Special Edition For Visitors Day

BROOKHAVEN BULLETIN

Published by the Brookhaven National Laboratory Public Relations Office

Special Edition 1970-71

Program . . .

VISITORS' DAYS 1970

Visitors' Day guests are welcomed at the **Reception Center** – a good meeting place for groups that separate during the tour. For your convenience, a desk to handle **General Information, Lost and Found,** and **Messages** is located here. **Refreshments** are available in the Cafeteria, which is in the same building.

PROGRAM FEATURES WITHIN WALKING DISTANCE:

Exhibits:

Solid State Physics exhibits and demonstrations are in the Exhibit Hall on Brookhaven Avenue.

Chemistry displays are on view in the west wing of the Chemistry Building, Lewis Road (please enter by the west door).

Exhibits showing other examples of research at Brookhaven will be found in the Gymnasium.

These buildings will be open until 4:00 p.m.

The Scientific Answer Men are located in the Gymnasium. Please feel free to ask questions on any scientific or technical programs. A few minutes spent with the Answer Men will clarify many points that may arise but cannot be discussed in detail during the tour.

Motion Pictures: Films are being shown on the hour from 10:00 a.m. until 4:00 p.m. in the Theatre on Brookhaven Avenue. The films are "The Brookhaven Spectrum" (25 minutes) – produced by Brookhaven as a survey of the interesting and varied aspects of nuclear research and engineering being carried on at the Laboratory; and "The Atom: Year of Purpose" (29 minutes) which describes recent developments in the peaceful uses of nuclear energy.

BUS TOUR

Buses start from 3 Center Street, the exit of the Gymnasium.

The first bus will be dispatched at 9:30 a.m. and the last at 3:00 p.m.

The order of the stops on the tour:

The Central Scientific Computing Facility
Low Energy Accelerator Facility
High Intensity Radiation Development Laboratory
Alternating Gradient Synchrotron and High Energy Physics Exhibits

and back to the Gymnasium. The buses move around the circuit continuously, and do not wait for you at each stop; please remember to keep your personal belongings with you. If any research facility on the tour becomes overcrowded and is temporarily bypassed by the bus you are riding, you may visit it later by making another circuit of the bus tour and skipping the places you have already seen. Walking or driving to the places on the bus tour is not permitted.

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Photographs: Visitors may take pictures anywhere on the Laboratory site, provided that they are for personal use. Pictures for professional or commercial use should be cleared with the BNL Public Relations Office.

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Emergency: In case of emergency, pick up any telephone and dial the Reception Center, extension 7209 or 7251.

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For detailed information on Exhibits and on the Research Facilities on the bus tour, please refer to the Brookhaven Bulletin Supplement. A map of the site is included to help you plan your tour.

Brookhaven Laboratory Founded In 1947 As National Center For Atomic Research

It's a long way from "Yip, Yip, Yaphank" to a walk on the moon, but the site of Brookhaven National Laboratory has been a part of it all. During World War I, these 7500 acres became Camp Upton and it was here that Irving Berlin first staged his musical and introduced the universial lament "Oh How I Hate To Get Up In The Morning." After the war the camp lay idle until occupied by a contingent of CCC men who came and went during the Depression and planted the beautiful white pines now evident here. From the late 30's to the outbreak of World War II, Camp Upton was again empty. Then once again the military took over and the site served as a basic training camp, a prisoner of war camp, and, in the closing days of the war, as a medical rehabilitation center. When the last GI left, the Camp was again closed down and its military history came to an end.

Brookhaven Lab Started

On March 22, 1947, the government, through the Atomic Energy Commission turned over the site to the Associated Universities, Inc., an association of nine universities, and Brookhaven National Laboratory was born. The word Brookhaven described its location and the word National defined its scope.

Not only the site changed from war to peace, but many of the scientists who had worked on the Manhattan Project during World War II, turned to the development of the atom for peaceful uses. Through the Associated Universities, Inc., they were able to continue research on atomic energy which would have required facilities and talents too great for any single university to undertake.

As a former military site, Brookhaven started with complete utility and road system, a gymnasium, a swimming pool, tennis courts, office buildings and apartments and dormitories. Since that time much more has been added and many of the old barracks have been replaced by modern buildings and laboratories.

Reactor First Project

One of the first projects was to design and build a nuclear reactor that would be devoted exclusively to research. It was called the Brookhaven Graphite Research Reactor and it began operating in 1952, the first reactor of its kind.

The Graphite Reactor was followed by a series of accelerators – the Van de Graaff, the Cyclotron, the Cosmotron, and ultimately the Alternating Gradient Synchrotron, which at 33 BeV (billion electron volts) of energy, was the world's largest for many years. The Graphite Research Reactor and the Cosmotron have now been retired, but the AGS is still the largest accelerator in full-time experimental operation in the western world. Today, Brookhaven is one of the world's foremost centers for physics research.

Other Facilities Added

Over the years, BNL has added a Medical Research Reactor, a High Flux Beam Reactor and a High Intensity Radiation Development Laboratory as part of the development of a broad complex of research facilities and programs, not only in physics but in the life sciences and chemistry as well. The successful operation of these many programs requires equally complex and sophisticated instrumentation, health physics, engineering, mathematics and other complementary activities.

The design, development, operation and maintenance of the sophisticated research facilities requires special talents and skilled personnel. Besides the Laboratory's highly trained regular staff, scientists from U.S. institutions and abroad spend varying periods of time at Brookhaven collaborating on research and using the facilities for which we were created.

A Welcome From BNL's Director

On this, our 21st Annual Visitors Day, I am delighted to welcome you to Brookhaven National Laboratory.

Twenty-one years ago the Laboratory was just beginning to take form. We were a small staff of 1350. The finishing touches were being given to our graphite reactor before beginning operation. The Alternating Gradient Synchrotron had not yet been proposed nor had the High Flux Beam Reactor been thought of.

Much has happened in two decades. The staff has more than doubled. The Brookhaven Graphite Research Reactor has been put on a stand-by basis after a highly successful career. The AGS is the western world's highest energy accelerator and the HFBR is a working productive reactor.

We have a research hospital whose staff is making great strides in medical research and the Tandem Van De Graaff is ready for use. We have sent biology experiments into orbit with the Biosatellite II project and we have a neutrino observatory out in South Dakota which is searching for neutrinos from the sun.

We plan to push on, to try to lift the veil from further unknowns in the fields of physics, chemistry, the life sciences, engineering, mathematics and instrumentation.

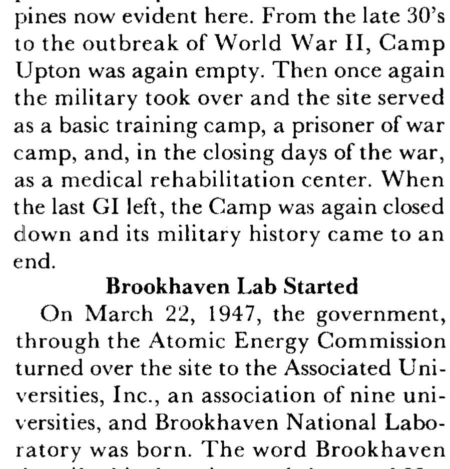
Many exciting discoveries have been made through the perfecting of our research techniques and through the skill of our scientists and university collaborators.

Two recent significant developments in research may soon have wide application: the use of L-Dopa as a treatment for Parkinson's disease has been developed here by Dr. Cotzias and his group at the Medical Center; an improved type of concrete called "concrete polymer" made by using radiation to combine conventional concrete and plastic is being developed by the Radiation Division of the Department of Applied Science.

We have invited you here today to see for yourselves what we are accomplishing and to keep you informed of the latest developments in scientific research so vital to our life and times.

It is my sincere hope that you will find your visit both rewarding and inspiring.

Linear Accelerator



A completely shielded room has been constructed to house the Cockcroft-Walton injector for the new Linac of the Alternating Gradient Synchrotron. In this shielded room the particles will originate that eventually reach a speed of 99.9% the speed of light before striking a target.

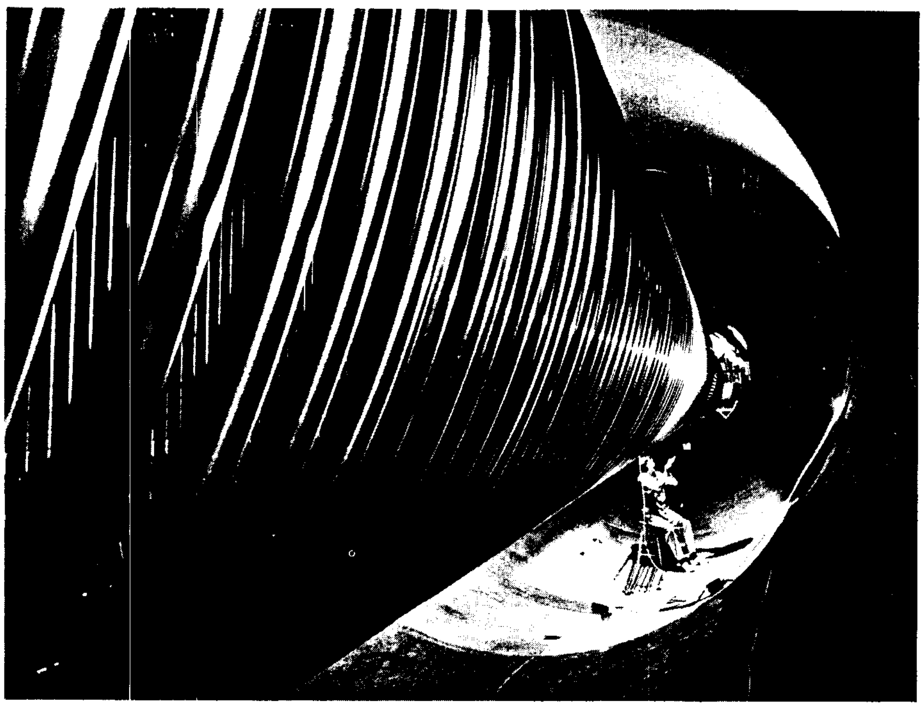
Lab Operated For AEC By University Group

Brookhaven National Laboratory, as an integral part of our nation's atomic energy research facilities, is a national center for fundamental and applied research in the nuclear and related sciences.

The Laboratory is operated by Associated Universities, Inc., a nonprofit national research management corporation, under contract to the United States Atomic Energy Commission. There are nine sponsoring universities: Columbia, Cornell, Harvard, Johns Hopkins, Massachusetts Institute of Technology, Princeton, University of Pennsylvania, University of Rochester, and Yale.

While it has been possible to present in this paper a brief outline of the current major research activities of the Laboratory, it is impossible to do more than suggest some of the new fields of endeavor that will open up in the years ahead. The lines of approach to problems are constantly shifting as new discoveries are made in all the rapidly developing areas of nuclear science and technology.

Inside The Tandem Van de Graaff



The Tandem Van de Graaff was under construction for several years and began operating this year. This picture shows work being done inside one of the containment tanks of the accelerator.

Cyclotron & Van de Graaff Low Energy Accelerators

The Tandem Van de Graaff began operation in 1970. It consists of two Van de Graaff accelerators arranged to allow operation of each independently, with energies up to 20 MeV, or of both in series, as a 30-MeV accelerator. This arrangement makes it possible to perform a wide variety of experiments on nuclear structure at energies ranging from a few MeV to 30 MeV for singly charged particles.

The 60-inch Cyclotron accelerates particles by repeatedly passing them through an electric field as they spiral outward in the field between the poles of a large electromagnet (the pole diameter is 60 inches). Modifications to the magnet pole tips and the radiofrequency oscillator have been made to allow the acceleration of deuterons (heavy hydrogen nuclei) to 20 MeV, protons and alpha particles (helium nuclei) to 40 MeV, and helium-3 ions to 60 MeV. These accelerated particles are used for nuclear reaction studies, the production of radioactive materials, and irradiation of biological systems.

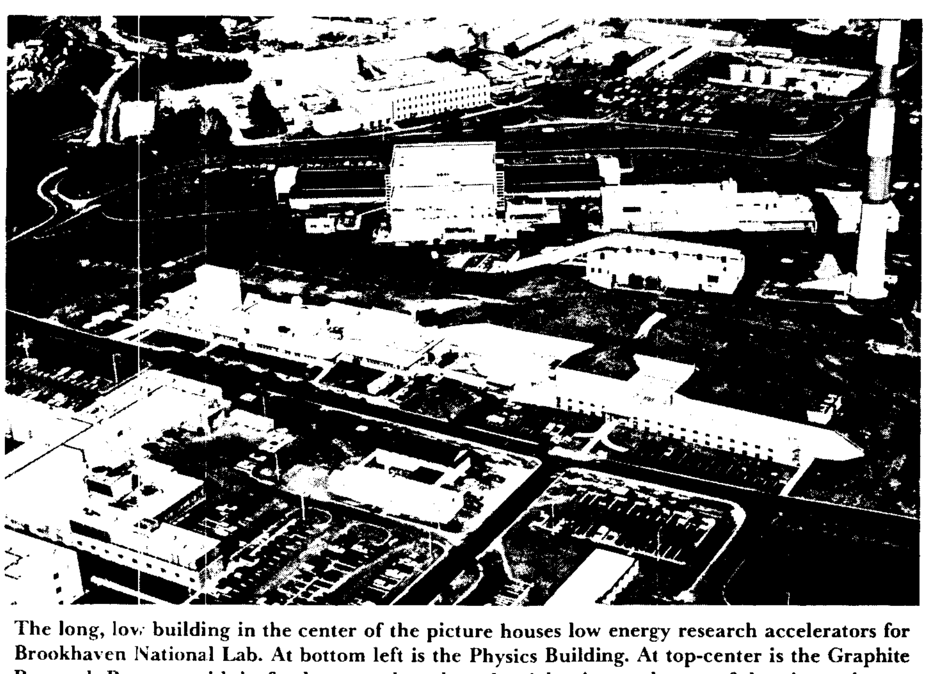
Nuclear Reactors

The reactors at Brookhaven play a very important role in the research program. These machines provide beams of neutrons for various types of experiments. Neutrons, as a fundamental part of the atom, are studied in themselves and are among the most powerful tools available to experimenters in such fields as nuclear and solid state physics, metallurgy, and nuclear and structural chemistry. The Brookhaven reactors are also used to produce radioactive isotopes for research.

Brookhaven Research Varied

Brookhaven's research covers a wide variety of specific areas in the physical, life, and related sciences in which the development and exploitation of nuclear science and technology are involved.

Research interests sometime overlap from one scientific field to another, and similar problems are often approached from several points of view. Moreover, nuclear research is frequently supported or complemented by nonnuclear research.

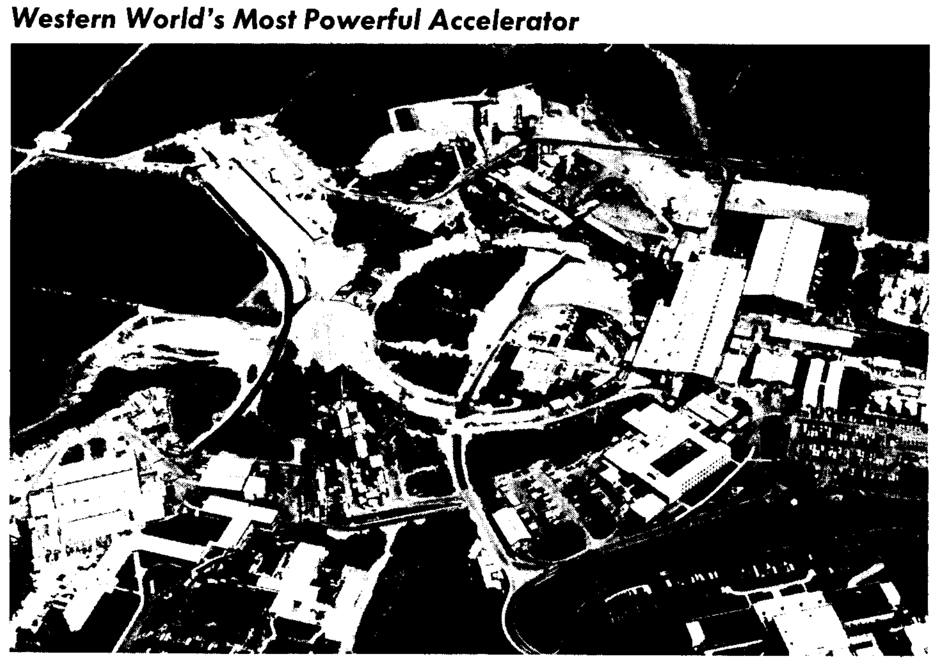


The long, low building in the center of the picture houses low energy research accelerators for Brookhaven National Lab. At bottom left is the Physics Building. At top-center is the Graphite Research Reactor, with its fan house and stack to the right. Across the top of the picture is part of the Alternating Gradient Synchrotron complex.

Protons Jogged by 33-Billion Electron Volts Reach 99.9% Speed Of Light In Synchrotron

The Alternating Gradient Synchrotron (AGS) was designed and built by Brookhaven scientists to explore the relatively unknown regions of high energy physics. The AGS is now the world's second largest accelerator; it was the largest from 1960 to 1968. This proton synchrotron operates at energies up to 33 BeV. The protons (from hydrogen atoms) are started on their journey to high energies by the Cockcroft-Walton generator, which provides an initial energy of 750,000 electron volts to the protons. They are then injected into a 110-foot-long, 50-million-electron-volt (MeV) linear accelerator, one of the largest proton linear accelerators in the world, which in turn injects the protons into the circular path of the AGS. In the main accelerating section of the synchrotron, contained in an underground tunnel 18 by 18 feet in cross section and one-half mile in circumference, the particles are accelerated in a vacuum chamber that is positioned in the jaws of 240 strong-focusing magnets. These magnets serve to keep the protons in their proper orbits. Acceleration is accomplished by means of radiofrequency accelerating stations spaced around the vacuum chamber. Within one second the protons travel more than 300,000 times around the machine, reaching a speed more than 99.9% of the speed of light (about 186,000 miles per second) with an energy greater than 30 BeV. At this time a target is inserted into the proton beam inside the vacuum chamber, or the proton beam is extracted magnetically and conveyed to a target outside the accelerator tunnel. When the protons strike the nuclei of the target atoms, various high energy particles are produced. Beams of these particles are conducted into the experimental areas, where they are detected in bubble chambers, spark chambers, scintillation counters, or photographic emulsions. The results serve to increase knowledge of the complicated nature of elementary particles and sometimes produce previously unknown or unobserved particles such as the omega-minus hyperon.

Western World's Most Powerful Accelerator



An air view of the AGS shows the circular ring of the accelerator together with the various research facilities used in conjunction with the accelerator. Clockwise from lower left are: 7′ Bubble Chamber; 200 MeV Linac; 80″ Bubble Chamber; Experimental Buildings; and Office and Laboratory space.

Form And Property Of Matter Studied At Brookhaven

In the field of particle physics, atomic structure and forces are studied by bombarding nuclei with ultra-high-energy particles from accelerators such as the 33-billion-electron-volt Alternating Gradient Synchrotron (AGS). When such accelerated particles collide and interact with nuclei, part of their energy is transformed into new particles which fly off from the target nuclei. These particles are then detected or their paths are made visible by devices such as scintillation counters, Cerenkov counters, bubble chambers, spark chambers, and photographs. By such means many new particles including mesons and hyperons have been discovered at the AGS and subsequently studied. Particle accelerators are used at many different energy levels in this research, since the type and number of nuclear events obtained vary with the energy and type of the bombarding particles.

The ultra-high-energy particles produced by the Alternating Gradient Synchrotron are also used by chemists in studies of high energy nuclear reactions.

Low energy physics and low energy nuclear chemistry include investigation of various properties of nuclei. These studies require low energy particles from facilities such as the High Flux Beam Research Reactor, the Van de Graaff accelerators, and the 60-inch Cyclotron.

In solid state physics and structural chemistry studies, molecular and crystal structures are determined by the complementary techniques of x-ray and neutron diffraction. Neutron diffraction also reveals the atomic arrangements which determine the microscopic properties of magnetic materials.

The field of physical chemistry covers a wide range of experimental and theoretical studies subjects such as electron exchange reactions, reactivities of organic systems, ion-molecule reactions.

Isotope chemistry investigations are concerned with the differences in the physical and chemical properties of isotopes and the uses of these differences in pure and applied science. These studies, which deal mostly with stable (nonradioactive) isotopes, are relevant to the understanding of the fundamental properties of molecules and to the separation of isotopes by chemical methods.

EXHIBIT SUPPLEMENT

Film Service Office Open Visitor's Days

The Film Service Office located in the Gymnasium Building, which is normally open from 9:00 – 3:00 Monday through Friday, will be open from 9:00 – 4:00 on Visitor's Days, October 17 and 31.

Film, flash bulbs, batteries and other camera supplies will be on sale. A camera rental service will be a special feature for the two days. Rental fee will be $1.00; or, if you leave your film for processing, there will be no rental charge. A deposit of $5.00 will be required on all camera rentals.

Instrumentation Division

The "Star Game" is a small diversion used to illustrate one of the many technologies which go into instrument design. It functions as a small, fixed-program computer and uses the much publicized and extremely useful "integrated circuit" as its basic building block.

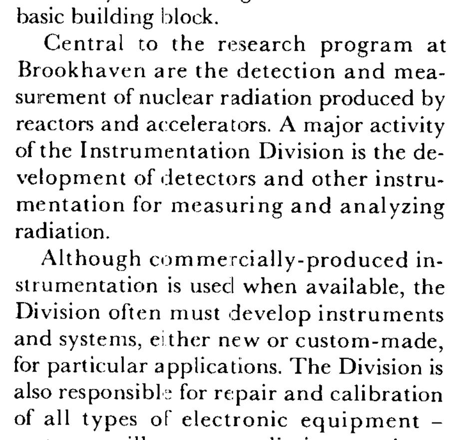
Central to the research program at Brookhaven are the detection and measurement of nuclear radiation produced by reactors and accelerators. A major activity of the Instrumentation Division is the development of detectors and other instrumentation for measuring and analyzing radiation.

Although commercially-produced instrumentation is used when available, the Division often must develop instruments and systems, either new or custom-made, for particular applications. The Division is also responsible for repair and calibration of all types of electronic equipment – meters, oscilloscopes, radiation monitors, and digital computers.

Health Physics Division

The Health Physics Division is concerned with the protection of the individual and his environment from the effects of ionizing radiations. The Health Physicist provides many services to the BNL research groups, most important of which is the evaluation of radiation hazards. At the Health Physics exhibit, some of the tools of the Health Physicist are explained and demonstrated. The role of the Health Physicist as an adjunct to the other research groups is also explained.

Lunar Sample Display



A Brookhaven Laboratory Security Officer stands guard at the moon sample display. The 12-gram sample mounted in the middle of a plastic sphere was part of a larger rock that was brought back to earth from the moon during the first attempt to land a man on the moon.

Tandem Van De Graaff Accelerator Facility

Brookhaven has recently completed the largest tandem accelerator facility in the world. A new building, constructed partially underground, houses two large tandem Van de Graaff electrostatic accelerators, each over 80 ft long. Although other laboratories possess this same type of accelerator (including Minnesota, Rochester, and Yale Universities in the U.S.), the combination of two in a single laboratory is unique.

Each of the Brookhaven accelerators is capable of operating independently; however, when combined they provide particles of higher energy than previously available from any existing electrostatic accelerator. Protons can be accelerated to 30 million electron volts (MeV) energy and other nuclei in the form of "heavy ions" to energies over 100 MeV.

This new facility expands research in nuclear physics not only to higher energies but also to include a wider spectrum of particle interactions. Reactions between a large fraction of all known nuclear species can be started by simply accelerating one nucleus to a velocity sufficient to allow it to "fuse" with another. For example, the common isotopes of silicon (^{28}Si) and calcium (^{40}Ca) may be fused to form a new isotope of selenium (^{68}Se) which is so rare that it has never before been observed in the laboratory. In this case ^{28}Si ions must be accelerated to energies in excess of 100 MeV before the reaction will occur. Many new and exotic nuclei will be created and studied using these accelerators.

The higher energy capability of this facility combined with the great precision intrinsic to Van de Graaff accelerators wll permit scientists at Brookhaven to pursue the study of basic nuclear structure to a degree not possible in any other laboratory. From these new capabilities for the study of basic nuclear research will come a better understanding of nature, and especially the the stars whose internal nuclear "fires" generate life-sustaining energy yet whose very existence remains one of the riddles of the universe.

Medical Exhibit

Several different aspects of the research program of the Medical Research Center are illustrated in the Medical Exhibit, with displays which explain BNL work on **Extracorporeal Irradiation of Blood, Hypertension, Drosophila Melanogaster and Fall-Out.**

Extracorporeal Irradiation

"Extracorporeal irradiation of the blood" (ECIB) is the process of irradiating blood, outside the body, in a controlled manner. Because one of the constituents of blood, the lymphocyte, is much more sensitive to radiation than the other elements of the blood, this technique was originally used in studies aimed at an understanding of the traffic patterns of the lymphocyte. Subsequently, it became clear that certain human diseases, such as leukemia, in which there is an excess of lymphocytes in the blood stream, could possibly be treated by ECIB.

ECIB was made feasible by certain technical advances in surgical methods along with the development of new plastic materials that would allow the blood to leave the body from an artery, circulate through an irradiator, and re-enter the body via a vein. Within the irradiator, the blood is exposed to the energetic gamma rays emitted by a radiation source such as cobalt-60 or cesium-137.

Hypertension

There is much evidence to suggest that common table salt (NaCl) is involved in the development of hypertension, generally known as high blood pressure. Although the evidence for man is circumstantial, the evidence for rats, used in laboratory experiments, is positive.

At the Medical Center two unique strains of rats have been selectively bred for use in studies to investigate the factors relating to hypertension. One strain rapidly and predictably develops fatal hypertension while on a salt diet to which the other responds only midly. Because these two strains respond to other factors which cause experimentally induced hypertension the same way as they do to salt, the evidence seems to indicate that the genetic make-up of the animal is most critical in determining whether or not the animal will develop hypertension after being subjected to a suitable stimulus.

For about the last century, the kidney has been implicated in one way or another in every explanation of the basic mechanism for the development of hypertension.

Drosophila Melanogaster

Drosophila Melanogaster, or the common fruit fly, has been used since 1927 in experiments employing ionizing radiation such as x rays to cause genetic changes, called mutations, which are permanent and are transmitted from one generation to the next.

Three of the many reasons why scientists use the fruit fly to study the biological effects of ionizing radiation are illustrated by the displays. First, since the generation time of the fruit fly is about nine days, it is possible to complete in less than two months, using fruit flies, experiments which would require more than a century with man. Secondly, structural changes in genetic material following exposure to ionizing radiation can be studied readily by observing the chromosomes of the cells of the salivary glands, which, in fruit flies, are very large and are distinctively marked with dark bands along their legs.

Fall-Out

Personnel from the Medical Center have been making periodic medical surveys of the people of Rongelap and Utirich Atolls who had been exposed to fall-out radiation in 1954. These people had been accidentally exposed to fall-out following a detonation of a high-yield thermonuclear device during experiments at Bikini. Sixty-four inhabitants of the island of Rongelap, 105 miles away from the detonation, received the largest exposure to fall-out, an estimated 175 rads of whole-body gamma radiation.

After careful evaluation of radioactive contamination, the inhabitants of Rongelap, who had been evacuated 2 days after the accident, were returned to their island and installed in a new village in 1957. Since that time, teams of medical personnel have made annual trips to Rongelap to study the health of these people and to look for any late medical effects resulting from their high but sub-lethal exposure to fall-out.

Generally, the findings have been negative, except for the late incidence of thyroid gland nodules in those young people who had been exposed to the fall-out while below the age puberty.

Alternating Gradient Synchrotron

The Accelerator Department and the Physics Departments have joined together to show the **why** and **how** of high energy particle physics in the east experimental building at the AGS. The Physics Department will explain the **why** of the high energy particle physics while the Accelerator Department will demonstrate the **how** with machines and equipment that are used to get the sub-atomic particles from the accelerator to the experimenter's counters or bubble chambers. The visitor touring through the building will see an experimental set up for Dr. Collins of BNL complete with special magnets, vacuum chambers, spark chambers, and counter equipment.

Two short movies will be shown and department physicists and engineers will be available to answer questions and explain the equipment that is on view.

HIRDL

The High Intensiy Radiation Development Laboratory (HIRDL) serves as a focal point for radiation research and development in the United States. Over two million curies of cobalt-60 and large quantities of cesium-137 and strontium-90 are in experimental use in the two large hot cells and underwater facilities of HIRDL. The research and development program at HIRDL includes such subjects as high level gamma and beta dosimetry; the effects of intense radiation fluxes on homogeneous and heterogeneous targets; and the design, standardized production, handling, transportation and use of large gamma sources. Portable irradiators, designed at HIRDL, are currently in use in India, Pakistan, Argentina, Chile, Israel, and Korea.

Biology Exhibit

The display for the biology exhibit consists of four panels showing The Aging Process; Effects of Nuclear Radiation on Plants; Biological Studies in the Space Program; and, Genetically Controlled Tumor Formation.

Using radiation as a tool, the somatic mutation theory, one explanation for the aging process, is aptly illustrated with live x-irradiated and unirradiated mice. The effects of ionizing radiations on plants showing growth inhibition, flower color mutation and radiosensitivity are demonstrated utilizing live plants.

The third panel presents the biological studies in the NASA space program, indicating our role in the "Biosatellite II" flight of September 1967. The induction of tumor formation in plants and how it is genetically controlled is described in the fourth panel and featured by a color sound movie.

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Brookhaven National Laboratory

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Solid State Physics

The Solid State Physics exhibit will be on display in the Exhibit Hall. The exhibit is divided into roughly four main sections: (1) Low Temperature Physics, (2) Thermoluminescence and Radiation Damage, (3) Crystal Growth and (4) Magnetism and Holography.

Low Temperature Physics – The Uncommon Cold

Experiments using liquid nitrogen will be performed to demonstrate system expansion in liquid to gas phase transitions. Whirling wheels and popping ballons and corks make it entertaining as well as educational. A fourteen-minute demonstration and talk will explain methods of refrigeration used to reach temperatures near absolute zero, and the reasons for seeking these low temperatures. An "On-Line" computer, which is simply a teletype that is in telephone contact with a computer, stands ready to accept all challenges to a game of Tic-Tac-Toe. The machine has been programmed so it can be beaten with the right sequence of moves. So try your skill.

Thermoluminescence and Radiation Damage

Many minerals emit light when heated, a phenomenon called thermoluminescence. If the samples are exposed to x-rays or gamma rays prior to heating the emission is greatly increased. Simultaneous measurements of the mineral temperature, and the intensity and wavelength of the emitted light provide data to obtain a "three-dimensional" thermoluminescence spectrum using a computer. Each mineral, and often different varieties of the same mineral, has a characteristic "3-D" spectrum.

Crystal Growth

Advances in solid state science depend critically on the availability of single crystal specimens. Because of this, enormous amounts of time and labor are expended in developing growth techniques, suitable for the chemical system in which one is interested. On display will be three of the many ways which single crystals are grown. Two of the methods, growth by vapor transport, and solution growth of oxides, involve the use of high temperatures. The third, crystal growth in a gel, is done at room temperature and might even be tried at home.

Magnetism and Holography

In addition to three holograms, the display will include a filmed version of a computer solution for the behavior, in time, of the atomic magnetic moments in a typical magnet.

Chain Reaction

A model demonstrates the principle of an uncontrolled chain reaction using ping pong balls to show how the number of neutrons released by the fissioning of Uranium-235 rapidly increases with time. Controlled chain reactions are used in nuclear reactors to provide electrical power.

Central Scientific Computing Facility

Brookhaven National Laboratory conducts research programs involving an amazing range of subjects. Atmospheric currents, marine creatures in the mud of bay bottoms, crystals of complex biological compounds, power supplies for the future, elusive particles that yield hints of the ultimate structure of matter – all these disparate phenomena and a thousand more fall into the domain of one or more of Brookhaven's various departments.

What is the unifying factor, the single stream fed by these diverse springs? Knowledge. Like symphonies and washing machines, knowledge is a product. Like these, too, it cannot spring full blown from the output of a special machine, a single design or an isolated mind but is the highly refined end-product of a long chain of human and mechanical action and interaction, trial and re-trial. Unlike the raw material for most familiar products, however, the raw material that feeds the "manufacturing process" called research is *information* – mainly quantitative by nature and frequently staggering in amount.

The most complex – the only indispensible – type of research equipment at any laboratory is the mind of the investigating scientist. He is, however, much too valuable (and much too short-lived!) to be flooded with a niagara of unprocessed information. To digest, condense, order and analyze this ceaseless torrent of raw research information so as to make it accessible to human interpretation and synthesis we need a very powerful, fast and versatile machine – the electronic computer.

The Applied Mathematics Department supplies a central computing facility for Brookhaven Laboratory. Their main general purpose computing processors are two CDC 6600 digital computers each with a "central memory" of over 65,000 words (numbers or other units of information). These two machines share a further million words of memory called Extended Core Storage (essentially a large, fast-access storage device).

Other computers such as the CDC 3200 located in the same building and a number of smaller computers located in various remote buildings on site can "communicate" (send and receive data, commands or programs) with the 6600 computers through communications networks called Brooknet and Focus. These networks permit experimental equipment to send data directly to the main computers and to allow operators at remote sites to communicate not only through the high speed punched card readers, magnetic tape units and line printers but also through "people oriented" terminals such as teletypes and visual display scopes.

How fast are the 6600 computers? Well, assuming you took 100 seconds to read this far, during this time one of the 6600's could have done about 100 million multiplications and printed out about 6.6 thousand lines of output without operating at its maximum possible efficiency.

Amateur Radio Club

The Brookhaven National Laboratory Radio Club is sponsored by the Brookhaven Employee Recreation Association as are many other social, cultural, and physical activities. The Radio Club is dedicated to public service. Passing of messages from one area of the world to another is an example. Each year a radio station is operated in the gymnasium in order to acquaint the many guests on visitors day with this aspect of amateur radio.

You are cordially invited to stop by and avail yourself of this service.

Meteorology

Instruments employed to measure meteorological data and sample airborne pollutants are displayed. A series of slides will be shown to describe some current environmental projects of the Group. Meteorology staff members will be present to answer questions.

Meteorology and Climatology are an integral part of the research at Brookhaven for the general benfit of nuclear science and air pollution studies. The distribution of airborne particles and gases is studied by the use of tracer materials.

Chemistry Exhibit

As you enter the Chemistry Department, the first laboratory that you see is the one devoted to Mass Spectrometry. In this laboratory are five mass spectrometers which are versatile instruments used in applied and basic research and are capable of providing a diversity of information about many chemical systems. For example, the determination of the qualitative and quantitative composition of a mixture of gases, ionization potentials, bond energies, rate constants, vapor pressures, and various thermodynamic quantities are all possible with the mass spectrometer.

In a mass spectrometer the sample is ionized by bombardment with electrons and the positively-charged ions are extracted from the source and sent into the analyzer by a high voltage field. The analyzer itself is usually a strong magnetic field which separates ions according to their mass. The intensity of each mass component is then measured and recorded.

In this laboratory an example of basic research being done with the mass spectrometer is the study of reactions between various ions and neutral molecules. In such studies one obtains much more detailed information about chemical reactions than is possible with normal chemical techniques. This is so because one of the reactants has a well-defined energy and direction and the reaction products may be identified and analyzed at specified angles to the collision site.

The next large laboratory contains the complex vacuum systems used to analyze products from two large-scale experiments being performed by members of the Chemistry Department.

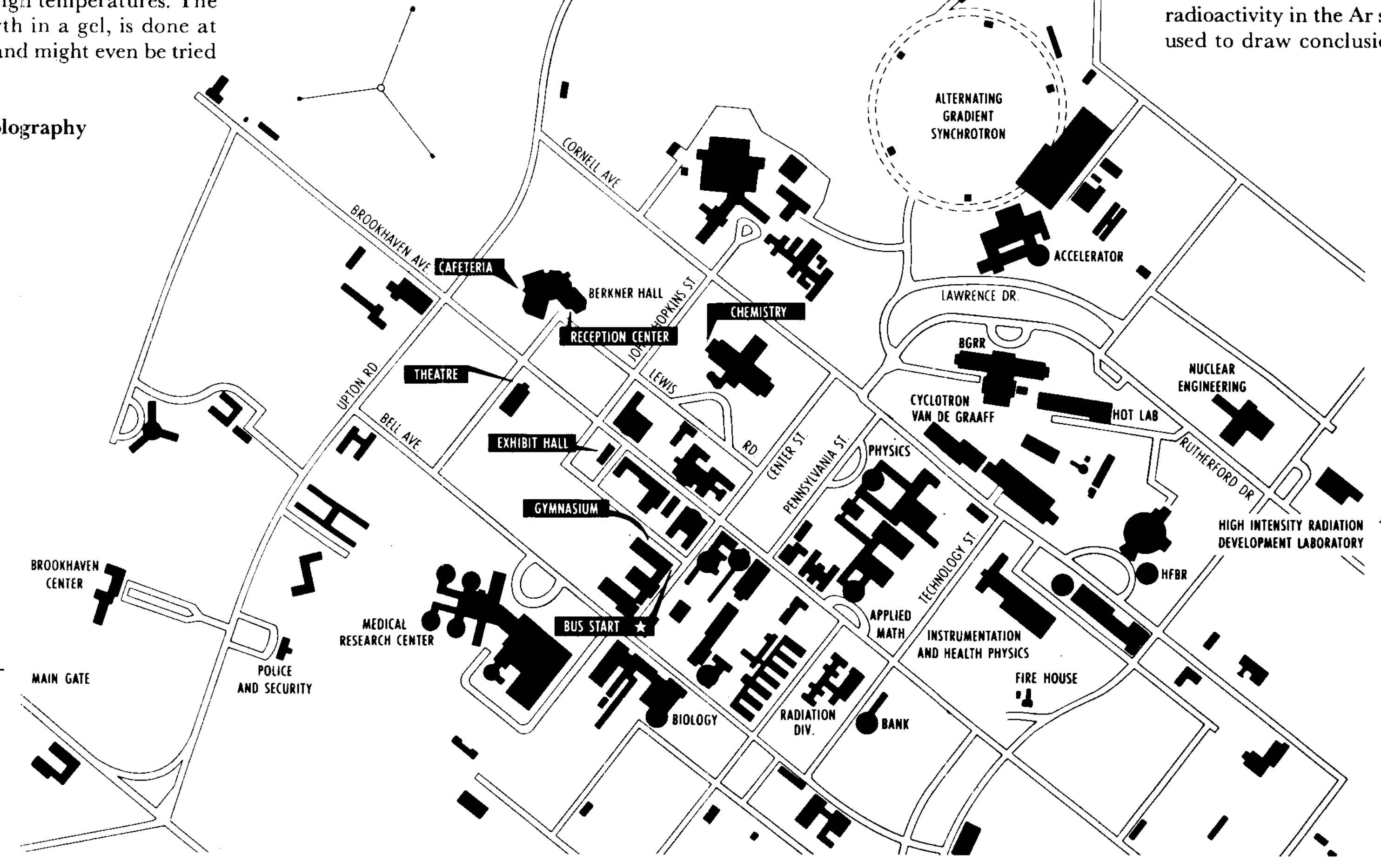
In one experiment, 100,000 gallons of perchloroethylene, the solvent used by dry cleaners, serves as a target to detect neutrinos emitted in nuclear reactions taking place in the center of the sun. This target is situated about one mile below the earth's surface in the Homestake Gold Mine in Lead, South Dakota. After irradiation, radioactive Ar gas atoms formed by neutrinos interacting with target atoms, are removed from the tank and the samples of gas are brought back to BNL for purification in the laboratory. The amount of radioactivity in the Ar samples can then be used to draw conclusions about the temperature and types of nuclear reactions taking place in the core of the sun.

The same apparatus has been used to analyze samples of lunar material.

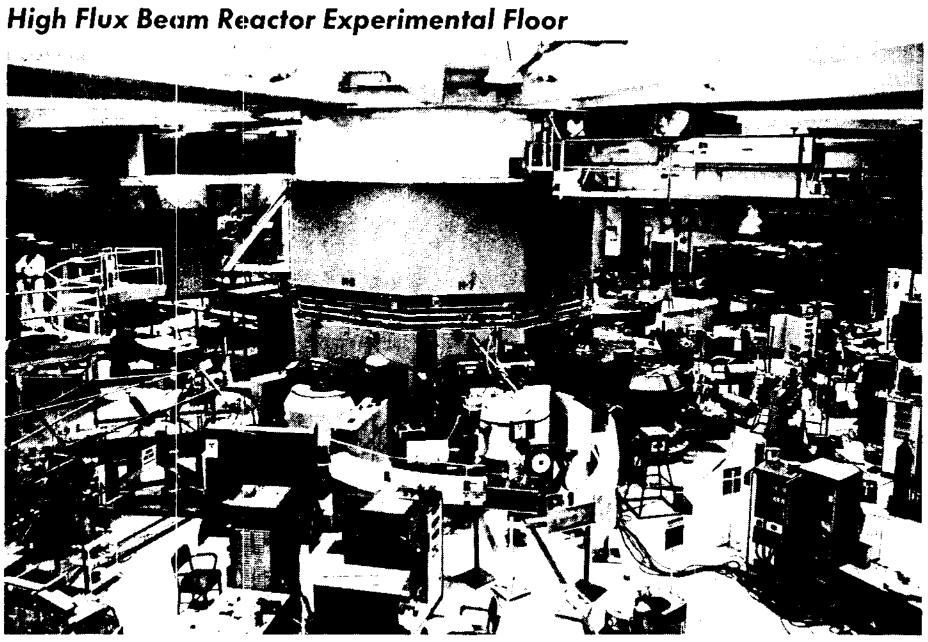
In this case the amounts of radioactive tritium and argon tell us something about the history of the moon and about the nature of solar flares and the solar wind.

As you pass through the lobby on your way out of the building you have the opportunity of viewing a piece of lunar material brought back in the Apollo XI mission on July 20, 1969.

This rock weighs 10 grams and is a vesicular basaltic-type igneous rock.



High Flux Beam Reactor Experimental Floor



The experimental floor of the High Flux Beam Research Reactor is crowded with experimental equipment utilizing the 40-million watt power of the reactor to supply an intense beam of neutrons for nuclear research. The floor above the one pictured is used for control and fuel loading, and the floor below houses operating machinery and spent fuel storage facilities.

New Instrumentation Designed At Brookhaven

Instrumentation above and beyond the general standard is a necessity for modern research. Many research programs at Brookhaven require the design and development of instruments not commercially available. Examples are seimconductor detectors to permit more precise energy measurements of heavy charged particles; multichannel analyzers to determine the energies of the gamma rays or particles from radioactive materials; systems of fast circuits to make measurements in billionths of a second and to count up to 100 million pulses per second to handle the fast counting rates in detectors at the accelerators; and data systems to detect nuclear interactions, store the information in a memory system, and at the same time transmit previously obtained data to a computer for analysis.

Computer Facility

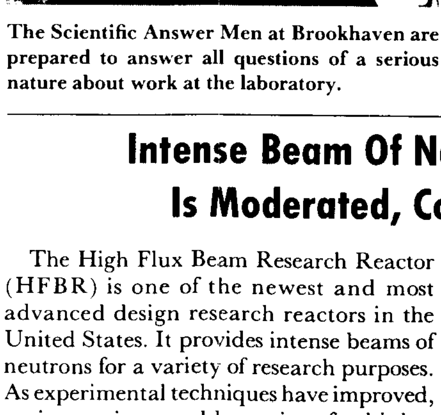
Computers have revolutionized the conduct of scientific investigations and have become an indispensable tool in many fields of research. At Brookhaven, a large computer facility is centrally located to serve all the Laboratory's research programs, and smaller computers are used at experimental sites for specific applications.

In October 1962 the first on-line computer physics experiments were performed by Brookhaven scientists at the AGS. This series of experiments, which lasted a few months, would have required more than 10 years to complete by previous techniques. The use of on-line computers has spread rapidly, and in 1964 an on-line data facility for physics research was established at Brookhaven. Early in 1965 a compact computer permanently mounted in a 40-foot trailer was added to this facility. This computer, intended primarily for particle research, is designed to be used simultaneously by several operators and accepts input from as many as 128 detection devices.

At the High Flux Beam Research Reactor a group of eight neutron spectrometers will be under the control of a single stored-program digital computer. The computer will control the operation of all the neutron detectors and monitors and, in addition, will handle the computation of the experimental data for all spectrometers.

Computer Control Console

Scientific Answer Man



The Scientific Answer Men at Brookhaven are prepared to answer all questions of a serious nature about work at the laboratory.

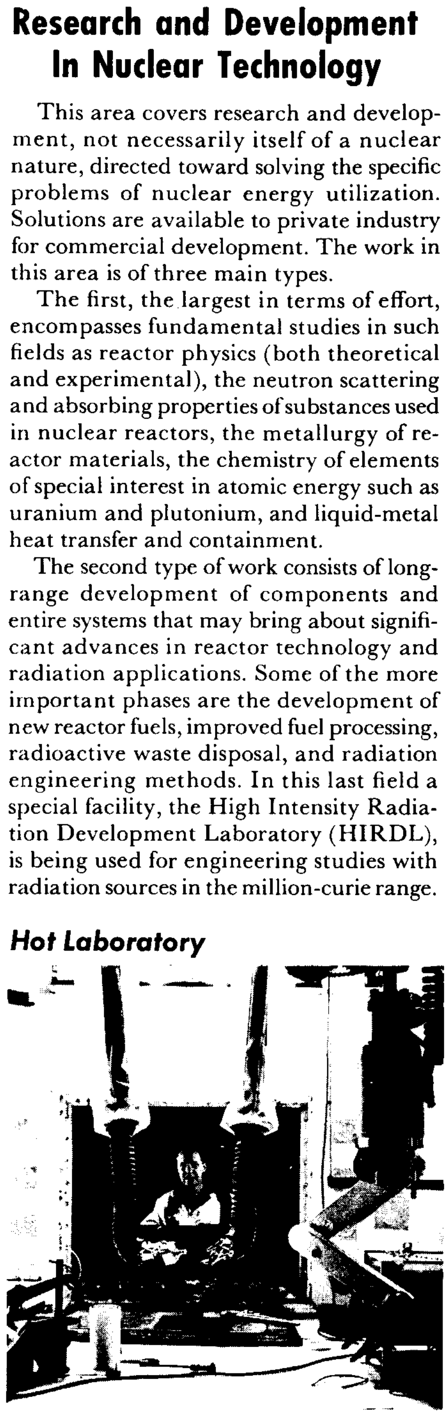
Research and Development In Nuclear Technology

This area covers research and development, not necessarily itself of a nuclear nature, directed toward solving the specific problems of nuclear energy utilization. Solutions are available to private industry for commercial development. The work in this area is of three main types.

The first, the largest in terms of effort, encompasses fundamental studies in such fields as reactor physics (both theoretical and experimental), the neutron scattering and absorbing properties of substances used in nuclear reactors, the metallurgy of reactor materials, the chemistry of elements of special interest in atomic energy such as uranium and plutonium, and liquid-metal heat transfer and containment.

The second type of work consists of long-range development of components and entire systems that may bring about significant advances in reactor technology and radiation applications. Some of the more important phases are the development of new reactor fuels, improved fuel processing, radioactive waste disposal, and radiation engineering methods. In this last field a special facility, the High Intensity Radiation Development Laboratory (HIRDL), is being used for engineering studies with radiation sources in the million-curie range.

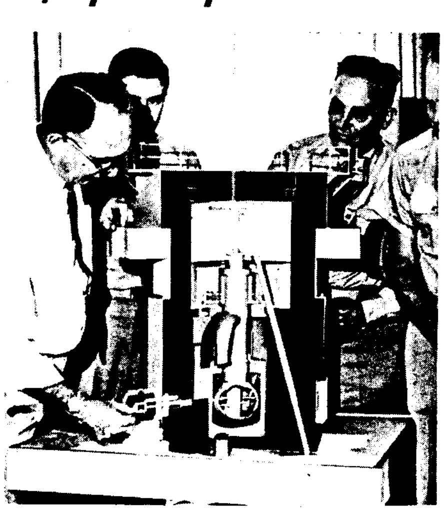
Hot Laboratory



The Hot Laboratory is designed for experimentation with highly radioactive material in "hot cells," where radioactve materials may be safely handled by "master-slave" manipulators and other special remotely operated devices. An important part of the work at the Hot Laboratory has been processing and packaging of radioactive isotopes to be used at laboratories and hospitals all over the world.

Intense Beam Of New Research Reactor Is Moderated, Cooled, By Heavy Water

The High Flux Beam Research Reactor (HFBR) is one of the newest and most advanced design research reactors in the United States. It provides intense beams of neutrons for a variety of research purposes. As experimental techniques have improved, an increasing need has arisen for higher neutron fluxes. The essential feature of the HFBR is its compact core of enriched uranium fuel elements operating at high power density in heavy water. The heavy water surrounding the core serves as coolant, moderator, and reflector. The maximum total flux is about 1.6×10^{15} neutrons per square centimeter per second. The HFBR is housed in a three-story airtight, domed building. The bottom floor houses the operating machinery and the spent-fuel storage canal, the second or ground floor is for beam experiments and laboratories, and the top floor accommodates the control room, irradiation experiments, and fuel handling operations.



A model of the core of the HFBR is explained to visitors. This reactor is loaded from the top with enriched uranium fuel elements, that are removed from the bottom of the reactor when they are spent.

Electron Microscope

A metal sample is prepared for insertion into an electron microscope for metallographic examination in the Instrumentation and Health Physics Department. Besides the scanning machine, the Microscopy Laboratory has three transmission electron microscopes and several optical microscopes. The optical microscopes are used for preliminary examination of samples, and for precision mounting of specimens in the electron microscopes.

Radiation Lab Uses Cobalt-60 In Research

The High Intensity Radiation Development Laboratory (HIRDL) has been designated by the Atomic Energy Commission to serve as a focal point for radiation research and development in the United States. In this laboratory cobalt-60 and cesium-137 are used in obtaining data on a variety of radiation sources in the million-curie range and in developing more efficient techniques for handling large-scale radiation sources. The facility is also widely used in research on irradiation of food for extension of shelf-life (pasteurization dose) or for indefinte storage without refrigeration (sterilization dose).

The research and development program at HIRDL covers such subjects as high-level dosimetry with solid state, glass, and chemical dosimeters; the effects of intense radiation fluxes on both homogeneous and heterogeneous samples; self-absorption of gamma rays in large sources or source arrays; and the design, standardized production, handling, transportation, and use of large gamma sources. This information is used at Brookhaven to design special irradiation facilities, two examples of which are a shipboard irradiator to pasteurize fish as it is caught and a bulk grain irradiator to destroy insects in grain prior to its storage or shipment.

Mechanical Hands

Visitors at HIRDL are fascinated as they watch mechanical hands write initials on souvenir booklets.

Concrete Polymer

The concrete-polymer was developed at the Brookhaven National Laboratory by saturating ordinary concrete with a liquid monomer plastic and then irradiating it with gamma rays to solidify the plastic into a polymer. The result is a new concrete-polymer that is four times stronger than ordinary concrete, is virtually water-proof, and highly resistant to many sources of corrosion. Concrete-polymer can be produced in a variety of shapes and sizes for building and many other uses. When polished, it takes on the appearance of marble. The new product was developed in a joint program with the Department of the Interior's Bureau of Reclamation and Office of Saline Water.

Health Physics Checks Hazards

Health Physics personnel are responsible for insuring that no one, on or off the site, is exposed to harmful amounts of radiation originating at the Laboratory. Many types of fixed and portable instruments are used to measure the radiation levels in work areas to insure that no hazards exist, and bio-assays and individual dosimeters such as film badges are employed to make certain that no one at the Laboratory is receiving harmful amounts of radiation. Radiation levels are continuously measured to insure that allowable limits are not being exceeded.

Ecology Forest

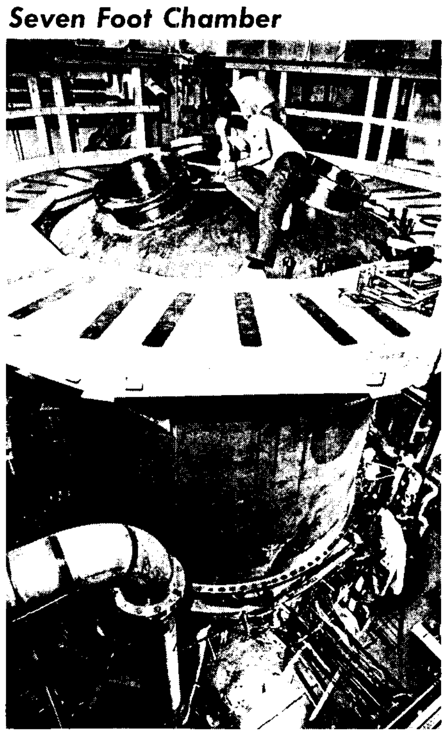
A BNL ecologist looks at the holder for a 9,500-curie source of cesium-137 that is slowly killing vegetation in the 50-acre forest. This long term study is designed for investigating the effects of chronic exposure to ionizing radiation.

Medical Research Center

Although all the special facilities of the Laboratory are available to the scientists working in the field of nuclear medicine, most of their research activities are carried on in the Medical Research Center. The Center includes laboratories, offices, special service facilities, a medical library, an industrial medicine clinic, and a 48-bed research hospital to accommodate patients referred to Brookhaven by physicians in connection with special observations and therapy under development. A unique feature of the Center is the Medical Research Reactor, constructed for the purpose of exploring the possible applications of nuclear reactors in the study of man and the diseases of man. Other special features of the Center include whole-body counters, which are shielded to minimize interference from background radiation.

The Medical Research Reactor (MRR) is an integral part of the Medical Research Center, connected by air-lock doors to laboratories for medical physics, pathology, microbiology, biochemistry, and physiology. The core of enriched uranium fuel elements is cooled and moderated by natural water, and the graphite reflector is cooled by forced air. Two ports, one on each side of the reactor, permit streams of neutrons from the core to pass through the heavy concrete shielding walls to research rooms.

Seven Foot Chamber



The seven foot test bubble chamber was built with super-conducting coils that provide more power to electromagnets than conventional coils. At Brookhaven there are four bubble chambers in operation; a 30", a 31", and an 80" as well as the 7' test chamber.

Whole Body Counting For Medical Research

Whole-body counting is accomplished in the Medical Research Center by this 54-crystal low level counter. One array of 27 crystals is above the patient and another similar array is below. The counter is housed in a shielded room to reduce background radiation levels as much as possible.

Radioisotopes And Other Nuclear Tools Used In Research

This very broad and diversified area involves the use of electromagnetic radiation, neutrons, charged particles, and radioactive isotopes in all branches of scientific research and development. Radiation and particles are used as probes to study physical and chemical structures by observing their penetration and reflection or to effect changes of an informative nature. Similarly, radioactive isotopes, employed as "tracers" because they can be readily located, have become a very useful and versatile tool.

In the field of chemistry, radioactive isotopes are being used as tracers either to study the way in which chemical reactions take place and the rates at which they occur, or to label complex compounds to determine how they are involved in the chemical or biochemical synthesis of other complex compounds.

The biology research program is concerned with the interaction of radiation and radioactive isotopes with living matter and the use of these tools in studying fundamental biological processes. The use of mathematical methods is rapidly making biology an exact science in which biological function is studied at the atomic and molecular level. The chromosomes, which determine the function of the cell, are composed of special molecules so constructed that they can be assembled in an almost infinite number of ways. Protein molecules are extremely complex and can therefore perform extremely exacting tasks in the cell. The way in which sunlight is transformed into food by a plant (photosynthesis) is one of the most complex and important chemical reactions known. These are some of the problems in biology attacked at the molecular level, mainly through the use of radioactive isotopes. Radioisotopes are excellent tracers for studying the structure of extremely complex organic molecules and the reactions in which they take part.

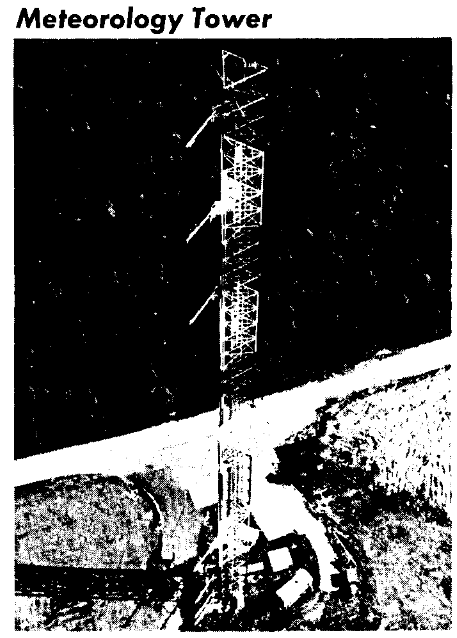
Physical, Chemical, And Biological Effects Of Radiation Are Studied

Studies in this area are of interest in clarifying the effects themselves and as a means of gaining information about the fundamental properties of the substances or organisms involved.

The problems of biology and medicine are increasingly being studied and understood in terms of the structures and functions of the molecules that make up the living cell.

In the medical research program the broad effort to improve understanding of the biological processes in man includes studies to improve diagnosis and therapy and to define more clearly the character of certain diseases, as well as basic investigations at the subcellular, biochemical, and molecular levels.

Meteorology Tower



The 420-foot-high Ace tower

Air Pollution Studied Closely

Meteorology and Climatology are an integral part of the research at Brookhaven for the general benfit of nuclear science and air pollution studies. The distribution of airborne particles and gases is studied by the use of tracer materials such as variously colored smokes and fogs, which show the movements of air and the rate at which materials in it are dispersed or deposited on the ground. The effect of forests and other heavy vegetation on the dispersion of materials in the atmosphere is also a major interest. Two towers, 160 and 420 feet high, have instruments to record weather data and can be used to release smoke or fog trails at various heights.

Moon Sample At Brookhaven

The 12-gram lunar sample at Brookhaven National Laboratory is a vesicular fine-grained basalt type rock. It is designated as specimen number 10057, 28 by NASA, and is part of a larger rock that weighed 919 grams when it was brought back to earth by the Apollo 11 astronauts.

According to Dr. Raymond Davis, Senior Scientist, and a principal investigator for the NASA lunar research effort, the minerals in the rock are feldspar, pyroxene and ilmenite. The specimen is abundant in spherical vesicules (cavities) from one-half to one and one-half millimeters in diameter. The rock contains two sets of fine fractures and is considered a moderately shocked rock, indicating that it was thrown out of the lunar surface by a meteorite impact. The surface shows a number of fine craters formed by micrometeorite impacts when the rock was resting on the lunar surface.

The research at BNL involves heating the sample to drive off the gases it contains, and then analyzing the gases for their radioactivity. The principal gases analyzed are argon, krypton, and xenon. By comparing their analysis of the radioactive (non-stable) gas, which has a known half-life, with the stable isotopes of the same gas, much new information can be learned about moon history, and hence add to man's knowledge about outer space and our universe.