool summer days, enough snow in winter for downhill and cross-country skiing, and sunshine all year. Daytime high temperatures average 72 degrees from April through September and 47 degrees from October through March. Average humidity is 40 percent, and total annual precipitation is about 18 inches. Snowfalls can be heavy, with a total of 50 inches each winter, but the snow melts quickly, leaving most streets and sidewalks clear within a few days.

Snow makes Los Alamos a natural setting for skiing. Pajarito Mountain Ski Hill, owned and operated by a volunteer group of residents, is located 5 miles west of the town. It has twenty-six runs, the majority suitable for intermediate skiers, and receives an average annual snowfall of 150 inches. Many cross-country ski areas are nearby.

Clear mountain air and bright, sunny days encourage a variety of outdoor activities. Hiking trails abound for both the casual stroller and the avid backpacker. Fishing is permitted in nearby streams of the Jemez Mountains or close to town at Los Alamos reservoir, a favorite place for children. Hunters can find an abundance of game in season. Runners and joggers appreciate the canyon and forest trails and the local track. In addition, two exercise par courses—one in Los Alamos and one in White Rock—offer graded exercise.

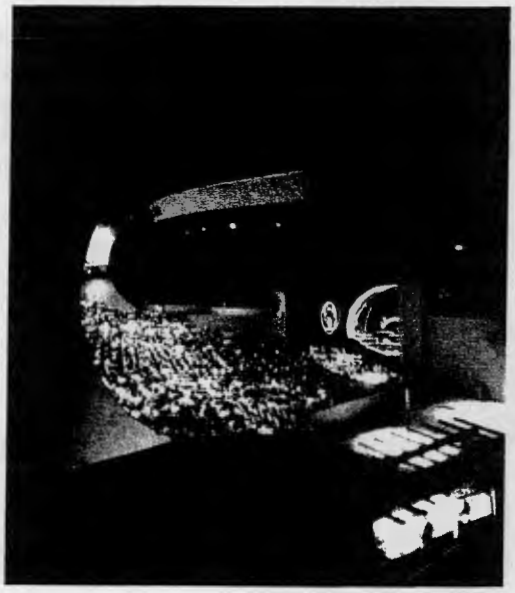
Los Alamos County maintains an eighteen-hole golf course, as well as several county parks with ball fields, tennis courts, picnic areas, and playgrounds.

ATTRACTIONS AND SPECIAL EVENTS

Los Alamos is just 34 miles from Santa Fe, the state capital and home of the Santa Fe Opera. For almost three decades the opera company has performed classical operas and world premiers under the stars. Its season runs from July through August.

Bandelier National Monument, operated by the National Park Service, is a well-known natural attraction. Located in Frijoles Canyon, 5 miles from White Rock, the monument includes Indian ruins from the fourteenth century. Some cliff dwellings in the soft volcanic rock have been restored, and a partially reconstructed pueblo sits beside a stream lined with cottonwoods. Museum pamphlets and guided trails describe ancient Indian life and environmental resources.

The history of Los Alamos is depicted at the Historical Museum located downtown in the Fuller Lodge Cultural Center. The museum offers local historical archives, exhibits, programs, and tours. Ruins of a prehistoric Indian pueblo are nearby, and a self-guided historical walk through the townsite begins at Fuller Lodge.

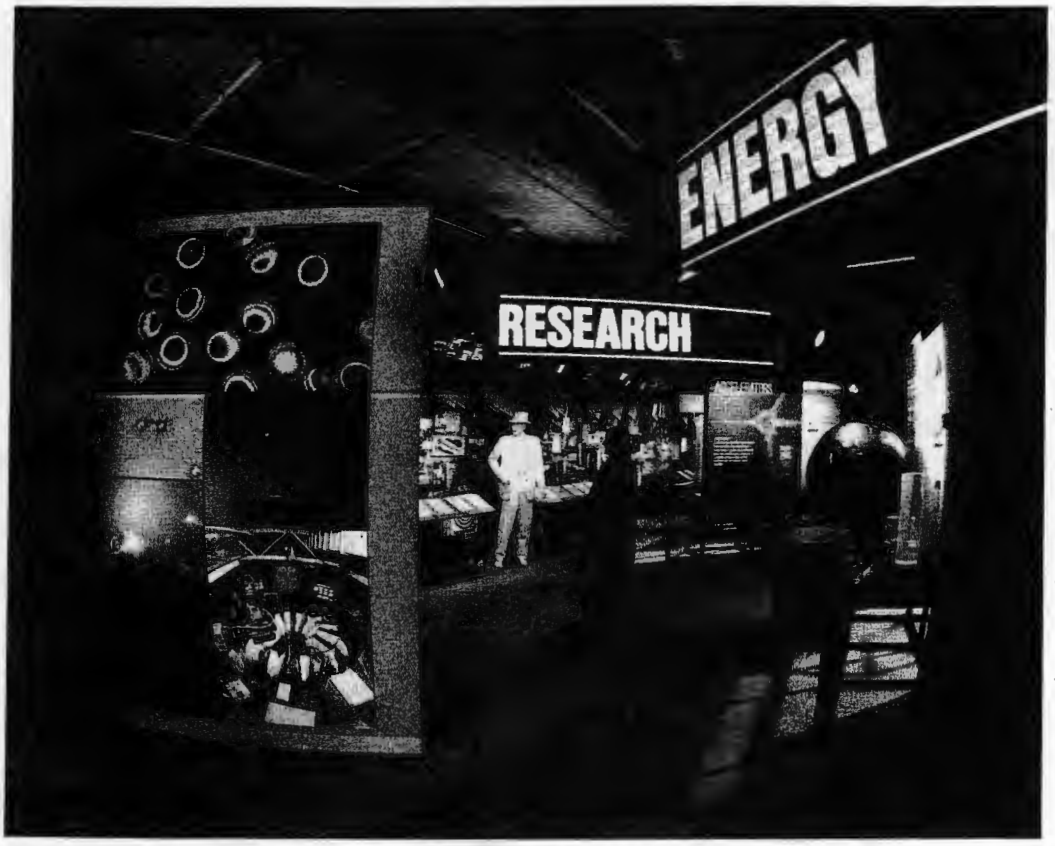


An alumnus of Los Alamos Ranch School founded the renowned Santa Fe Opera in 1957. The present opera house was constructed after a fire destroyed the original structure in 1967.

The Bradbury Science Museum, operated by the Laboratory, presents various Laboratory research activities and history. Exhibits range from photographs and documents about early days to displays on recent work in geothermal energy, inertial fusion, and nuclear safeguards. The museum features demonstrations of actual Laboratory equipment, visitor-participation exhibits, nuclear fission and fusion models and mockups, and highlights of ongoing Laboratory programs in energy and biomedical research. The Bradbury Science Museum is open to the public from 9:00 A.M. to 5:00 P.M. Tuesdays through Fridays and from 1:00 to 5:00 P.M. Saturdays, Sundays, and Mondays. It is closed on Laboratory holidays. Cameras are permitted, and there is no admission charge.

Sports fans enjoy annual athletic events in Los Alamos, such as the high-altitude mini-marathon, the Tour de Los Alamos bicycle race, and the triathlon, which combines bicycling, running, and swimming. Another highlight is the annual women's run, geared to all levels and designed for fun and health. For golfers, the Atomic City Invitational Tournament attracts players from the entire Southwest. Skiesta, held the last day of each ski season, features races and other events.

The county arts festival in August combines musical events, dance, films, and an arts and crafts fair. Other arts and crafts fairs are held in spring and fall; all display the best work of artisans from Los Alamos and surrounding communities in northern New Mexico. August is also county fair and rodeo time, when the flavor of the West permeates Los Alamos.



Just inside the entrance to Bradbury Science Museum, a life-sized plaster cast of J. Robert Oppenheimer stands in front of a display of World War II memorabilia.

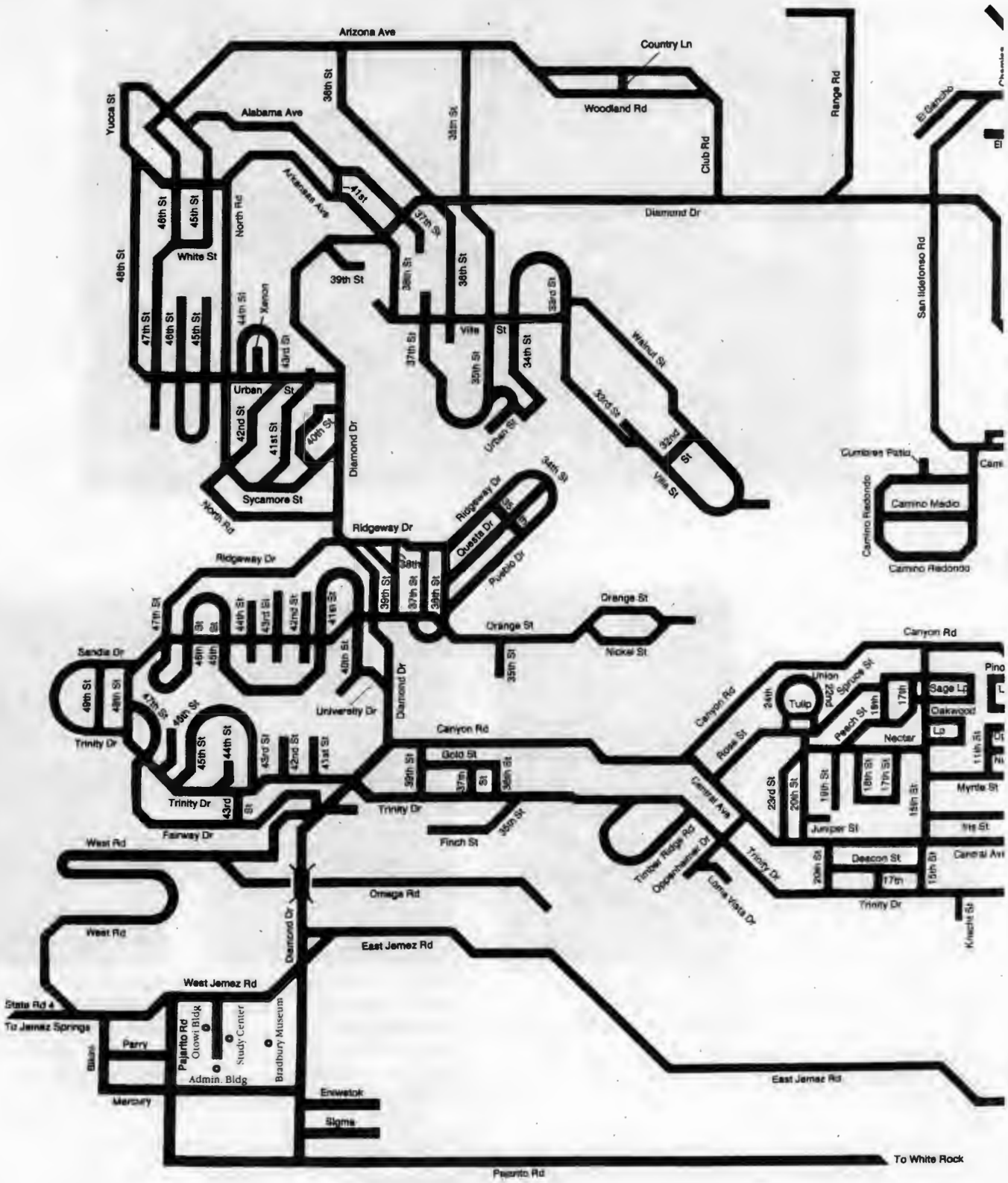
The Albuquerque International Balloon Fiesta is an annual fall event.

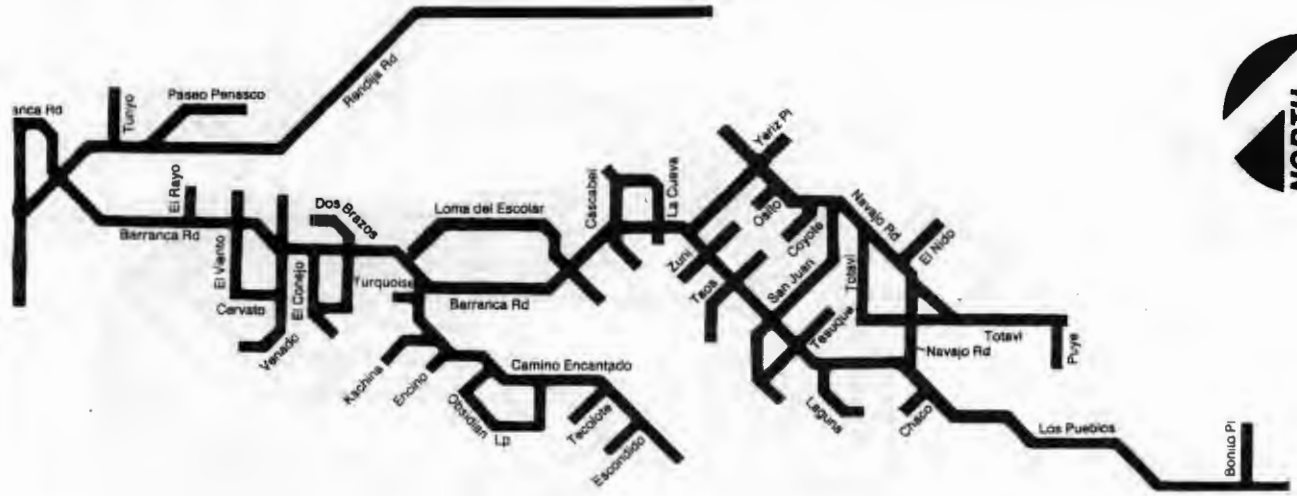
At Puyé, an excellent example of ancient Pajaritan culture, anthropologists have unearthed stone houses, cliff dwellings, sanctuaries, anthropomorphic idols, pictographs, implements, and utensils.

Today Fuller Lodge, once the mess hall for Los Alamos Ranch School, is used for community and cultural events.

MAPS

Los Alamos

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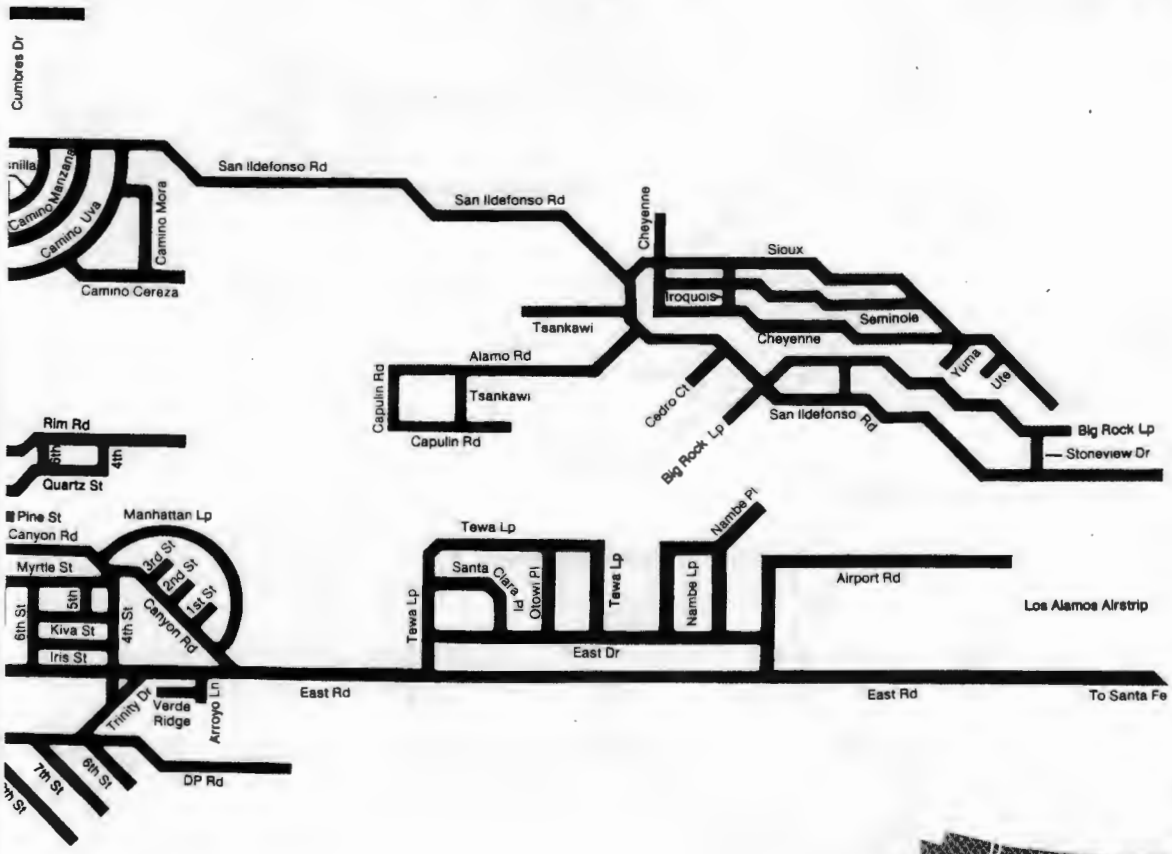
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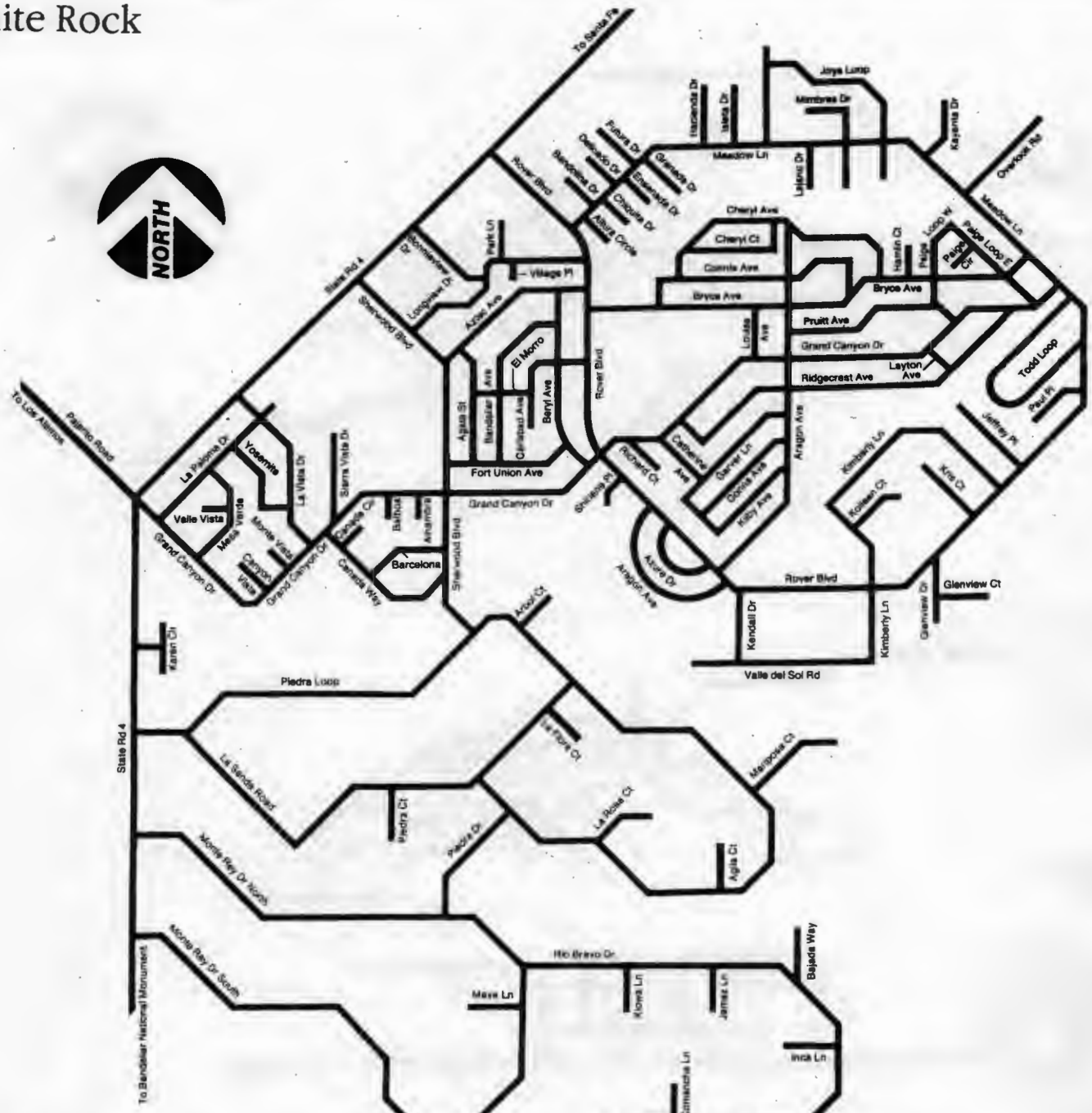

New Mexico Roads