

PUERTO RICO NUCLEAR CENTER

RESEARCH AND TRAINING

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PUERTO RICO NUCLEAR CENTER

Following the rapid evolution of nuclear weapons, it became possible to devote increasing resources to the non-military applications of atomic energy. In 1953, President Dwight D. Eisenhower proposed to the United Nations General Assembly that the nuclear powers should associate in this effort under the aegis of the United Nations. The United States forthwith began a series of moves in compliance with the international commitment. Bilateral agreements with over 30 nations were made to form the basis for effective international cooperation in reactor development with special reference to nuclear power. The first Geneva Conference in 1955 involved the massive declassification of reactor technology and much fundamental information concerning nuclear reactions and their physical constants. The value of international cooperation being evident from this conference, the next step was the establishment of the International Atomic Energy Agency as a special agency of the United Nations.

Much of the early program involved the European nations, Russia, United Kingdom, Canada and the United States; countries that had had a substantial research and development interest in the field since the beginning. Nuclear power development was pushed vigorously in the United Kingdom while in other countries the greater availability of fossil fuels permitted a broader exploration of reactor concepts before the selection of the types most profitable to exploit.

Although the prospective need for nuclear power in Latin America seemed rather remote at the time, it was the general opinion that the countries comprising Spanish and Portuguese speaking America would eventually find themselves confronted with the necessity of moving to nuclear power. In the meantime, substantial immediate advantages should accrue from a vigorous atomic energy program in general scientific development, and especially in medicine and agriculture.

At the 1956 Panama meeting of the Organization of American States President Eisenhower urged action by the Organization of American States to hasten the beneficial uses of nuclear energy. As part of its effort to this end, a study of the needs and potentials of Latin American countries was made by Admiral Paul Foster, then Deputy General Manager of the United States Atomic Energy Commission. This indicated the great need for technical training in a Latin American framework to make available the latest knowledge and technology in the field. As a result of the study and his conferences with the officials of the University of Puerto Rico, Admiral Foster recommended to the United States Atomic Energy Commission the creation of a Nuclear Center in Puerto Rico to be managed by the University of Puerto Rico. The recommendation was approved by the Commission and by the Department of State.

Joint planning studies were initiated by the University of Puerto Rico and the United States Atomic Energy Commission (USAEC) for the

proposed Nuclear Center. The responsibility for implementing and administering the contract for the new Center was assigned to the Oak Ridge Operations Office whose Operations Manager, Mr. Sam Sapirie, negotiated with the University the contract which gave substance and direction to the original concept.

As part of the forward planning, the Tenth Oak Ridge Regional Symposium was held at the University of Puerto Rico in January, 1957. In an address to the Symposium, Chairman Lewis L. Strauss of the Atomic Energy Commission said: "The broadened program will provide the University of Puerto Rico with unique training and research facilities. And because these facilities will be truly outstanding---the most up-to-date in concept and design---and because the instruction will be in Spanish, the University of Puerto Rico may well become a training center to many countries of the hemisphere. I can tell you that we will cooperate enthusiastically in the expansion".

By January 23, 1957, Chancellor Jaime Benítez had appointed an Ad Hoc Committee of the University faculty to explore the development of graduate work in the natural sciences at the University of Puerto Rico, with particular reference to possible developments in the field of nuclear energy. Members of the Committee were:

Dr. Marston Bates, Chairman, Director of Research
 Dr. Conrado Asenjo, Department of Biochemistry, School of Medicine
 Dr. Amador Cobas, Department of Physics, Río Piedras
 Dr. Mariano García Rodríguez, Department of Mathematics, College of Agriculture and Mechanic Arts
 Dr. Víctor Rodríguez-Benítez, Rum Pilot Plant
 Mrs. Marie Barton, Executive Secretary

The Ad Hoc Committee recommended to Chancellor Benítez the establishment of graduate studies and research at the University as the Committee felt that graduate studies and research are necessarily interdependent. It was further recommended that the proposed nuclear reactor be located in Mayaguez.

Anticipating the formal conclusion of a contract, the USAEC awarded a grant of \$216,950 to the University of Puerto Rico to purchase equipment for the Radioisotope Techniques Training Center in Río Piedras and to establish a program in Nuclear Science and Technology at Mayaguez.

Representatives of the USAEC and the University of Puerto Rico signed contract AT-(40-1)-1833 to operate the Nuclear Center on October 2, 1957. The University undertook to operate the facilities and program on a cost reimbursable basis but without fee. The USAEC also announced on this date the appointment of Mr. John J. Thomas, former Deputy Manager of its Hanford Operations Office, as Resident Manager of a new Atomic Energy Commission area office in Puerto Rico,

to administer the various contracts being developed in the Caribbean area.

The goal of the Puerto Rico Nuclear Center (PRNC) is to develop a comprehensive program for research and training in nuclear science and engineering and in the applications of nuclear energy in medicine, agriculture, and industry. These programs employ the Spanish language and are available to students from the American Republics.

The University of Puerto Rico is itself a charter member of the Union of Latin American Universities and at the time of the establishment of the Puerto Rico Nuclear Center there were 313 students from 19 American Republics in its student body. The total enrollment of the University of Puerto Rico during the academic year 1956-57 was approximately 16,000 with a full time faculty of 1,064.

Dr. Charles F. Bonilla, from Columbia University, agreed to serve as Director of the Puerto Rico Nuclear Center for two years beginning October 16, 1957; Dr. José L. García de Quevedo was appointed Head of Research and Head of the Reactor Division; Dr. Amador Cobas was appointed Head of the Radioisotopes Division; and Dr. Fred Soltero was named Head of the Nuclear Science and Technology Division.

The first meeting of the complete PRNC staff was held on January 17, 1958, and an organization plan was discussed. Professor Warren Miller, Director of the Nuclear Technology Program at Pennsylvania State University, gave a seminar and acted as consultant to the staff.

On July 26, 1958, groundbreaking ceremonies for the Reactor Building of PRNC were held in Mayaguez with Dr. Milton Eisenhower acting as official representative of the U.S. Government.

An 8000 curie Cobalt-60 Therapy Unit was installed in April, 1959, at the Cancer Hospital where it remained until transfer to the Bio-Medical Building in early 1963.

Dr. Charles Bonilla returned to Columbia University at the expiration of his leave of absence in September, 1959 and Dr. José L. García de Quevedo served as Acting Director until July 1, 1960 when Dr. John C. Bugher was appointed. Dr. Bugher is a member of the Rockefeller Foundation and is on loan to PRNC at the request of Chancellor Benítez. Dr. Henry Gomberg joined the Nuclear Center as Deputy Director in October, 1961.

On August 23, 1960 the PRNC Research Reactor was dedicated with Chancellor Jaime Benítez acting as Master of Ceremonies. Among the distinguished guests at the dedication were Senator Hickenlooper of the Joint Committee on Atomic Energy, Mr. Robert E. Wilson, Commissioner of the Atomic Energy Commission, and Mr. Sol Luis Descartes, Vice-President of the Banco Crédito y Ahorro Ponceño.

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The first section of the Bio-Medical Building in the new Puerto Rico Medical Center at Río Piedras was occupied in April, 1961. In January, 1963, the Dr. I. González Martínez Oncologic Hospital was inaugurated and it became possible for the medical programs of PRNC to be more effectively consolidated.

The Marine Biology and Oceanography program was greatly benefited by the acquisition from the U.S. Army of a 100 ton Diesel propelled vessel. It was renamed the "Shimada" in honor of the distinguished marine biologist, Bell Masayuki Shimada, who lost his life in an air crash in Mexico in 1958. This vessel has proved to be excellently adapted to the requirements of the ocean-going operations of PRNC.

The ecological studies of the Luquillo Experimental Forest were made possible by the U.S. Forestry Service which provided an extensive tract for the Terrestrial Ecology Program.

The years covered by this condensed report were ones of construction of facilities at several locations, of recruitment and training of staff, and of the continual expansion of the educational activities into all of the disciplines to which nuclear reactions are relevant. As the year ended, PRNC was a vigorous and well rounded institution, operating on all of the campuses of the University of Puerto Rico and active in all of the science departments of the University. From the small nucleus of personnel who had had the courage to initiate the new project, the staff had grown to a total of 226 persons by the end of 1963. The physical plant was completely operative but the program had expanded so much more rapidly than the available space that many laboratories had to be obtained in University buildings and temporary structures had to be erected to house the growing activities.

PROGRAMS

In the first year of the operation of the Puerto Rico Nuclear Center, it was necessary to conduct a considerable portion of the training program at the undergraduate level. With the growth of the University's graduate program, it was feasible to incorporate many of these elementary courses in the regular undergraduate curriculum and to replace them with work at the graduate level in the Nuclear Center.

As a further expression of policy, it became generally accepted that the Puerto Rico Nuclear Center should function as an extension of the various scientific departments having graduate programs so that graduate students would approach the Nuclear Center through the normal admission procedures of the University. Each graduate student consequently has his proper academic home under the general guidance of the head of his department, with members of the Puerto Rico Nuclear Center staff participating on the appropriate committees.

The creation of the new Department of Nuclear Engineering in the College of Engineering completed a structure in which there is a department of the University corresponding to every phase of graduate education and training in the Nuclear Center.

At the date of this report, the graduate programs are operating at the Master of Science level although some of the Departments will be prepared to operate at the doctorate level in the not too distant future. Since a thesis is part of the requirements for a Master of Science degree, every graduate student taking work in the Nuclear Center is expected to complete a reasonable research problem as part of the required work. The problem is selected in consultation with the student and his advisors. Such thesis research naturally tends to be directed to problems of limited time demand and which have a high probability of yielding a reasonable solution in the time available. Thesis research associated with the degree programs tends to be more restricted in scope and requires more immediate supervision than does that conducted at the post-doctoral and long term project level.

In accordance with the policy of considering graduate education as high-level training, a large part of the research capacity of the Puerto Rico Nuclear Center has been increasingly absorbed in thesis research conducted by candidates for M.S. degrees. Generally the research problems selected are those of direct concern to the United States and especially to Puerto Rico. The graduate student or visiting scientist who comes to the Puerto Rico Nuclear Center, works on problems whose nature and dimensions he can study at first hand and where the results of his research may be put into perspective together with all of the other factors that compose the problem. Thus, for example, he learns about reactors, their design and operation, and the economic and engineering problems that must be solved if practical power production is to be achieved. He conducts his studies in an environment where he can observe a power system which, at a high level of efficiency, exploits hydroelectric, fossil fuel and nuclear power plants, all subject to the same bases of economic analysis and all feeding into the same power grid. He can observe, if he wishes, the interrelations of rural electrification, small industries and agriculture, all with unsolved problems and, in some instances, essentially with the same dilemmas that he finds in his own country.

The Nuclear Center thus does not attempt to tell the student or visitor what the solutions to his country's development problems are; rather he participates in a Puerto Rican effort to solve what are fundamentally U.S. problems: In special cases and where the circumstances are favorable, the student may work on a scientific problem of primary importance to his own country but this is the exception rather than the rule.

The concept of "training" has been extended to a much higher level of performance than is usually meant by the term. Graduate education and its associated research become in themselves training at a mature

level. In the process, the student is stimulated to think of his national problems and to project possible practical ways of attaching them. The scientific output of his work becomes available to all and, with time, some of this work may have an appreciable economic impact in the area. A good example of values obtained in this way is in the studies of retardation of spoilage of tropical fruits through moderate doses of radiation. The arrest of ripening of bananas, mangoes, etc. can permit a marked reduction of losses in shipping and of the requirements for refrigeration. All of this work has been done by graduate students and can continue for a considerable period of time into the future.

Under the Education and Training Program there is a substantial volume of thesis research which is oriented to the needs of the graduate student. Many of the major problems of modern science are not well adapted to sub-division into small projects which can be effectively conducted by graduate students. Inevitably the Nuclear Center has moved to additional research programs which are primarily directed to the development of new knowledge and only secondarily useful to the program of graduate education. These research projects are supported by the appropriate divisions of US-AEC. Here the objective is the research itself, rather than training; but these activities have had a profound effect on the vigor and content of the training programs.

Slightly more than one half of the total program of the Puerto Rico Nuclear Center is devoted to training and education with the other portion being concerned with advanced research. All of the advanced research is directed to matters of concern to the United States and to the immediate Caribbean region. Among these activities are those devoted to developing knowledge concerning the long-term effects of radiation and fission products on marine life and similar questions pertaining to the cycling of radioactive elements in tropical forests, questions which are intimately linked with the feasibility of constructing a new canal through Central America or the Isthmus of Panama using nuclear explosives for the earth removal.

The development of the scientific program has involved many sharp decisions concerning the areas in which the Puerto Rico Nuclear Center should exert itself. A relatively small institution of a multidisciplinary nature cannot expect to be effective in all scientific fields. A careful choice has been made, therefore, of those fields of endeavor wherein an institution on an island in the tropics can operate to advantage.

RADIOISOTOPE APPLICATIONS DIVISION

BASIC COURSE IN RADIOISOTOPE TECHNIQUES

A four-weeks course offered five times a year which gives a thorough and intense introduction to the use of radioisotopes in scientific work. Topics discussed in lectures include a review of mathematics and physics, nuclear physics, statistics, radiochemistry, radiobiology, and health physics. Medical applications are also considered. Training in laboratory work is emphasized.

RADIOCHEMISTRY

Designed specifically for chemistry students, this is a one-semester course with three hours of lecture and one laboratory period a week. The student is introduced to the fundamentals of radioisotope techniques in scientific research. The course covers the chemical aspects of nuclear processes and stresses the application of radioisotopes to chemical research.

NUCLEAR TECHNIQUES IN BIOLOGICAL RESEARCH

Designed specifically for biology students, this is a one-semester course with three hours of lecture and one laboratory period a week. The course covers the fundamentals of radioisotope techniques in scientific research, and the biological aspects of nuclear processes, and stresses the application of radioisotopes to biological research.

RADIOLOGICAL PHYSICS AND RADIOBIOLOGY

This is a three-month course given once a year, from August to October. One-hour lectures are given three times a week, plus one-hour of laboratory twice a week. It is offered to Doctors in Medicine who are residents in Radiology in local hospitals. The course covers the fundamental concepts of radiological physics, the physics of diagnostic roentgenology, radiation measuring instruments, dosimetry, radiobiology, radiation protection and history of radiology.

THESIS RESEARCH FOR M.S. DEGREE IN CHEMISTRY

The required thesis research may be done at the Puerto Rico Nuclear Center on a subject of mutual interest to the graduate student and his PRNC advisor. This division has active research programs in

Organic Chemistry, Solution Chemistry, Photochemistry, Radiation Chemistry and Physical Chemistry which provide excellent opportunities for graduate students.

The research program in Chemistry is divided into three principal parts: Organic Chemistry, Radiation Chemistry and Photochemistry, and Physical Chemistry. In addition there is a new program in Solid State Physics.

The Organic Chemistry Program under the direction of Dr. H. Harry Szmant includes the following projects:

NUCLEOPHILIC SUBSTITUTION REACTIONS OF IMIDATES
with E.P. Olavarria (supported by National Institute of Health grant)

The purpose of the research is to develop a method of replacing an alcoholic hydroxyl group by a nucleophile via the imidate derived from the alcohol and a negatively substituted nitrile. In the first phase of this research there is being investigated the mechanism of the base-catalyzed imidate formation by kinetic means. Interesting and unexpected differences are being encountered in the reactivity of the isomeric cyanopyridines and different alcohols and glycols.

BETA-HYDROXY SULFOXIDES with J. J. Rigau

As part of a program dealing with radiation protective agents, there has been synthesized a series of beta-hydroxy sulfoxides by the oxidative addition of thiols to styrene and indene. The compound 2-(p-aminophenyl thionyl)-1-phenylethanol is now being tested at the Oak Ridge National Laboratories. Since the reaction produces four stereoisomers, these are being separated by chromatographic means and it is hoped that infrared and nuclear magnetic resonance spectra will permit the assignment of the configurations to each isomer. Of special interest will be the relation between intramolecular hydrogen bond formation as a function of the substituents in the aryl sulfoxide portion of the molecule.

NUCLEOPHILIC SUBSTITUTION REACTIONS OF AROMATIC SYSTEMS
with A. Carrasquillo, Dept. of Chemistry, U.P.R.

In connection with another problem, it is of interest to prepare p-iodobenzoic acid, p-iodobenzophenone and p,p¹-diiodobenzophenone containing radioactive iodine, and this is being attempted using nucleophilic substitution of iodine by iodide-131. The nucleophilic substitution reactions of aromatic systems in which the activating group is not a nitro substituent have been little investigated, and thus the kinetics of these reactions should be of fundamental interest.

NEW REACTIONS OF SULFOXIDES

with O. Cox, Dept. of Chemistry, U.P.R.

There are being explored reactions of sulfoxides in which the oxygen atom is transferred to either (a) another sulfoxide molecule, or (b) to a suitable acceptor other than sulfoxide. Of special interest is the newly discovered reaction of sulfoxides with triphenylphosphine, the mechanism of which is being investigated by the variation of reaction conditions and of the structures of the sulfoxides.

CHEMISTRY OF HALOGEN-CONTAINING CARBOHYDRATES

with Yolanda Vaillant, Dept. of Chemistry, U.P.R.

In continuation of previous work, there are being investigated reactions designed to cause a direct replacement of a hydroxyl group of carbohydrates by a chlorine substituent. Of special interest in this research is the use of thionyl chloride.

Also, there are being carried out dehydrohalogenation reactions with alpha-and-beta-chloraloses in an attempt to relate the structures of both compounds through the expected common product, namely the 1,2-dichloroketene acetal derivative of D-glucofuranose.

ORGANIC DERIVATIVES OF DIBORON - with L.F. Pazos (supported by the Petroleum Research Fund, American Chemical Society)

There have been prepared several members of a new class of derivatives of diboron and polyfunctional alcohols. The rates of formation of the new compounds, and the infrared spectra of the latter are also being investigated in order to relate the position of the B-O bands with ring size and the nature of substituents.

The Radiation Chemistry and Photochemistry Program under the supervision of Dr. Malcolm Daniels consists of the following projects:

RADIATION CHEMISTRY AND PHOTOCHEMISTRY OF NUCLEIC ACIDS AND RELATED COMPOUNDS (supported by National Institute of Health grant)

The work to date has been devoted to aspects of the photochemistry of thymine. Using radiations from low pressure Hg lamps and appropriate filters it has been shown that thymine is rapidly photolyzed at 1849 Å but not at 2537 Å. This rapid photolysis seems to be dependent on the presence of oxygen, and it has been found that a major product is a thymine hydroperoxide, together with hydrogen peroxide. Work in progress is devoted to identifying the other major products chromatographically and investigating in detail the kinetics of the reactions involved.

This work promises to be of considerable importance if reactions of higher excited states are involved in radiation chemical processes, and should also clarify the mechanism of dimerisation of thymine which seems to be of major importance in photobiology.

Quite recently a rotating cylinder (Couette-type) viscometer has been acquired and work complementary to the above is being started on D.N.A.

RADIATION CHEMISTRY AND PHOTOCHEMISTRY OF OXYANIONS (supported by USAEC Division of Biology and Medicine)

Work started December, 1962. Spectral investigations preliminary to photolytic work have been carried out. In addition, studies on the photolysis of nitrate ion at 313 m μ have been performed. Preliminary experiments indicated a strong and interesting pH dependence of nitrate formation in the alkaline region. There are three regions of obvious interest:

- a) rate independent of pH from pH 2 - pH 6
- b) the small plateau centering on pH 10
- c) the strong increase from pH 11.5 to pH 14.

The mechanism and kinetics of photolysis have been investigated for the first two of the above regions.

The Physical Chemistry Research Program under the direction of Dr. Edwin Roig consists of the following projects:

COMPLEXING OF THALLIUM (III) WITH AZIDE with R. Figueroa

Spectrophotometric evidence shows that thallium (III) complexes with azide. Data are not as yet conclusive but it seems the complexing is in a 1 to 1 molar ratio with a rather small association constant. Experiments are now being conducted to confirm results.

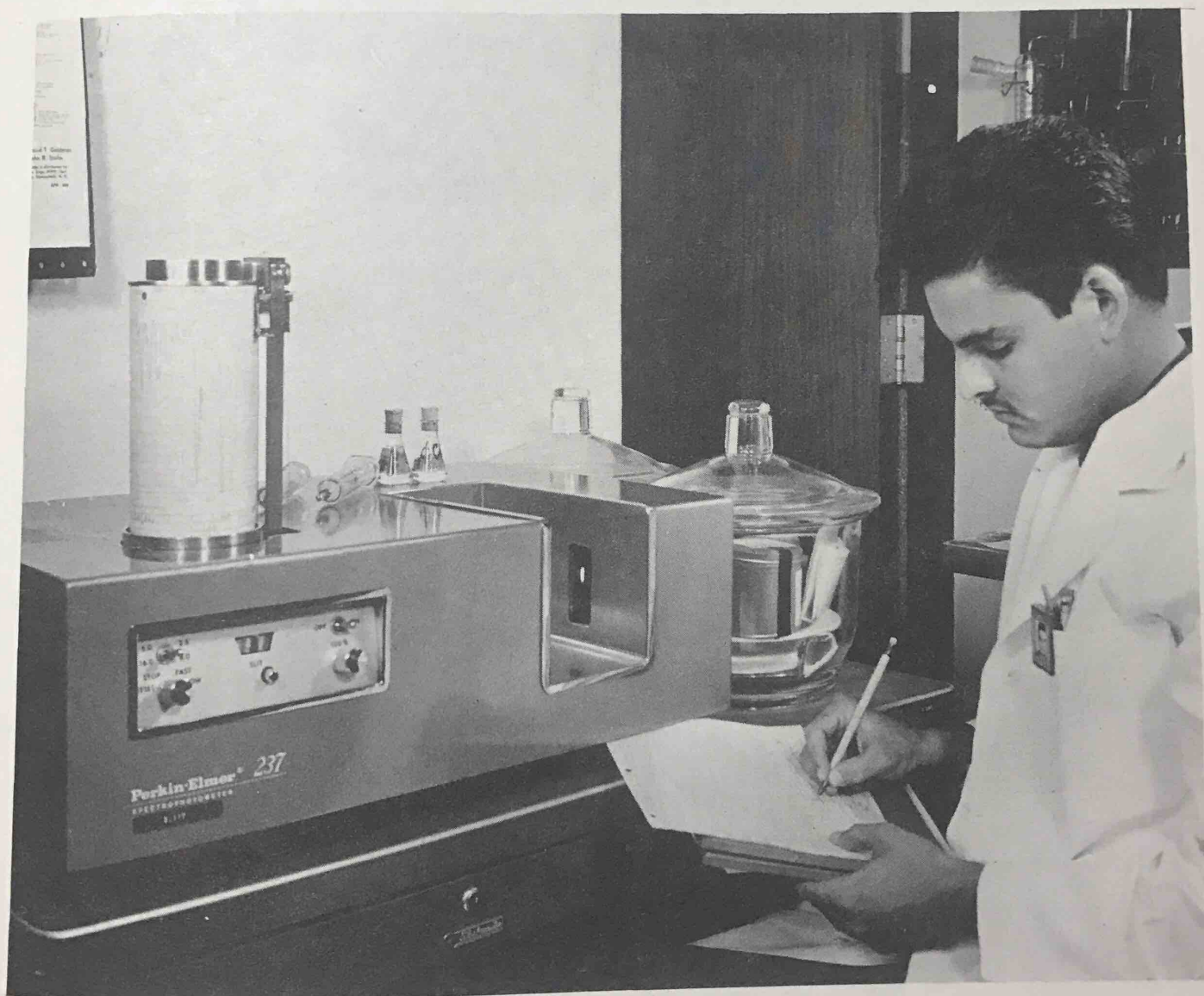
DETERMINATION OF THE HYDROLYSIS CONSTANTS OF THE THALLIC SPECIES with J. Anziani

There is some doubt as to the hydrolysis constants found in the literature. The constants will be determined by potentiometric acid titrations of thallium (I)-thallium (III) solutions with constant ionic strength. After a long and tedious procedure of purifying reagents, all stock solutions required for the study have been prepared. At present the work is being delayed because of difficulties in eliminating leakage of very small currents through the null detector in the potentiometer arrangement.

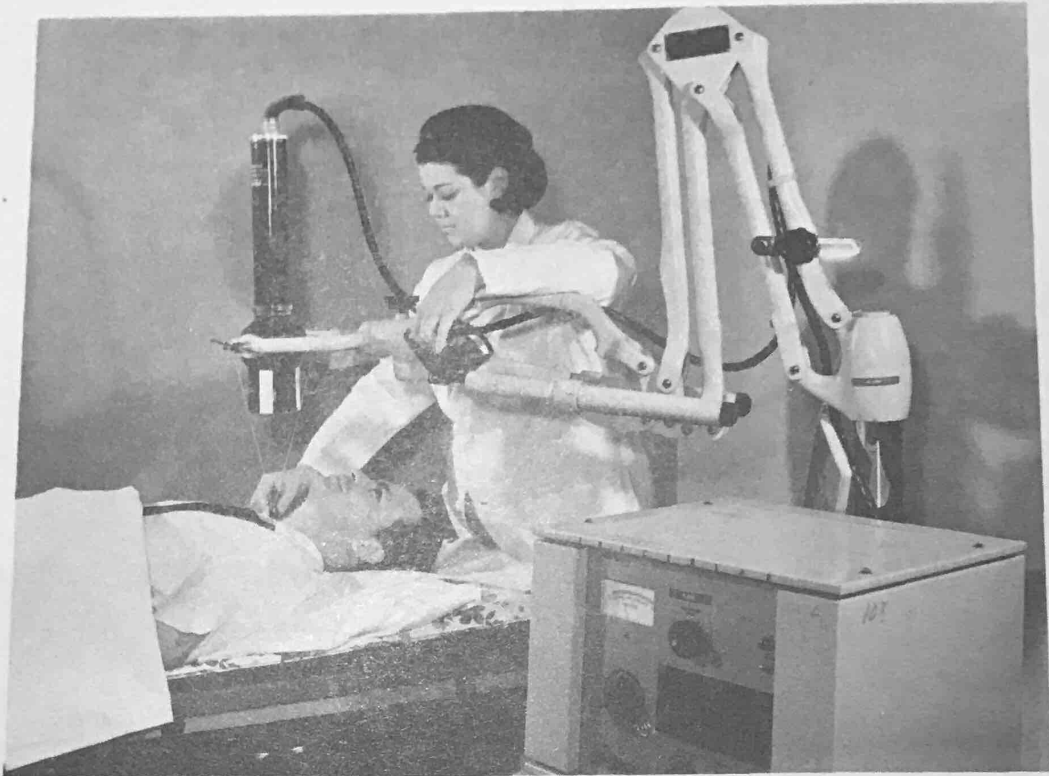
A Solid State Physics Research Program has been developed recently by Dr. Amador Cobas:

STUDY OF RADIATION DAMAGE IN ORGANIC CRYSTALS USING ELECTRICAL CONDUCTIVITY (supported by USAEC Division of Research)

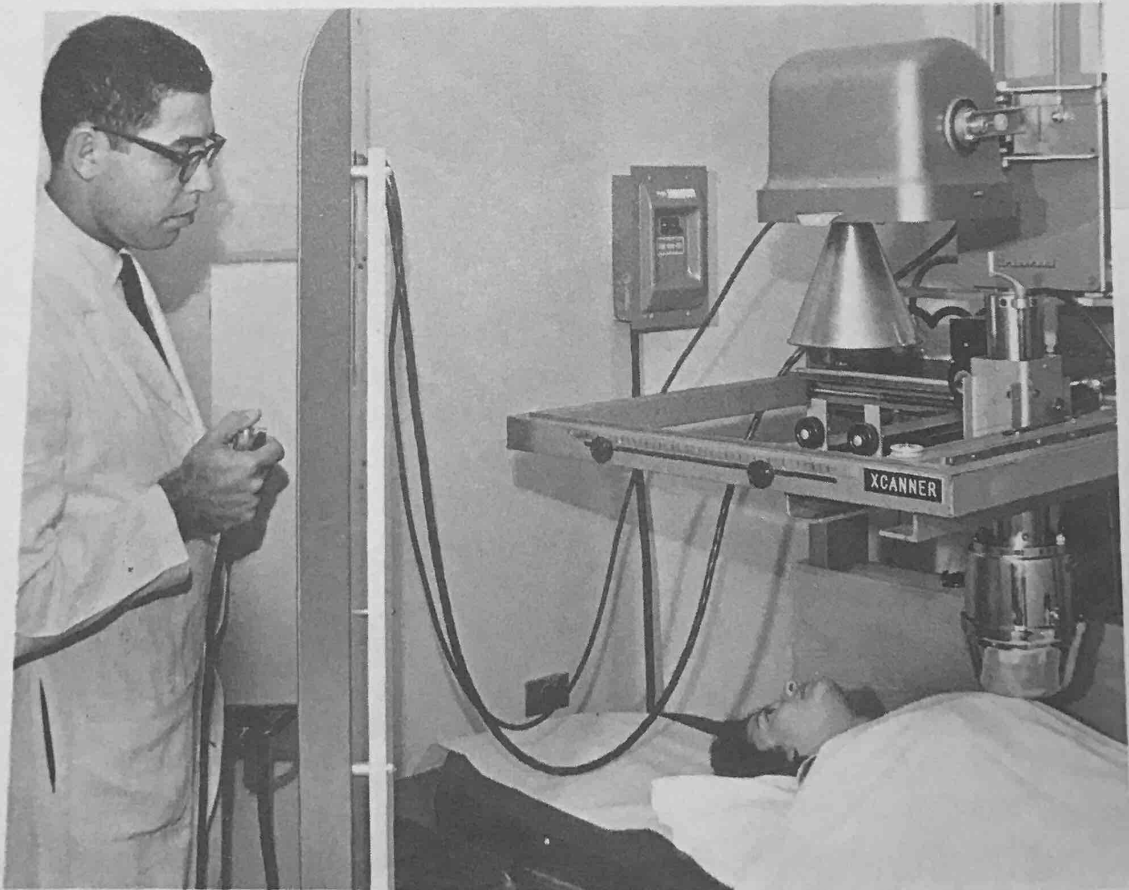
The effect of neutron, gamma, and X-ray irradiation on the electrical conductivity of anthracene crystals is being measured. The initial experiments have measured the changes in dark and photoconductivity in anthracene crystals after neutron bombardment. In extensions of this work trap densities and depths of penetration will be measured by studying the mobility and conductivity as a function of temperature. This work will be extended to other organic crystals. The presence of reaction products from the anthracene crystal after repeated irradiation will be studied spectroscopically and by vapor phase chromatography.



Infrared Spectrophotometer used in confirming molecular structures



Thyroid Uptake Unit



Photoscanning equipment for tumor localization

CLINICAL APPLICATIONS DIVISION

SHORT COURSE IN CLINICAL APPLICATIONS OF RADIOISOTOPES

Training is given over a two-month period in the clinical uses of radioisotopes in diagnosis and therapy. This course consists of formal lectures, demonstrations, seminars, roundtable discussions, review of literature and laboratory work. Two techniques are introduced each week, preceded by an explanation of the theory and medical aspects of the tests. Participants perform approximately 80 tests during the eight-week period. Procedures included are thyroid function studies, blood volume and cardiac flow, erythrocyte survival, location of cancerous metastases, gastrointestinal absorption, renal and hepatic function.

LONG COURSE IN CLINICAL APPLICATIONS OF RADIOISOTOPES

This is a six-month to one-year course which stresses the research aspects of radioisotopes in clinical medicine. The trainee concentrates on a special basic technique and pursues a research project within the scope of the Nuclear Center's research program which is of particular interest to him. A preparatory period is allowed during which the trainee meets regularly with members of the staff to discuss problems related to such matters as experimental procedures, techniques, and biological supplies.

ORIENTATION IN RADIOISOTOPE TECHNIQUES

This is a one-semester course designed to orient the prospective physician to the uses and medical aspects of radioisotopes in clinical practice. Subject matter covers the general application of radioisotopes for diagnosis and treatment in medical practice.

Under the direction of Dr. Sergio Irizarry a varied program of medical research utilizing radioisotopes and biochemistry, has been developed. A summary of the research project follows:

THYROID PROJECT (in collaboration with Dr. Lillian Haddock, Head Endocrinology Section, University Hospital)

A total of 310 cases from University Hospital records were abstracted to date. From these records we selected 11 hyperthyroid

cases, 10 euthyroid cases, and 12 hyperthyroid cases that were typical of these functional conditions of the thyroid gland utilizing rigorous clinical laboratory criteria. From these patients the following data was obtained: (a) Hyperthyroid ranged from 61.1% to 97%. Average was 77.57%. Standard deviation was 10.1%. Average minus three standard deviations was 47.27%. Total number of measurements taken from this group was 22. (b) Euthyroid ranged from 19.2% to 39%. Average was 25.23%. Standard deviation was 5.8%. Average minus three standard deviations was 7.83%. Average plus three standard deviations was 42.63%. Total number of measurements was 12. (c) Hypothyroid ranged from 1.1% to 12.4%. Average was 5.74%. Standard deviation was 3.6%. Average plus three standard deviations was 16.64%.

Our values have an overlapping between the hypothyroid and the euthyroid groups. This overlapping is theoretically of the order of 13.2% on the basis of isotope studies alone in the group of hypothyroid and euthyroid patients having an uptake between 8% and 16-1/2%. We applied values between 16-1/2% and 47% for normal and from 0 to 8% for hypothyroid and on this basis the group found to be unclassified occurred in 17% of the measurements.

Additional work will continue in defining the limits between hypothyroids and normals by collecting more cases. The differentiation between normals and hyperthyroids appears to be good.

INTESTINAL FAT ABSORPTION PROJECT (in collaboration with Dr. A. A. Cintrón Rivera, Head, Clinical Research Laboratory, University Hospital)

This is a study of intestinal absorption in patients undergoing radiotherapy. Seventeen patients have been examined to date and it was noted that a depression in oleic acid levels occurred in five of them while undergoing radiotherapy to the abdomen.

TRIPLE ABSORPTION TESTS

This study is designed to determine the feasibility of doing vitamin A, I-131 tagged oleic acid, and xylose determinations in the same patient simultaneously. Fifteen patients were examined to date and in 6 of them the three tests correlated well. Vitamin A and oleic acid correlated more closely than xylose in the group tested. Results were: 11 normal and 4 abnormal results with Vitamin A, 13 normal and 2 abnormal results with Radio-oleic acid, and 7 normal and 8 abnormal results with xylose.

BLOOD LEVELS OF RADIO-OLEIC ACID IN HYPERTHYROID INDIVIDUALS

This project is designed to test the capacity of the unblocked hyperthyroid gland to affect the blood level measurements of oleic acid absorbed from the gastrointestinal tract. The unblocked hyperthyroid gland supposedly will remove inorganic radioactive iodine from the blood, therefore, causing a depression in the level of circulating radioactivity. We have measured 10 hyperthyroid patients and have found the expected depression in the blood radioactivity level in all of them.

TUMOR LOCALIZATION

The scanning equipment for tumor localization has been modified to include a photoscanning unit underneath the examining table which at the same time operates as an ordinary X-ray cassette, so that we are able to get a dot scanning on paper in patients as before; a photoscanning image with the original photoscanning equipment; and a simultaneous radiographic image of the organ scanned on the final photoscanning record. In this way the final photoscanning record is really determined by the effect of light rays and the X-rays on the radiographic film. This combined use of X-ray and gamma photo-recording is called by us gamma-radiography. At present we have been able to apply this technique successfully to the study of tumors and organ visualization. So far we have obtained experience in the study of the thyroid gland, the liver, kidney, and some tumors. We anticipate the extension of this method to study other organs and tumors.

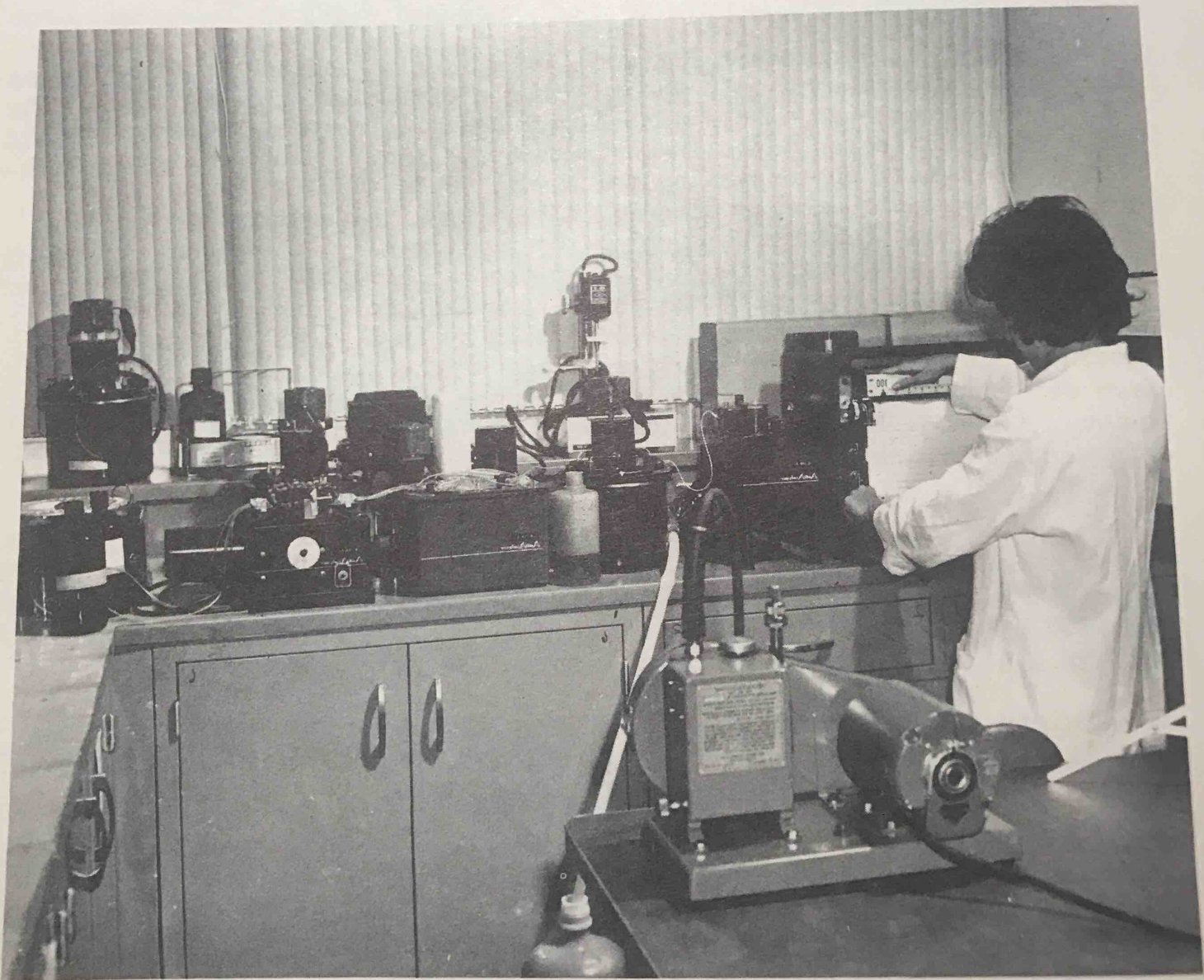
RENOGRAM STUDIES IN RABBITS RENOGRAPHIC CHANGES IN PARTIALLY RADIATED KIDNEYS IN RABBITS (in collaboration with Captain William L. Caldwell, Army Tropical Research Laboratory)

Thirty-two rabbits were subjected to partial renal damage by radiation. Renal function is being followed up by sequential examinations employing the hippuric acid radioisotope renogram.

DETECTION OF EARLY RENAL DYSFUNCTION BY MEANS OF TUBULAR LOADING DURING RENOGRAMS Dr. Marcelo Bertholds

Nine patients in whom equal damage was suspected but not proved by routine laboratory methods were subjected to a double isotope study: (a) The standard renographic procedure. (b) Renography under the load of 2 grams of sodium-para-aminohippurate (P.A.H.) given by slow intravenous injection. In eight of the nine patients in whom a routine

renogram revealed no abnormality, the second procedure using the P.A.H. load affected either the ascending (tubular part) of the curve or the descending (excretory part) of the curve. In some cases both parts of the curve were affected. Since the function of a normal kidney is not affected by a P.A.H. load, early renal dysfunction could be postulated in these patients. The occurrence of reactions such as palpitations, fainting sensation, etc. during the load procedure in 4 out of the 9 patients has prompted us to discontinue the project.



Automated Biochemical Analysis

RADIOTHERAPY AND CANCER DIVISION

RADIOTHERAPY RESIDENCY PROGRAM

This is an approved program for radiotherapists that fulfills the requirements of the American Board of Radiology. Physicians with a year of internship or equivalent clinical experience are accepted. The training period lasts three years, but trainees are required to take an additional year of supervised practice (preceptorship) before admission to the specialty examinations. Trainees learn to diagnose cancer, to determine the extent and radiosensitivity of a tumor, to choose the appropriate treatment, and to plan and conduct radiological therapy. Background in clinical oncology is imparted to residents through work with new, follow-up, and hospitalized cancer patients. Radiation therapy experience is acquired by working with roentgen-therapy machines of various voltages, cobalt teletherapy units, and the application of radioactive materials such as radium, strontium cobalt, and iridium. Trainees become familiar with cancer control activities in Puerto Rico which include a central cancer registry, tumor clinic work, cancer detection, and public and professional education in cancer. Regular teaching activities include: bi-weekly treatment planning conferences, weekly clinical cancer conferences, weekly Oncologic Hospital Tumor Board conferences, weekly University Hospital tumor conferences, weekly Nuclear Center seminars, weekly hospital grandrounds, bimonthly and monthly cancer seminars. The following special courses are included: Radiological Physics, Medical Statistics, Bio-Chemistry of Cancer, Radioisotope Techniques, Radiobiology, and Tumor and Tissue Culture.

SHORT TERM RADIOTHERAPY TRAINING PROGRAM

Special programs are prepared according to the needs of the applicant. Participants may engage in a research project and may participate in all teaching activities of the Radiotherapy and Cancer Division, but are not given patient responsibility.

Under the direction of Dr. Víctor A. Marcial an active program of cancer research has been developed:

CARCINOMA OF THE PENIS (in collaboration with Dr. J. Colón, Oncologic Hospital, and Drs. J. Figueroa Colón and Raúl A. Marcial Rojas, School of Medicine)

Data obtained indicated that cancer of the penis is three times as frequent in Puerto Rico as in the continental United States. Regarding treatment it was found that small lesions can be treated with radiation therapy sparing amputation of the organ with a satisfactory five year survival (65%). The results were published in Radiology, August, 1962.

CANCER OF THE ESOPHAGUS (in collaboration with Dr. Pablo Morales, Auxilio Mutuo Hospital, and Dr. Raúl A. Marcial Rojas, School of Medicine)

The first phase of the project concerns epidemiological investigation of the problem of cancer of the esophagus in Puerto Rico. It has been found that the mortality from cancer of the esophagus in Puerto Rico in both sexes is the highest in the world. The second phase of the project concerns investigation of the clinical features of 400 cases of cancer of the esophagus from the Dr. I. González Martínez Oncologic Hospital. The task of abstracting information from the patients' records, the preparation of coding sheets and perforation of IBM cards was completed. We are awaiting the radiodiagnostic and histopathological evaluation of the cases before proceeding with the final report.

HODGKIN'S DISEASE (in collaboration with Dr. Eduardo de León, School of Medicine)

In this project 83 cases with Hodgkin's disease from Dr. I. González Martínez Oncologic Hospital records were investigated. It was found that the highest survival was achieved in the last seven years when the modalities of treatment included radiation therapy for the involved areas and the adjoining potentially involved regions. The data on these cases will be placed on IBM cards for final analysis and publication.

CARCINOMA OF THE ANTERIOR TWO THIRDS OF THE TONGUE (this is a clinical project by Dr. José M. Tomé, and Dr. Víctor Marcial)

An evaluation of the clinical aspects of 197 cases of cancer of the anterior two thirds of the tongue seen at the Dr. I. González Martínez Oncologic Hospital is in progress. Etiological factors and evolution of the disease are considered. An appraisal of the benefits of various treatment methods is also included.

EVALUATION OF RADIATION RESPONSE IN CASES WITH CANCER OF THE CERVIX UTERI TREATED WITH RADIOTHERAPY BY MEANS OF EXFOLIATIVE CYTOLOGY (in collaboration with personnel of the Cytology Laboratory of the Puerto Rico Department of Health)

The aim of the project is to determine the validity of exfoliative cytology as a prognostic tool in cases with cancer of the cervix uteri treated with radiation. So far, 356 cases have been studied. This is a long term project that will require a minimum of two years of observation in each case. Only 152 cases qualify for the minimal two year follow-up. As an initial step in the analysis of the data collected, a study of the significance of persistent tumor cells in the vaginal smear at the end of external radiation therapy is being

conducted. The purpose of this initial analysis is to determine if the presence of persistent tumor cells at the end of external radiation is related to poor prognosis. Cases with at least two year follow-ups will be used for this study.

IRRADIATION OF THE KIDNEY (in collaboration with Dr. William Caldwell of the Rodríguez Army Hospital)

The objective of the study is to devise treatment techniques for cancer in or around the kidney area that would prevent damage to this organ. One aspect of the study concerns investigation of shielding portions of the kidney during irradiation. For this, a group of 32 rabbits were divided at random into four groups of 8 animals each. The animals were given localizing excretory urograms and were subsequently irradiated with 2000 rads in a single dose with cobalt 60. The following portals were used:

- Group I - The lower half of both kidneys was irradiated
- Group II - The medial half of both kidneys was irradiated
- Group III - Both kidneys were irradiated
- Group IV - (control) - the left kidney was irradiated

At present, three months after irradiation, 19 rabbits are still alive; 6 in group I, 5 in group II, 2 in group III, and 6 in group IV. As expected, animals in group III did the poorest. Twenty-six weeks after the conclusion of renal irradiation the animals remaining will be killed and necropsies with histologic examinations of the renal tissues will be done.

Renograms using Hippuran I¹³¹ before irradiation, 2-1/2 weeks, 4-1/2 weeks and 8-1/2 weeks after irradiation have been informed. The data will be analyzed after the study is completed.

A preliminary study was performed in which young adult New Zealand rabbits had the left kidney irradiated with a dose of 3,900 rads in 3 weeks. One group received 25 mg. of L-Triiodothyronine daily and the other group was the control. Triiodothyronine did not protect the kidney against radiation, but made it worse. The average kidney weight in animals irradiated and receiving L-Triiodothyronine was 1.8 gm., and the average kidney weight in animals of the control group was 3.4 gm. The right kidney that was not irradiated had a similar weight in both groups, 11.7 and 11.9 gm.

IRRADIATION OF THE EYE

The objective is to develop treatment techniques for tumors in and around the eye with preservation of vision. The initial part of the project concerns the investigation of the role of oxygen in the radio-sensitivity of the lens.

USE OF FLUORODS FOR RADIATION DOSIMETRY

The objective is to test the usefulness of fluorods (silver activated phosphate glass rods) in clinical radiation dosimetry. Plans are under way to test the low Z Silver-Activated phosphate glass rods (fluorods) as a possible dosimeter for isodose curve plotting with the 300 KVP X-ray unit. Isodose curves have already been determined using Victoreen r-chambers, in water. The fluorods will be tested against such chambers for the possibility of a more simple and reliable method for plotting isodose curves. Positive results would also justify the use of fluorods with patients treated routinely with the above x-ray unit. Photographic films will also be used to provide qualitative information.



8,000 Curie Cobalt-60 Teletherapy Unit being adjusted prior to irradiation

MEDICAL SCIENCES AND RADIOBIOLOGY DIVISION

Training activities of this new division have been directed to improving the competence of PRNC biomedical technicians in tissue culture techniques, virological procedures, entomology, etc. Beginning 1964, it should be possible to accept a small number of students from other countries.

Under the direction of Dr. M. Paul Weinbren the following research activities have been initiated:

STUDY OF CHROMOSOMES IN CULTURED HUMAN LEUCOCYTES (in collaboration with Col. M. Dacquisto, Director, U.S. Army Tropical Research Medical Laboratory)

Specimens have been prepared from more than 100 persons with the majority taken from normal healthy individuals. The abnormalities currently under study are drawn from patients receiving radiation therapy for malignant disease and from those suffering from "sprue".

OBSCURE ACUTE NEUROLOGICAL SYNDROMES IN CHILDREN (in collaboration with Dr. Dolores Méndez Cashion, Pediatrics Dept., University Hospital--support from National Institutes of Health)

Part of this program consists of a systematic search for the presence of enteroviruses in serial rectal swabs from the children under study. The tissue culture unit of this division undertook the screening of 100 pairs of swabs in August, 1963 and from 22 of the 200 sets of culture tubes inoculated we recovered agents which caused a cytopathogenic effect both in the primary tubes and on passage. Material has been saved for transmission to NIH for final identification of these agents. In 6 cases "agents" came from paired swabs and in the remaining 10, only from one of the pair in spite of repeated isolation attempts from the "sterile partner".

RADIATION INDUCED VARIABILITY IN INDIGENOUS ARTHROPOD- BORNE ANIMAL VIRUSES OF PUERTO RICO--TERRESTRIAL ECOLOGY PROGRAM, PART II (support from USAEC Division of Biology and Medicine)

Support for this program was received in April, 1963, but the initial few months were spent in recruiting personnel and training them. Now we have established a mouse colony holding space and

laboratory quarters and the program has been activated. It is anticipated that the permanent small animal facility and laboratory will be ready for occupation before the end of 1964, or at the latest, in the first quarter of 1965. Field operations to date have been oriented towards mosquitoes and rodents. Permanent trap lines have been laid and are set weekly to trap rodents which are marked and released. At selected intervals the rodents are bled for antibody studies and also for attempted virus isolation. Mosquitoes are caught in light traps and also when alighting on human bait. After identification the mosquitoes are triturated in bovine plasma albumin and the resulting suspension inoculated into mice to attempt virus isolation. To date no virus isolations have been made from material collected at the El Verde Field Station.

DENGUE VIRUS ISOLATION

In August, 1963 a "Dengue-like" illness occurred in an epidemic scale in the town of Manatí, Puerto Rico. Manatí is situated 3.5 miles inland at the mid point of the northern coast 26 miles west of San Juan. It is probable that cases of the disease occurred elsewhere on the island before the epidemic at Manatí. Shortly after Manatí was declared an epidemic area, cases occurred in the San Juan area and notably in Bayamón. From here it "moved" to the eastern end of the island and then down the coast with what would appear to be the last cases in the neighborhood of Ponce which is situated to the west of center on the southern coast.

The Puerto Rico Nuclear Center became involved in the measures taken to study the disease when the Arbovirus unit of the Medical Sciences Division was invited to join Dr. Costa Mandry's team from the Department of Health and a team from the Communicable Disease Center, Atlanta, Georgia. On August 23 it was arranged that specimens could be collected from acutely ill patients in Manatí and 24 patients were bled by the team of the Puerto Rico Nuclear Center to which Dr. Agustín Cajigas of the Department of Health had been assigned for duty during the investigation.

On August 29, 1963, Dr. Telford Work, Chief, Virology Section at C.D.C. visited Manatí with Dr. Cajigas and they obtained specimens from 6 individuals previously bled and 5 who claimed to have been afflicted in the past 3-4 weeks. On receipt of these specimens, at about 9:00 P.M., they were immediately processed and set up in an haemagglutination-inhibition test against Dengue type I antigen provided by C.D.C., Atlanta. The erythrocytes were added to the test at 5:00 A.M. and the test read at 6:00 A.M. on August 30. The results are set out below; the results identified by letters pertain to the sera from the individuals with a "history" of disease.

<u>Specimen</u>	<u>Acute serum titer</u>	<u>Convalescent serum titer</u>
# 6	1:20	1:80
#10	1:20	1:2560
#12	1:20	1:80
#15	1:20	1:160
#19	1:20	1:160
#22	1:20	1:10240
A		1:640
B		1:10240
C		1:80
D		1:20
E		1:20

From these results it was clear that the disease was associated with an agent which is related to Dengue I type virus. (Until such time as an agent is adapted to regularly kill a laboratory animal, it is not possible to establish its exact identity). The agent which caused the illness in Puerto Rico was in all probability the same as that which caused the epidemic in Jamaica a few weeks earlier. It has proved unusually hard to adapt to either laboratory mice or tissue culture. Several different groups have been working with it but none has had any success in fully adapting an agent from many samples of material.

The contribution of the Puerto Rico Nuclear Center to the overall effort lay largely in the initial preparation and screening of specimens collected in the field. In all 1,237 human blood specimens were centrifuged, the serum separated and ampouled. One ml of each serum was prepared for testing by the haemagglutination inhibition test. Aliquots of all specimens were sent to C.D.C., Atlanta, both for attempted virus isolation and serological study.

Of the 1,237 sera 88 were taken in the first 12 hours of illness and in the PRNC laboratory were inoculated into infant mice and tissue cultures to attempt virus isolation. Mosquitoes were processed in 208 pools. The distribution by species is shown below:

A. aegypti	6,849
C. quinquefasciatus	10,983
C. nigripalpus	26
Culex species	<u>85</u>
Total	17,943

From the acute blood specimens and from some pools of mosquitoes, agents have been obtained which cause transient illness in infant mice

and a cytopathogenic effect in African green monkey (*Cercopithecus aethiops*) kidney tissue cultures. The presence of virus may be shown in both infected mouse brain and tissue culture cells by means of the fluorescent antibody technique. In the hopes of increasing their pathogenicity, two strains of virus are in continuous passage in infant mice and two more are in serial passage in infant mice which have been irradiated with 250 rep of X Ray (from a 350 KVP machine) prior to inoculation in order to decrease their natural resistance to the agent. An haemagglutinin has been made from 2 strains of virus but its potency is so low that it is of little value for practical purposes.

SCHISTOSOMIASIS (supported by USAEC Division of Biology and Medicine)

Authorization for this program was received on December 3rd, 1963, and although at this time no results are available, the program is based upon work by Dr. John Villella and Dr. Henry J. Gomberg while at the University of Michigan, and on basically similar information published by Sadun et al. Both these groups reported an acquired resistance to challenge with virulent *S. mansoni* cercariae after infection by cercariae which had been damaged by exposure to gamma irradiation. The differences in the results of these groups appear to be related to the employment of different routes of infection; while Villella uses intraperitoneal infection, Sadun et al. prefer the percutaneous route. It is the object of the present program to perfect more delicate means of assessing the degree of protection obtained and then to establish the conditions required to produce the greatest possible degree of protection. Experiments have also been designed to test the duration of the protection conferred and the stages at which various serological tests yield positive results. When the optimal experimental procedures have been established it is intended to make a detailed study of all detectable reactions which occur between the challenging parasite and the "immune" host.

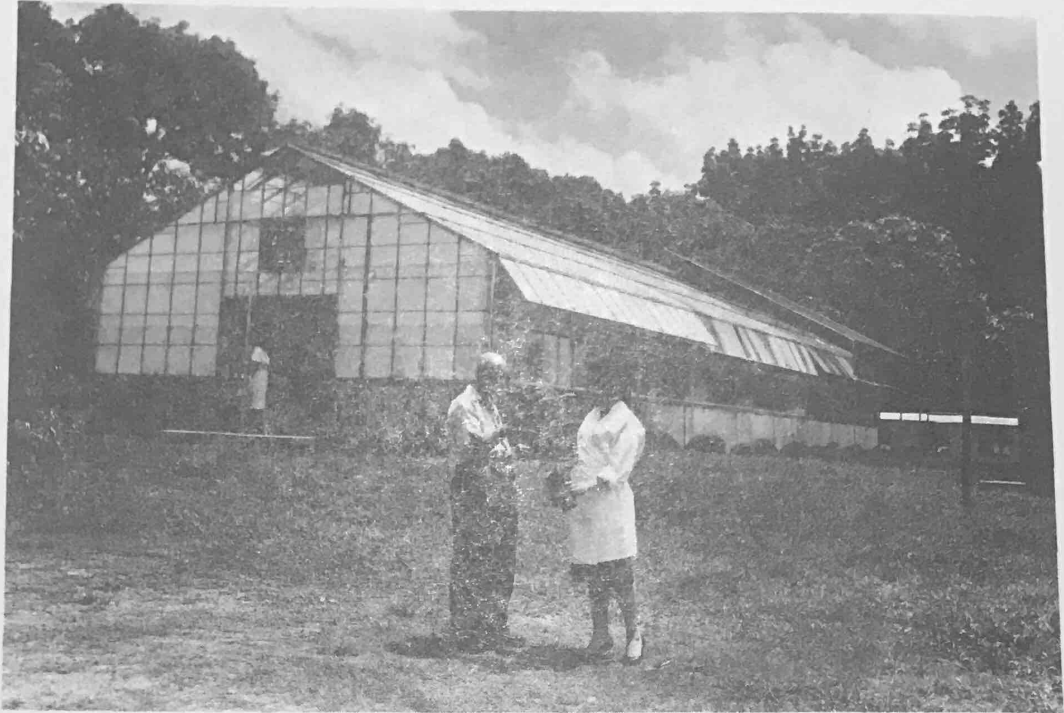
The problems attendant upon reasonably accurate quantitation of the "immune response" or degree of protection conferred upon a mouse which has been exposed to irradiated cercariae are virtually insuperable using techniques in current use by parasitologists. It is proposed to explore the possibility of defining an "infective dose" based on numbers of live cercariae.



Trapping mosquitoes in the rainforest



Mosquito identification



Greenhouse



Gamma Pool Facility

AGRICULTURAL BIO-SCIENCES DIVISION

The Agricultural Bio-Sciences Division had been under the direction of Dr. Howard J. Teas until November, 1962. At that time Dr. Teas was appointed Program Director of the Metabolic Biology Division of the National Science Foundation and Dr. John C. Bugher, Director of PRNC, assumed interim direction of the division, which has personnel and laboratory space at both laboratories of the Nuclear Center. The University of Puerto Rico has its Agricultural Experiment Station located in Río Piedras and its College of Agriculture located in Mayaguez. The U.S. Department of Agriculture operates an Experiment Station in Mayaguez. Educational opportunities available to students through this division include:

THESIS RESEARCH FOR M.S. DEGREE IN BIOLOGY

Courses for the M.S. Degree in Biology include: Radiobiology, Health Physics, Introduction to Bio-Physics, Nuclear Techniques in Biological Research, Marine Applications in Nuclear Science, Atomic and Nuclear Physics, and General Cytology. The required thesis may be done at the Nuclear Center on a problem of mutual interest to the graduate student and his PRNC advisor. Research in Biology, Radiobiology, Marine Biology and Entomology are described in this report.

MECHANISM FOR RADIATION-INDUCED BACK MUTATION Dr. F. K. S. Koo

Back mutation can be attributed either to a true reverse mutation at the mutated locus or to a suppressor gene that arises through mutation at a locus other than the mutated one. With the present knowledge of the fine structure of genes, the structure of the DNA molecule, and the amino acid sequence in some proteins, one may envisage another mechanism of back mutation; i.e., a process by which an impaired functional unit is restored to normal function by replacing a damaged unit with an identical or similar non-damaged one. The restoration through this mechanism can be achieved only by interchanges between the same arms of homologous chromosomes or sister chromatids where breaks have been induced by irradiation treatment. The replacement may occur at the levels of: (1) a single nucleotide pair; (2) a group of nucleotide pairs specifying an amino acid; and (3) a cistron. This mechanism is workable because of the existence of repeats of the same nucleotide pairs tandem sequences for a group of nucleotide and cistrons that control a single step in biosynthesis. The probability for two breaks to be induced by irradiation at suitable positions for a variable

interchange is small but by no means zero. A mis-replacement of the damaged genetic material might lead to a restoration of function as well. It is known that, in some cases, a modified protein enzyme with a changed amino acid sequence performs a function not recognizably different from that of a normal enzyme.

On the assumption that repeats exist at different levels in the genetic material, a mutation may be induced by impairment or loss of one of the members in the repeat and a back mutation by adding an identical member back through interchanges between homologous chromosomes or sister chromatids. This working hypothesis is to be tested by using yellow-green mutants of Oryza sativa in which normal green stripes representing back mutation events are expected to be detected in leaves following seed irradiation. Since back mutation in this test system presumably involves interchanges between sister chromatids, chromosomes must first be induced into a bipartite condition before being irradiated. The first phase of the program, i.e., induction of mutations, is being carried out with the aid of gamma and neutron irradiation. This study may also shed light on the nature of gene structure in higher plants.

STUDY OF THE RADIATION EFFECTS ON STIMULUS TRANSMISSION AND PULVINUS SENSITIVITY IN MIMOSA PUDICA Dr. F. K. S. Koo

This species appears to be relatively resistant to permanent damage by gamma radiation. The initial damage to stimulus transmission was more severe at all dosage levels than the damage to pulvinus sensitivity. At 50 Kr some reversible damage occurred. The speed and degree of recovery of stimulus transmission and pulvinus sensitivity appeared to be negatively correlated with radiation dosage.

ACTIONS OF 5-BROMOURACIL DEOXYRIBOSIDE (BUDR) ON PLANT CHROMOSOMES Dr. F. K. S. Koo

BUDR is a well known radiosensitizer in cell killing. In the present study with chromosomes in Zebrina pendula, Rhoeo discolor, and Allium cepa, several additional aspects of BUDR action have been revealed: (1) It induces breakages more readily at centromeres than at other chromosome regions. (2) It often prevents the contraction of the secondary constrictions while the other chromosome regions usually contract under the influence of p-dichlorobenzene. (3) It produces breakages directly (without incorporation) in the chromatids in addition to its chromosome-breaking action through incorporation. (4) In combined treatment with gamma rays, it interacts with radiation to increase chromosomal aberrations, resulting in synergistic effect. These forementioned actions appear to involve different mechanisms.

INHIBITION OF RIPENING OF BANANAS BY GAMMA RADIATION
Dr. Howard J. Teas with David Cuebas Quintana and Joaquín Oliver Campos

Unripe bananas of Johnson and Monte Cristo variety were exposed to gamma radiation and stored at room temperature. Ordinarily such fruit ripens in six to ten days. At doses of approximately 25 Kr the ripening of both varieties was retarded by ten days or ~~more~~ with little if any effect on flavor. Higher doses caused early blackening of the skin. The ripening process could be reactivated in the irradiated fruit by either 2 minutes dip of the fruit in 1000 ppm 2,4-dichlorophenoxy-acetic acid or exposing to 1 ppm ethylene gas. The use of radiation to slow the ripening of green bananas coupled with the possibility of ripening the fruit at any time by the application of ethylene offers a treatment of possible economic importance.

ACEROLA METABOLISM - Dr. Andrew Maretzki

Injection of acerola fruit during the earliest stages of development with uniformly labeled C_{14} glucose or sucrose resulted in no detectable uptake of radioactivity by ascorbic acid. Similar results were observed with uptake of these radioisotopes into acerola through the stem of the excised fruit, branches of the tree and into excised leaves. Conversion to ascorbic acid was not detectable in fruit slices incubated with the above mentioned precursors for periods of 5 minutes to 3 hours, or with acetate labeled in either the carboxyl or the methyl group carbon. These negative results suggest the possibility that a pathway of biosynthesis is operative, different from that observed in cross seedings, mung beans and strawberries. Extension of these investigations to fruit slices incubated with C_{14} -bicarbonate resulted in interesting labeling patterns. A very small amount of radioactive ascorbic acid was formed under these conditions. Considerable conversion into carbohydrates and organic acids took place. These conversions appeared to be triggered only partially by photosynthetic mechanisms. Further studies showed a remarkably higher rate of formation of one of the labeled substances than that calculated for the other major components. This substance behaved chromatographically very similar to ascorbic acid. Experiments to complete the identification of the unknown are still in progress. The information available at this time indicates a polycarboxylic acid with a neutralization equivalent of 90 and apparently different from any of the organic acids which commonly occur in plants.

During the year investigations were continued on the isolation and identification of biological antagonists from marine algae. A dinoflagellate from which we had previously isolated acrylic acid, inhibiting gram positive bacteria, and a high molecular weight substance, inhibiting yeast growth, was found to contain also a neurotoxin. This toxin appears to be related to the shellfish poisons.. Further work is

in progress on the purification of the toxin and on the isolation of larger quantities of the yeast inhibitor for degradation studies.

AUTOMATIC ANALYSIS OF THE SUCROSE CONTENT OF SUGARCANE - Dr. R. A. Luse

As background for proposed studies on sugarcane mutants, experiments have been done to test the feasibility of analyzing for sucrose content hundreds or thousands of plant tissue samples. Application of the Technicon Auto-Analyzer for this mass screening has been shown to be reasonable, since nearly 500 samples may be analyzed per day, with minimal operator attention. Over 1500 samples of sugarcane extracts have been analyzed during preliminary experiments designed to show variability of sucrose levels within a single plant and between several plants. Current studies are being carried out on sugarcane seedling and leaf tissue, to find whether or not there is correlation between early sucrose levels and sugar yield in the mature plant.

NEUTRON INDUCED HIGH-SUCROSE MUTANT Dr. R. A. Luse

The above studies will be combined in a more general research program to be carried out on a co-operative basis by investigators from PRNC and the Agricultural Experiment Station. In this program, the biochemistry of those sugarcane mutants produced by neutron seed irradiation which show high sucrose content will be investigated. Levels of enzyme which play a part in the biosynthesis of sucrose will be determined on those sugarcane plants with high sucrose (as shown by the mass screening). Such a program is expected to shed considerable light on the enzymology of sugar formation in sugarcane.

PARAMUTATION - Dr. Duane B. Linden

Genetics regulatory systems which control gene mutation are being investigated with major emphasis being given to the paramutation system as it occurs in maize. The nature of the regulator and its product as well as the type of alteration that is produced are the problems to be solved. Radiation treatments of the components of the system have indicated that the type of change which occurs in this system is an inactivation process rather than a true mutational event.

Experiments were designed to determine whether the paramutation inducing process has a radiosensitivity similar to gene mutational events. The source inducing the paramutation change (\underline{R}^{st} and \underline{R}^{nb}) and the site of action (\underline{R}^r) were each tested.

The experimental procedure was similar for all groups. Tassels were cut one day after they began to shed pollen and placed in flasks. They received 2000r from the gamma source and were bagged for use the following day. The tassels were used to make individual crosses onto the appropriate tester (i.e. \underline{R}^r for \underline{R}^{st} tassel etc.). The hybrids were then crossed to $\underline{r}^g \underline{r}^g$ stock, using the $\underline{r}^g \underline{r}^g$ as female.

When the site for paramutation change was irradiated before crossing to \underline{R}^{st} or \underline{R}^{mb} approximately 10% of the time (10 out of 170 ears) there is no apparent paramutation, (i.e. the testcross ears were 50% dark purple). In addition there is evidence that there is some alteration of the usual paramutation interaction in 15-20% of the rest of the ears. They appear to have either a reduced paramutational change or are segregating for paramutation alteration on the ear. Each ear traces back to a single irradiated pollen grain.

When the \underline{R}^{st} stock was irradiated prior to crossing to \underline{R}^r and then testcrossed 64% of the time there was no apparent effect. There were no ears that were 50% dark purple (i.e. no paramutation). However 23% of the ears had light spotted and dark spotted seed predominate with very few yellow and some dark purple kernels. There was a definite effect on the paramutation interaction but probably no instance of complete inactivation. The remainder of the ears are in a suspect category with light spotted predominate and some dark mottled of full purple seed, very few yellow. The ears appear to be significantly different from the majority class which had light spotted and full yellow seeds predominate.

The final group involved irradiation of the \underline{R}^{mb} with subsequent testcrossing identical to \underline{R}^{st} . Here there was 5% apparent complete inactivation of the paramutation interaction (i.e. ears were 50% dark purple). A reduced paramutation effect is more difficult to detect in the marbled induced change as the variability is greater. There was no effect on the paramutation interaction or perhaps some with reduced effect in 84% of the ears. The other 9% of the ears have what appears to be an increased paramutation expression. The seeds are predominately yellow and light spotted with no very dark mottled and no full purple seed on the ears. The altered \underline{R}^r seed appear very similar to the \underline{R}^r from \underline{R}^{st} induced paramutation change. This would indicate that the \underline{R}^{mb} source has some mechanism which inhibits full induction of the paramutation alteration.

RADIOECOLOGY OF A TROPICAL RAIN FOREST, TERRESTRIAL ECOLOGY PROGRAM, PART I (supported by USAEC Division of Biology and Medicine)

Under the direction of Dr. Howard T. Odum this program was started in the spring of 1963 with the objectives of determining effects of radiation on a tropical rain forest and the movement of fall-out

elements in the normal chemical cycles occurring in a rain forest. An area in the Luquillo Forest Reserve was provided by the U.S. Forestry Service and studies were initiated on the normal pattern before irradiation. The area was developed with trails, instrumentation, electric power, and work facilities. A new staff has begun measurements. Some specialists were brought in from universities in the mainland for short periods. A ten thousand curie Cesium source will be brought into the area around January, 1965 for irradiation of about three months. Studies of effects produced will follow to match those made prior to irradiation.

MARINE BIOLOGY PROGRAM (supported by USAEC Division of Biology and Medicine)

This program is under the direction of Dr. Frank Lowman. The acquisition of equipment began in February, 1962 and on July 3, 1962, a 100 ton ship, belonging to the U.S. Army, was delivered to San Juan, Puerto Rico by the U.S. Coast Guard. The vessel was named the "Shimada".

Five basic areas of research have been proposed:

MEASUREMENT OF MARINE PRODUCTIVITY BY MEANS OF C^{14} AND OXYGEN METHODS

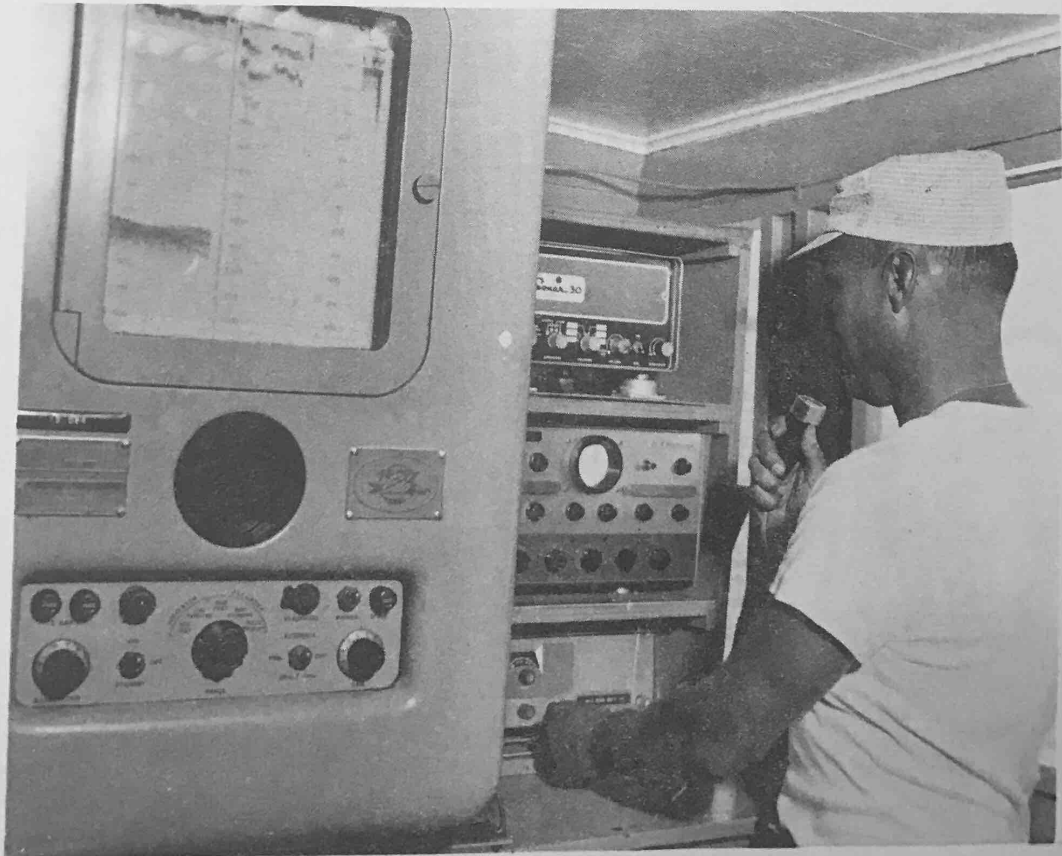
This phase has been delayed until our research vessel is completely equipped, since water samples must be taken at sea and the analysis must be done at sea to measure productivity.

DETERMINATION OF SELECTED STABLE ELEMENTS IN MARINE ORGANISMS, WATER, AND BOTTOM SEDIMENTS

In the analytical techniques used until now, the majority of investigations have been done using the technique of activation analysis. Samples of marine origin are difficult to analyze for trace elements by any technique due to the large amounts of NaCl present. Activation analysis methods have been developed for analyzing the following trace elements: Scandium⁴⁶, Silver¹¹⁰, Vanadium⁵², Manganese⁵⁶, Cobalt⁶⁰, Selenium⁷⁵, and Iodine¹²⁸. All elements selected for activation analysis with the exception of iodine may be coincidence counted. The coincidence counting results in the exclusion of counts other than those of the desired isotope, so that less rigorous chemical separations may be used than if ordinary gamma spectrometry were used.



The Shimada



Communications and Loran Equipment



Collecting ocean bottom specimens on the Shimada



Carbon nitrogen oxygen analysis of marine specimens

DETERMINATION OF CONCENTRATION FACTORS IN MARINE ORGANISMS WITH SELECTED RADIOELEMENTS

The uptake of radioactive scandium and ruthenium by marine algae and tunicates has been investigated. Organisms were maintained in a closed system in which water had been irradiated and temperature was controlled by pumping from a large reservoir. Contrary to the experiment in which these organisms were held in small volumes of contaminated water, the uptake of both radioactive elements was not high and proceeded at a very slow rate. At the end of two weeks the organisms had not reached an equilibrium state. Results obtained by other investigators using small volumes of water showed that equilibrium is reached in as little as four to eight hours. The explanation may lie in the fact that with a small volume of water the organism takes up all the radioactive elements present and then reaches equilibrium.

MEASUREMENT OF RADIOISOTOPES NOW PRESENT IN MARINE ORGANISMS, WATER AND BOTTOM SEDIMENTS

This work is well under way and rainwater samples were collected and analyzed. The following isotopes have been found in rainwater samples: Ce^{144} , Pr^{144} , Ru^{106} , Zr^{95} , Nb^{95} , Cs^{137} , and Ba^{137} . Sr^{90} - Y^{90} separations were made using a combination of nitric acid precipitation and ion exchange separations.

Biological specimens of the following types have also been analyzed: terrestrial plants, marine algae, marine angiosperms, and marine invertebrates. Results to date: in terrestrial plants no Cs^{137} was detected which is contrary to expectations.

In marine algae only Zr^{95} , Nb^{95} , Ru^{106} , Rh^{106} and K^{40} were found. It was expected to find Ce^{144} , Pr^{144} , Co^{57} , Co^{60} and Zn^{65} on the basis of findings in the Pacific Proving Ground.

COLLECTION OF BACKGROUND OBSERVATIONS IN PHYSICAL AND CHEMICAL OCEANOGRAPHY TO BE USED IN INTERPRETING DATA COLLECTED IN THE FIRST FOUR PROGRAMS

As of the end of the period covered by this report this part of the program was being activated.

In addition to the programs mentioned above, the Marine Biology group was asked to study the off-shore area at the BONUS reactor site for background data to be used in case of an accidental release of radioactivity through the salt water cooling system of the reactor.

This was accomplished using a Rhodamin-B fluorescent dye that is magenta in color and has a peak fluorescence at approximately 6,700 millimicrons when excited with ultraviolet light. The dye does not complex with beach or organic surfaces and is easy to see and photograph at dilutions of at least one part in ten billion parts of sea water.

RESONANCE IN RADIATION EFFECTS PROGRAM

Drs. H. J. Gomberg, R.A. Luse, and F. Vázquez Martínez

Experiments using monochromatic x-radiation in the energy range 6.4 - 8.3 Kev have shown increased inactivation of the metalloenzyme catalase at or near the K-absorption edge of iron (7.11 Kev). This is taken to confirm the resonance radiation hypothesis of Gomberg and previous experimental work of Emmons and Paraskevoudakis.

X-radiation intensities have been measured in the sample holder with a Fricke ferrous ammonium sulfate dosimeter. A more sensitive method for detection of the ferric ion produced has been developed using the ferrithiocyanate complex.

The x-ray emission system utilized for the present resonance radiation studies has been characterized quantitatively as to intensity and photon energy distribution and second harmonic contamination. The monochromatic x-ray beam resulting from crystal diffraction and collimation was analyzed horizontally across its front for (a) intensity distribution, utilizing a special moving slit device; and (b) photon energy distribution, using double diffraction by a second analyzer crystal.

Estimation of the extent of second harmonic energies was made from (a) absorption measurements relying on the different mass absorption coefficients at the first and second harmonic wave lengths and (b) double diffraction measurements in which photons with second harmonic energies were analyzed separately. Correction for percentage of reflection by second harmonic energies also was determined by the double diffractometer method. Contamination by higher harmonics was shown to be considerable at higher operation voltages; monochromatic beams can be obtained only by proper selection of tube potential.

The effects on the beam by varying the position of the various components in the x-ray system (tube, diffraction crystal, two soller slits) were determined and the system was selected which provides high uniformity of photon energy distribution. As a result, a diffraction system was developed which permits irradiation with photons of uniform energy distribution (only $\pm 50\text{ev}$ in 6-9 Kev).

NUCLEAR SCIENCE AND TECHNOLOGY DIVISION

This division concerns itself with graduate students in Chemistry and Physics interested in specializing in the nuclear aspects of these disciplines.

THESIS RESEARCH FOR THE M.S. DEGREE IN NUCLEAR SCIENCE AND TECHNOLOGY

The following topics are included in the required curricula for the course: Nuclear Physics, Nuclear Reactor Physics, Nuclear Reactor Technology, Radiological Safety, Mathematics of Modern Science, and Reactor Physics Laboratory. The following courses are offered as electives: Reactor Instrumentation and Control, Reactor Metallurgy, Chemical Processing of Nuclear Fuels, Nuclear Measurement and Instrumentation, Quantum Theory, Radiochemistry, and Servo Mechanisms. The required thesis research is based on scientific problems of interest to the graduate student and which are appropriate to the research capabilities of the Nuclear Center.

THESIS RESEARCH FOR THE M.S. DEGREE IN CHEMISTRY

The following topics are included in the required curriculum for the course: Advanced Inorganic Chemistry, Advanced Organic Chemistry, Nuclear Chemistry, Advanced Radiochemical Techniques, and Nuclear Measurements and Instrumentations. Among the electives available are the following: Mathematics of Modern Science, Advanced Inorganic Chemistry, Radiochemistry, and Health Physics. The required thesis research may be done at the Nuclear Center and is based on a scientific problem of mutual interest to the graduate student and his advisor from the Nuclear Center staff.

THESIS RESEARCH FOR THE M.S. DEGREE IN PHYSICS

The following courses are available to the graduate student in Physics: Nuclear Physics, Introduction to Theoretical Physics, Nuclear and Reactor Physics, Mathematical Physics, Introduction to Physical Statistics, Atomic and Nuclear Physics, Introduction to X-Ray Diffraction, Introduction to Quantum Theory, Introduction to Neutron Physics, Methods of Theoretical Physics, Interaction of Radiation with Matter, and Introduction to Celestial Mechanics. The required thesis research may be done at the Nuclear Center and is based on a problem of mutual interest to the graduate student and his advisor from PRNC.

Under the direction of Dr. Owen H. Wheeler the research in organic chemistry is as follows:

SYNTHESIS OF SUBSTITUTED STILBENES with H. Battle

Synthetic methods for preparing cis-and trans-stilbenes are being compared. The ultraviolet and infrared spectra and polarographic reduction potentials will be measured in relation to the effects of substituents. The spin-spin hydrogen coupling in the cis-stilbenes is being measured in conjunction with the Instituto de Química of the Universidad Nacional Autónoma de México.

RADIATION CHEMISTRY OF STEROIDS with R. Montalvo

The effect of gamma radiation on estrone and its derivatives is being studied in relation to the mechanism of hydroxylation of these compounds. Comparison will be made with the effect of x-rays and of chemical radical hydroxylation.

STEROID DERIVATIVES OF RADIOLOGICAL INTEREST

with C. Reyes

Derivatives of corticosteroids incorporating boric acid in the side chain are being prepared as neutron absorbers. Other derivatives incorporating sulphur compounds in ring D or the side-chain will be prepared as possible radiation-protecting drugs.

MECHANISM OF THERMAL REARRANGEMENTS with I. Casanova

The postulated intramolecular nature of the Chapman rearrangement of phenyl benziminio ethers is being checked using Carbon-14 labelled compounds. The allied rearrangement of the corresponding allyl ether will be studied using tritium labelling.

DEUTERIUM ISOTOPE EFFECT IN THE ETARD REACTION

The nature of the rate-determining step in the etard oxidation of toluene with chromyl chloride is being investigated using methyl-deuterated toluene.

NEUTRON DIFFRACTION PROGRAM - (supported by USAEC Division of Research). Dr. Ismael Almodóvar, Dr. Chalmers Frazer (Brookhaven National Laboratory), Dr. Helmut Bielen (Germany), and Dr. Kenkichi Okada (Japan)

The neutron spectrometer which was installed recently with the cooperation of the Brookhaven National Laboratory is now in operation. With the present shielding, it is estimated that the facility can be operated safely at reactor power levels up to at least two megawatts.

The spectrometer is a double crystal type, where the first crystal serves to select a monochromatic (or monoenergetic) neutron beam from the thermal spectrum by Bragg reflection; the second crystal is the sample to be investigated. The scattering or diffraction pattern from the sample is recorded semi-automatically using electronic counting equipment with appropriate control circuitry. This equipment can be used to study a wide variety of problems in structural chemistry and solid state physics.

Preliminary diffraction data are now being collected from a natural mineral sample of fayalite (Fe_2SiO_4) in preparation for later low temperature magnetic structure studies. The first problem expected to be completed on the spectrometer is a single crystal structure analysis of calcium tungstate (the mineral scheelite). This structure was examined many years ago using X-rays, but reliable oxygen coordinates could not be obtained because of the intense tungsten scattering. Work on the structure will commence upon the arrival of Dr. Mortimer Kay. Dr. Kay, of the Georgia Institute of Technology, collaborated with Dr. Almodóvar and Dr. Frazer on this problem. Subsequent research will fall into two general areas: the structural role of hydrogen in hydrogen-bonded crystals, and the magnetic spin structures of transition metal compounds. Some sample preparation work is now in progress for these later studies.

MODIFICATION OF THE THERMAL COLUMN IN THE PUERTO RICO NUCLEAR CENTER REACTOR - Dr. John A. Wethington (University of Florida) with Orlando Angleró

The cylindrical access position of the graphite thermal column is a convenient place for wet exponential experiments if a suitable source condition can be achieved. The exponential decrease of neutron flux across the bottom of this access, when the column is loaded with graphite, vitiates its use for such experiments.

Some graphite was removed from the thermal column assembly in order to create a graphite lined cavity or neutron hohlraum. Various configurations of reflectors were tried in order to achieve the most symmetrical flux distribution at the bottom of the vertical access.

Flux maps have been made using foil activation techniques, and it has been shown that the void pattern selected does give a suitable source condition. The flux data are being fitted with both cosine and Bessel functions in order to establish the best equations for neutron flux as a function of space coordinates.

In addition to the improvement in flux shape, use of the cavity has increased the absolute neutron flux by one decade in the vertical access position and by three decades in the horizontal access position.

RADIATION EFFECTS IN FLUOROCARBONS - Dr. John A. Wethington with F. Rosa González

The effect of reactor radiation on fluorocarbons is an unexplored field. Samples of C_3F_{13} , $(C_4F_9)_3N$, and $C-C_3F_{16}O$, supplied by the Minnesota Mining and Manufacturing Co., are being distilled in order to obtain known fractions for the determination of physical properties. Physical properties will be studied as a function of radiation dose.

CERIC DOSIMETRY - Dr. Fausto Muñoz Ribadeneira with Milagros Miró Villarini

Ceric sulfate has been widely used as an efficient chemical dosimeter for doses up to 10^8 Rad, but difficulties related to chemical purity and water quality make its use problematic due to the erratic "G" value changes from one determination to another.

The "G" values found by the ceric-cupric system are reported as follows:

"G" VALUES CERIC-CUPRIC SYSTEM

Cu^{++} Concentration Normality	Barnstead Water		Tri-Distilled Water		f
0.0	2.78	0.21	2.51	0.03	1.000
0.001	2.57	0.30	2.50	0.03	1.002
0.01	2.54	0.09	2.47	0.01	1.0006
0.1	2.22	0.02	2.22	0.01	1.0531

f = correction Factor

Inspecting the values obtained with Barnstead solutions one could say that the increase in copper concentration reduces the "G" values and at the same time produces good stability. In triple distilled water solutions, the "G" corresponding to solutions with copper concentrations in a range of 0 to 1×10^{-2} , are in agreement with several reports, also being very stable. For copper concentrations of 1×10^{-1} , both solutions present a "G" which is the same both in magnitude and limit of error.

The explanation of the physical chemistry of the copper concentration effect is being studied and more concentrated solutions of $\text{Ce}(\text{HSO}_4)_3$ are being used. Results are being tested using the new PRNC 2000 curie cobalt source.

RADIATION EFFECTS IN THE THERMAL EMISSIVITY OF GRAPHITE
 Professor Richard B. Knight (North Carolina State College) and
 Professor K. Soderstrom with Mr. Guillermo Rodríguez Figueroa

An apparatus consisting of a cylinder of graphite in an evacuated aluminum housing has been constructed and mounted in one of the beam tubes. The changes in the thermal emissivity of the graphite due to neutron bombardment are being studied by measuring the heat-loss of the graphite to a flow of cooling water in the outer-jacket, on heating the inner surface of the graphite.

FERROELECTRIC PROPERTIES OF TRIGLYCINE SULFATE
 CRYSTALS - Dr. Julio Gonzalo González with Juan López Alonso

The ferroelectric hysteresis behavior of crystals of triglycine sulfate is being studied over a range of frequencies and at ambient and low temperatures. The effects of x-ray and gamma radiation will be studied.

A GRAPHICAL METHOD FOR DETERMINING THE MINIMUM CRITICAL
 MASS OF A BARE HOMOGENEOUS REACTOR - Dr. Eddie Ortiz with
 Anneliese Kraft de Pérez

The minimum critical mass of a bare homogeneous reactor can be calculated from the critical mass equation. The tedious approach of point by point plotting to find the minimum mass from the curve so obtained for each fuel-moderator system demonstrates the necessity of finding a more simple method.

Introduction of the requirement for a minimum into the critical mass equation and a convenient transformation results in a transcendental equation which has only a graphical solution. The solution is given by the intersection of two functions, one represented by a straight

line whose direction depends only on the nuclear parameters of the moderator and an exponential function which depends only on the nuclear parameters of the moderator and an exponential function which depends only on the average number of fast fission neutrons emitted as a result of the capture of one thermal neutron in the fuel.

The graphical method in general terms leads immediately to the minimum critical mass for spherical, cubical, or cylindrical shapes of reactors for any moderator in combination with U^{235} .

HIGH ENERGY GAMMA PHOTON-NEUTRON CONVERSION DEVICE FOR HALF LIFE MEASUREMENTS - Dr. Eddie Ortiz with J. Facetti and S. Pinto Vega

The basic principle involved is the disintegration of deuterium by high energy gamma photons to produce fast neutrons which are moderated by an optimum thickness of paraffin to get the best balance between moderation and capture and then the neutrons are detected by a BF_3 counter.

The half-lives of Ca^{49} , As^{76} , Na^{24} , S^{37} , Mn^{56} , and of fission products from U^{235} fuel elements have been measured. Fission product decay has been measured using the fuel elements from the PRNC Swimming Pool Reactor and by separate irradiation of uranyl nitrate.

The arsenic sample showed a 3.66 min. activity in addition to the expected 26.8 hr As^{76} activity. Experiments are now in progress to identify this presumed new activity.

THEORETICAL AND EXPERIMENTAL STUDY OF FATIGUE IN PHOTOMULTIPLIER TUBES - Rev. Ignacio Cantarell

In spite of the wide-spread use of photomultiplier tubes for precise measurements, there exists a difficulty which has not been overcome and which continues to distort the measurements made with them. This difficulty is fatigue which is reflected in the abnormal variation in the gain with time.

The more explicit brochures from phototube suppliers attribute the fatigue to cesium migration and comment that this phenomenon is not fully understood. Before 1958, only a few qualitative and semi-quantitative studies had been made and the causes of fatigue remained unexplained.

It was decided to carry out a systematic quantitative and qualitative study of fatigue in multiplier phototubes. The variables which affect the phenomenon of fatigue were first determined. These were found to be: (a) working time, (b) rest time, (c) history

on previous use of tube, (d) intensity and nature of applied source, (e) applied voltage to dynodes, (f) nature of dynodes and (g) tube temperature.

The principal variable was time, since it fundamentally affects the fatigue, and is an effect which cannot be eliminated. Additional studies were later performed on the dependence of fatigue in relation to the other variables.

ANNEALING EXPERIMENTS IN NEUTRON IRRADIATED COMPOUNDS - Dr. J.F. Facetti with E. Trabal and S. Torres

Antimony-III and -V compounds were submitted to thermal annealing after neutron irradiation. The samples were analyzed by extraction with isopropyl ether and measured with NaI (TI) crystal coupled to a multi-channel pulse height analyzer.

The products of this type of Szilard-Chalmers process show annealing response similar to other oxyanions and oxides studied.

DISTRIBUTION OF RADIOACTIVE ANTIMONY FORMED BY NUCLEAR TRANSFORMATION IN ANTIMONY OXIDES - Dr. J. F. Facetti with E. Trabal and S. Torres

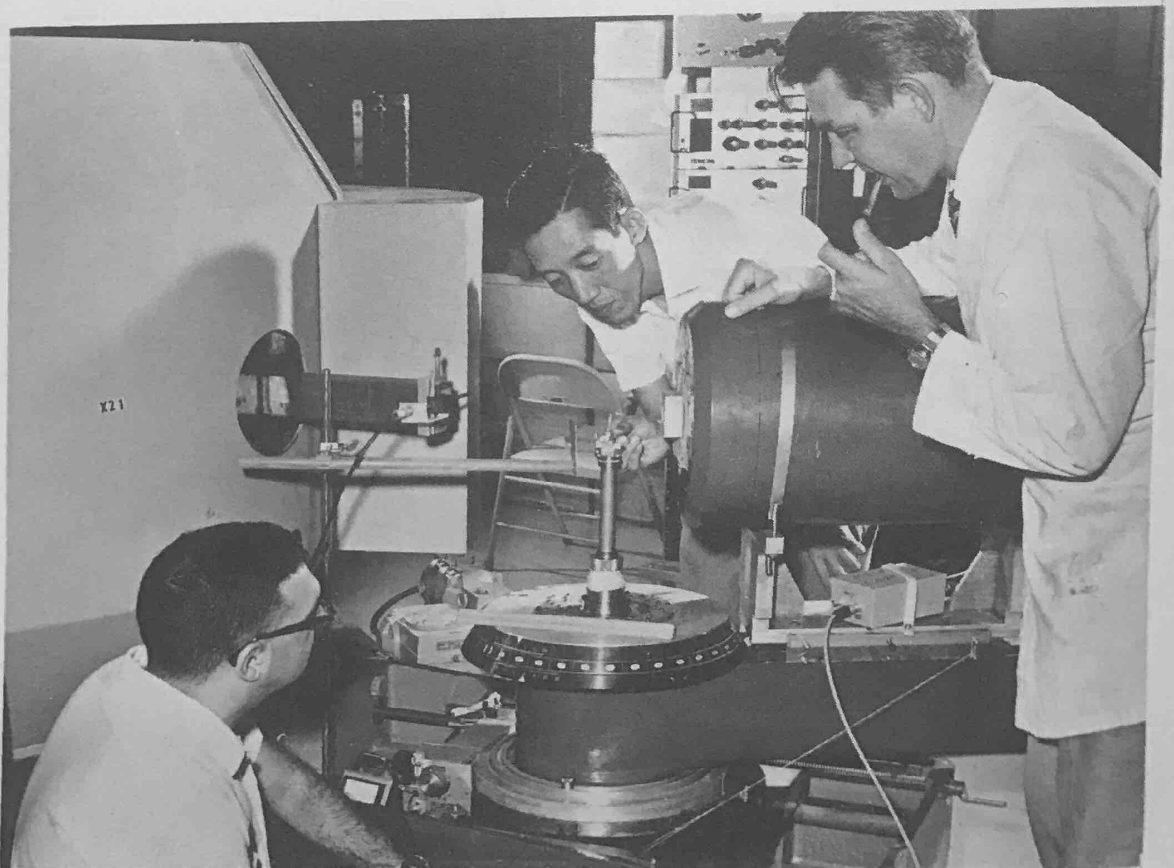
Antimony oxides were irradiated with neutrons in the PRNC nuclear reactor, to study the distribution of radioactive Sb^{122} and Sb^{124} between the tri and pentavalent oxidation states.

Antimony (V) was extracted with isopropyl ether. The radioactive samples were counted in a NaI (TI) well crystal coupled to a multi-channel analyzer.

The results show a linear relation between the composition of oxide and the percentage of radioactive Sb^V , similar to that obtained by other workers with arsenic oxides.



Loading film badges



Adjusting a specimen on the Neutron Spectrometer

HEALTH PHYSICS DIVISION

The primary function of this division is to establish and carry out a program guaranteeing the safety of all personnel working at the Puerto Rico Nuclear Center.

Prior to the operation of the one megawatt pool type research reactor, an environmental survey of the area around the Puerto Rico Nuclear Center laboratory in Mayaguez was conducted under the direction of Dr. José Ferrer Monge. The project is kept current by continuous sampling and gathering of data.

A graduate program leading to the M.S. Degree in Health Physics is approved by the US-AEC Special Fellowship Program administered by ORINS. Educational opportunities offered by this division include:

THESIS RESEARCH FOR M.S. DEGREE IN HEALTH PHYSICS

The graduate program in Health Physics includes the following courses: Radiological Safety, Radiobiology, Radiological Electronics, Atomic Physics, Nuclear Measurements and Instrumentation, Radiochemistry, Nuclear Techniques in Biological Research, Mathematics of Modern Science, Advanced Radiochemical Techniques, Nuclear Chemistry, Health Physics and Biological Oceanography. The required thesis research may be done at the Nuclear Center on a problem of mutual interest to the graduate student and his PRNC advisor.

SURVEY OF BONUS REACTOR SITE

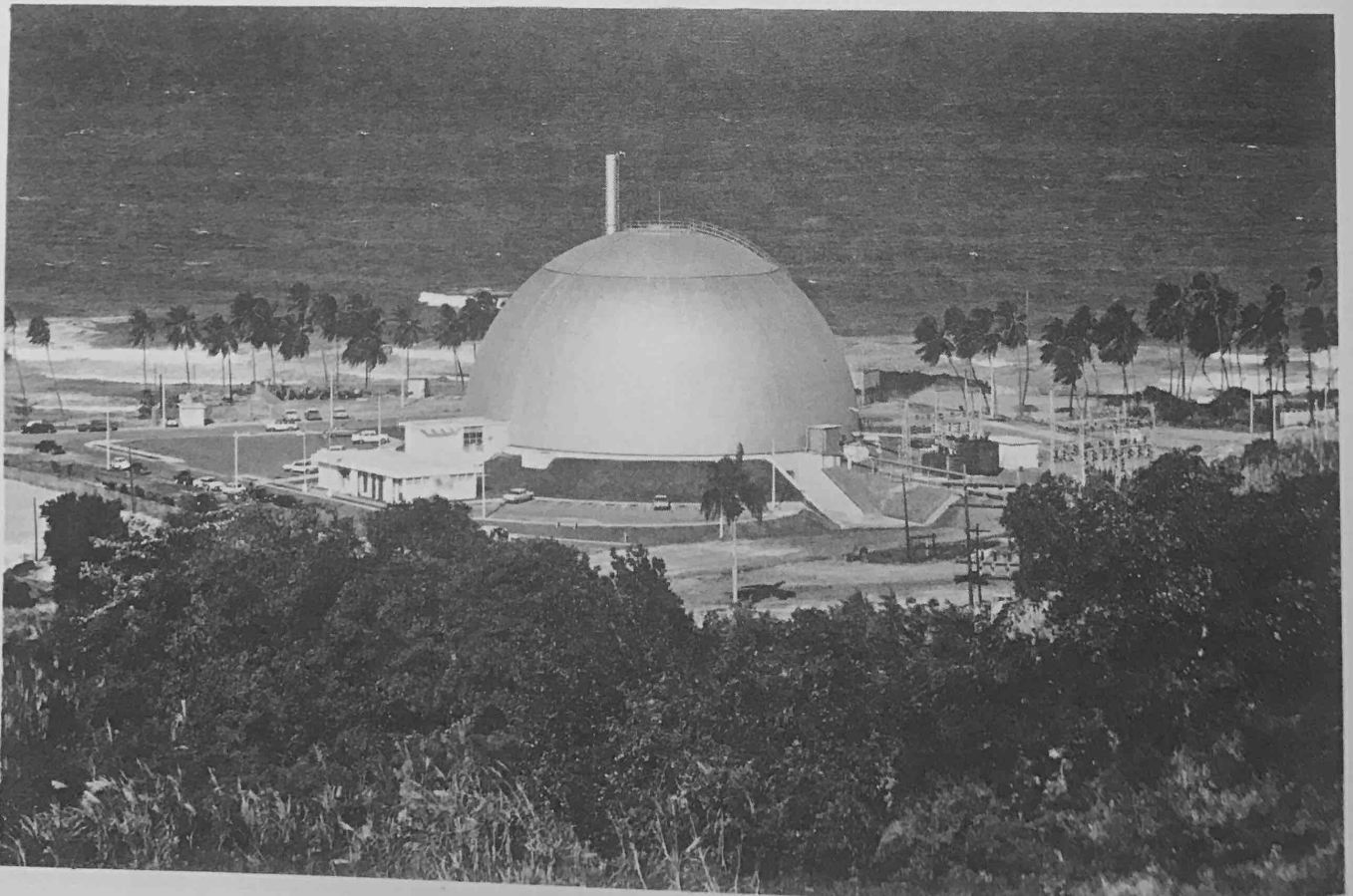
An ecological and environmental survey of the BONUS Reactor site in Rincón, Puerto Rico, is continuing. The general purposes of this project are to provide: data on radioisotopes now present in the area, and useful data for the Marine Biology and Oceanography Program of PRNC under the direction of Dr. Frank Lowman. The project is divided into five parts: (1) survey of biota, (2) determination of present radioactivity levels and composition of soil, rocks, water, air and biota, (3) determination of stable element composition of biota, (4) collection of background data of meteorological, hydrological, edaphic and topographic factors related to ecology, (5) integration of the data thus collected to make an evaluation related to a possible reactor accident.

FUNDAMENTALS OF RADIOLOGICAL HYGIENE

This is a one semester course offered for the first time during the second semester of the 1962-63 academic year to graduate students of the University of Puerto Rico School of Public Health. The following topics are covered in lectures and laboratory demonstrations: hygienic aspects of radiation exposure, mathematics of radiation, physics of radiation, detection and measurement of radiation, biological effects of radiation including somatic and genetic, sources of radiation including nuclear explosions, reactors, activated materials and fission products, apparatus for medical use, radioactive isotopes used in medicine, radioactive waste disposal, exposure criteria, legislation, control and administration.

SUMMER INSTITUTE IN RADIATION BIOLOGY

This is a six week program for secondary school science teachers designed to provide current information on contemporary biology and radiobiology to improve the teaching of these subjects. The National Science Foundation in cooperation with the Atomic Energy Commission has supported the Institute four times and the Department of Education of the Commonwealth of Puerto Rico provided support for participants once in cooperation with the Atomic Energy Commission.



Bonus Power Reactor

REACTOR DIVISION

The division operates and maintains two nuclear reactors in Mayaguez: an L-77 Homogeneous Reactor and an AMF pool type research reactor designed for operation at a 5 megawatt power level. It also is responsible for the operation of the hot cells, gamma irradiation facilities and shops. In addition it is responsible for the maintenance and operation of the physical plant and the meteorological station. It provides reactor and associated facilities for research work.

The PRNC Research Reactor is operated at its authorized power level of 1 megawatt. Modifications have been made to correct defects and improve operation. Control rods have been calibrated, new core configurations have been studied in which the control rod worth has been improved considerably and in which all control rod interaction has been eliminated; neutron flux mapping of the cores has been done and in general a complete determination of reactor parameters has been made.

An expanding research program utilizing the reactors is developing. Two of the beam tubes of the reactor are now being utilized fulltime. A neutron spectrometer has been installed in one and the Thermal Emissivity of Graphite Research Apparatus has been installed in another. A second larger neutron spectrometer was installed in a third beam tube.

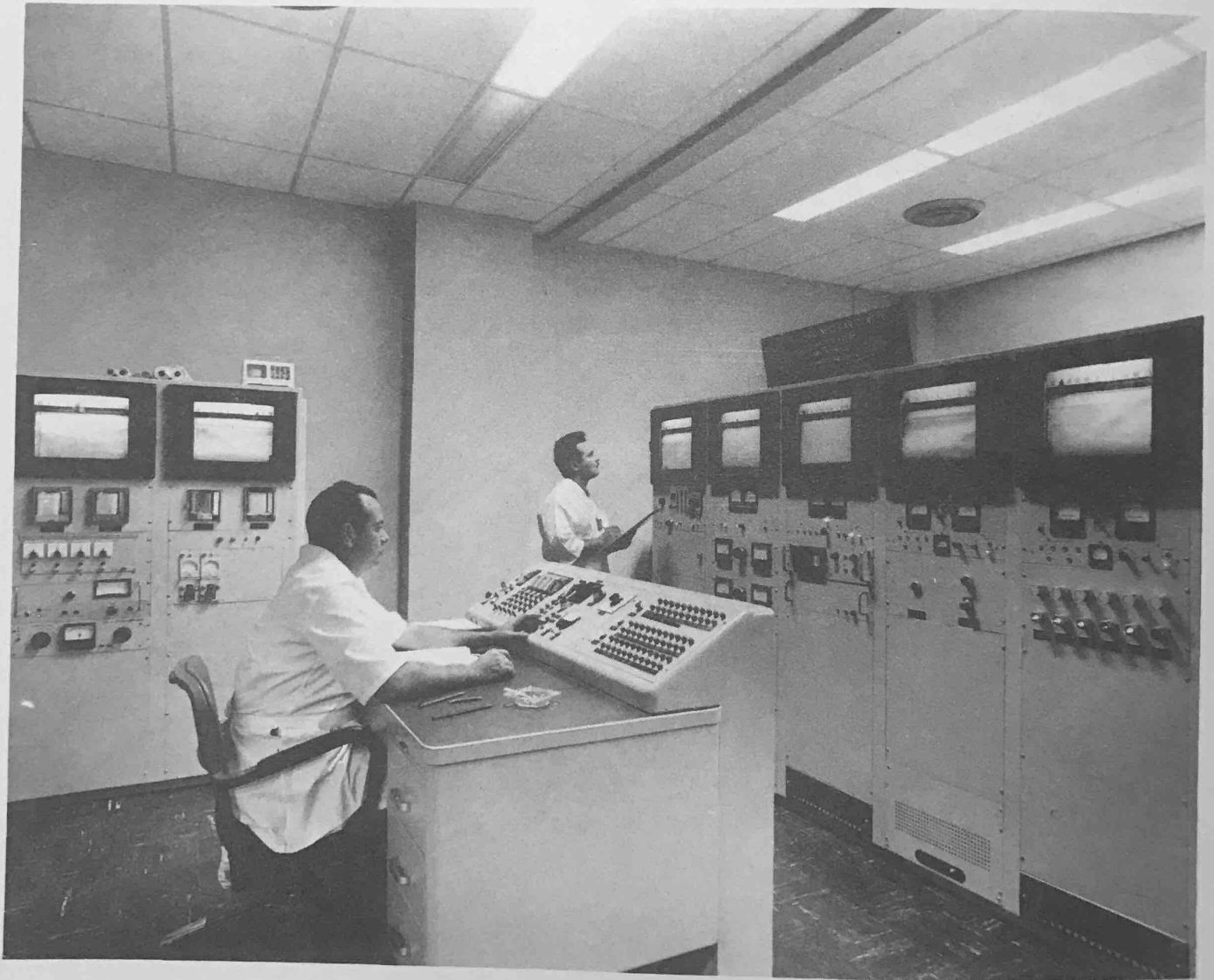
The Reactor Division has trained reactor operators for the new BONUS power reactor being constructed in Rincón, Puerto Rico which will be operated by the Puerto Rico Water Resources Authority for the U.S. Atomic Energy Commission.

REACTOR SUPERVISOR TRAINING

This course is based on individual needs and interests. The trainee becomes acquainted with the electrical, electronic, and mechanical equipment associated with the PRNC research reactor. He learns the rules and regulations governing operating procedures and becomes acquainted with and performs the duties of a reactor operator. Techniques and procedures for the irradiation of samples are demonstrated and reviewed as well as the techniques for the preparation of core flux mappings, neutron distribution and fuel burn-up calculations. The routine maintenance problems of reactor equipment and components are outlined as well as the basic problems of safe reactor operation.

REACTOR OPERATOR TRAINING

Basic information on physics, nuclear engineering, electromechanical engineering, health physics, chemistry, and mathematics are included in the training. Additional information on the nuclear plant and facilities is given to enhance the technical instruction on the operation and maintenance of research reactors. The remainder of the training entails the actual operation of the PRNC research reactor under supervision and the carrying out of all phases of reactor maintenance necessary for normal operation.



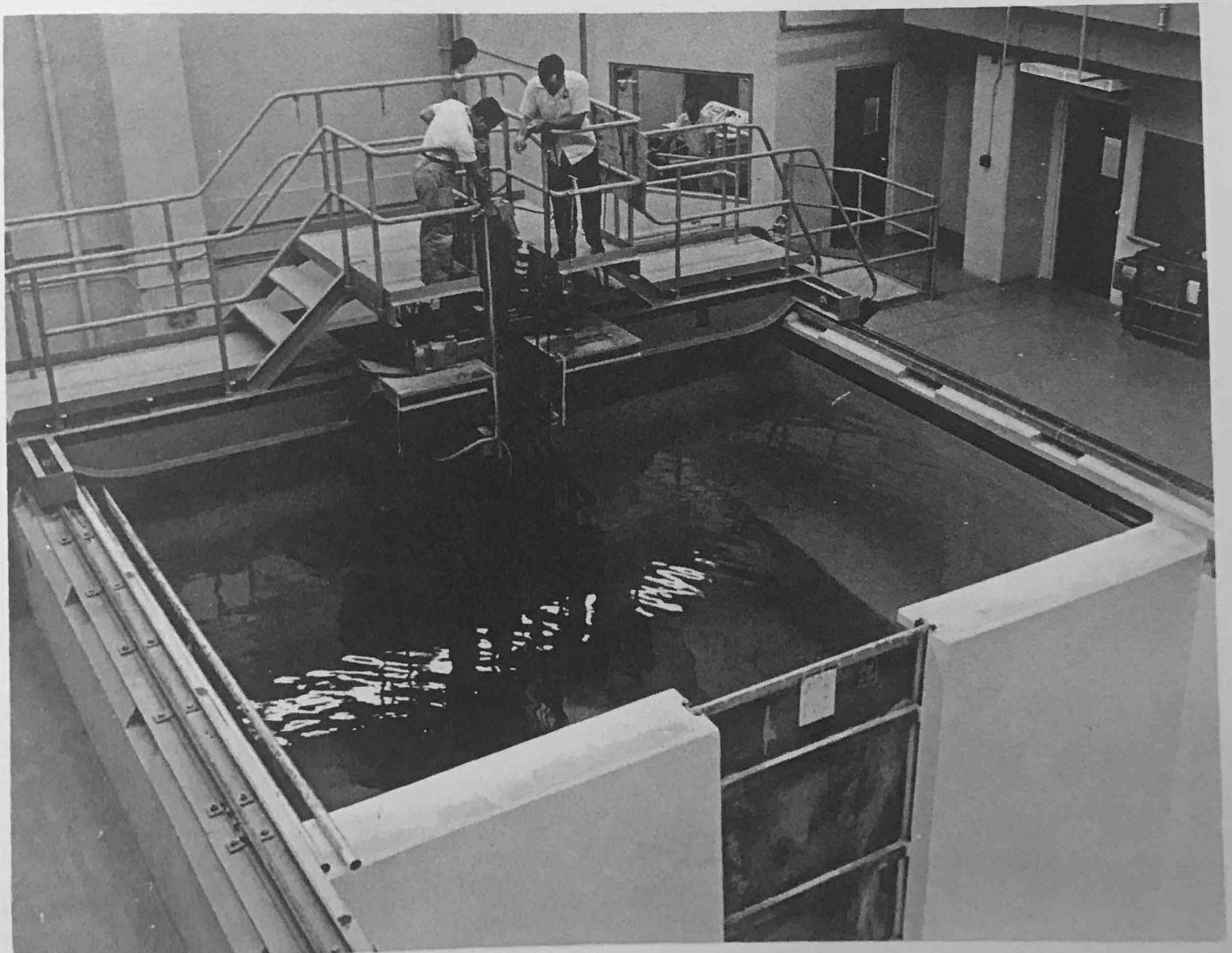
Control room for research reactor currently operating at one megawatt power level

NUCLEAR ENGINEERING DIVISION

This division was created in September, 1963, simultaneously with the establishment of the Department by the University. Educational opportunities are:

THESIS RESEARCH FOR M.S. DEGREE IN NUCLEAR ENGINEERING

The following graduate courses in Nuclear Engineering are available to students: Nuclear Reactor Technology, Nuclear Measurements and Instrumentation, Radiological Electronics, Reprocessing of Nuclear Materials, Reactor Instrumentation, Nuclear Reactor Metallurgy, Reactor Materials, Elementary and Advanced Reactor Theory, Nuclear Reactor Design, Radiation Shielding, and Radioisotopes in Engineering. The required thesis may be done at the Nuclear Center on a problem of mutual interest to the graduate student and his PRNC advisor.



, Research reactor pool and bridge from which the reactor core is suspended. Control room is visible in the background.

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Staff Publications

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Participation in Scientific Meetings

1958

<u>Author</u>	<u>Title</u>	<u>Place Presented</u>
Dr. Amador Cobas	Plans for a Health Physics Training Program at the Puerto Rico Nuclear Center	Symposium on Health Physics in Biology and Medicine- May, 1958 San Juan, Puerto Rico
Dr. Víctor Marcial	Cancer Morbidity in Puerto Rico	International Cancer Congress- July, 1958 London, England
	Cancer in the Puerto Rican Woman	Meeting of the Puerto Rico Medical Society- September 1958 San Juan, Puerto Rico
	The Importance of Cobalt Teletherapy in a Radiotherapy Department	Interamerican Congress of Radiology- Nov., 1958 Lima, Perú
	Cobalt Teletherapy in Cancer	Symposium on Health Physics in Biology and Medicine- May, 1958 San Juan, Puerto Rico

1959

Dr. Angel A. Cintrón Rivera	Hematology	2nd. Interamerican Atoms-for-Peace Symposium- May, 1959 Buenos Aires, Argentina
	Vitamin B-12 Absorption in Tropical Sprue	Regional Meeting of the American College of Physicians- Oct., 1959 San Juan, Puerto Rico
	Serium Electrophoretic Patterns in 1,100 cases of Schistosoma mansoni	56th Annual Meeting of the Medical Association of P.R.- Nov., 1959 San Juan, Puerto Rico

<u>Author</u>	<u>Title</u>	<u>Place Presented</u>
Dr. Juan D. Curet	The Absorption of Gamma and Beta Rays by Weakly Paramagnetic Substances	7th. Latin American Chemical Congress- April, 1959 Mexico City, Mexico
Dr. Víctor Marcial	Cancer of the Tongue	1st. Latin American Cancer Congress- October, 1959 Buenos Aires, Argentina
	Cancer Control in Puerto Rico- Ten Years Experience	56th. Annual Meeting of the Medical Association of P.R., Nov., 1959 San Juan, Puerto Rico
Mrs. Irma Rieckehoff Mrs. Consuelo Russo Dr. Juan D. Curet	The Demonstration of Chemical Principles by the Use of Radioisotopes	7th. Latin American Chemical Congress- April, 1959 Mexico City, Mexico
Dr. Fred V. Soltero	Training in Radio-chemistry in the Puerto Rico Nuclear Center	7th. Latin American Chemical Congress- April, 1959 Mexico City, Mexico
<u>1960</u>		
Dr. Ismael Almodóvar Mr. T.P. Kohman	The Thorium Isotopes Method for Dating Marine Sedimeters	Meeting of the American Chemical Society- September, 1960 New York
Dr. I. Almodóvar Rev. I. Cantarell	An Experimental Study of Fatigue in Photo-multipliers	Meeting of the American Chemical Society- September, 1960 New York
	A Practical Method for the Compensation of Fatigue Effects	Meeting of the American Chemical Society- September, 1960 New York
Dr. A.M. Andino Dr. A.L. Rodríguez	Radioactive Iodine Treatment in Hyperthyroidism	10th. Annual Meeting of the P.R. Chapter of the American College of Physicians- Oct., 1960 San Juan, Puerto Rico

<u>Author</u>	<u>Title</u>	<u>Place Presented</u>
Dr. Víctor Marcial	Treatment of Cancer of the Tongue	Sectional Meeting P.R. Chapter of the American College of Surgeons- August, 1960 San Juan, Puerto Rico
	Socio-economic Aspects of the Cancer Incidence in Puerto Rico	Conference on Society Culture and Health in the N.Y. Academy of Sciences- June, 1960 New York
Dr. Warren Miller Dr. Eddie Ortiz	Beta Spectra with a Plastic Scintillator	29th. Conference of the American Society of Physics Teachers- January, 1960 New York
	Instructional Laboratory Experiments with a Neutron Source	29th. Conference of the American Society of Physics Teachers- January, 1960 New York
	Compton Spectra	29th. Conference of the American Society of Physics Teachers - January, 1960 New York
Dr. A.L. Rodríguez Dr. Ernesto Marchand	Experience with and Integration of the Diodrast Renogram (a summary of the experience of 70 renograms)	10th. Annual Meeting of the P.R. Chapter of the American College of Physicians- Oct., 1960 San Juan, Puerto Rico
Dr. A.L. Rodríguez	Serial In-Vitro Uptake of Fe-59 by Bone Marrow Suspensions in Different Hematologic States	P.R. Medical Association Meeting- November, 1960 San Juan, Puerto Rico

1961

Dr. John C. Bugher	The Puerto Rico Nuclear Center Research Reactor: Characteristics and Program Plans	Symposium on the Programming and Utilization of Research Reactors- October, 1961 Vienna, Austria
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<u>Author</u>	<u>Title</u>	<u>Place Presented</u>
Rev. I. Cantarell Dr. Ismael Almodóvar	Fatigue in Photo-multiplier Tubes and its Relationship to the Matter Effect	Meeting of the American Nuclear Society- June, 1961 Pittsburg, Pennsylvania
Dr. John C. Bugher	Health Perspectives of our Radioactive World (The First Annual Bronfman Lecture)	2nd. General Session of the American Public Health Association, 89th. Annual Meeting, Nov., 1961 Detroit, Michigan
Dr. J.L. García de Quevedo	Education and Research Centers	IAEA, Regional Symposium on Education and Nuclear Energy- November, 1961 Bariloche, Argentina
Dr. Henry J. Gomberg	Fission, Fusion and Radiation Energy in a New Dimension	Samuel Sackett Series of Lectures on Nuclear Energy- October, 1961 Chicago, Illinois
Dr. Víctor Marcial	Cancer of the Esophagus	Annual Meeting P.R. Chapter of the American College of Surgeons- February, 1961 San Juan, Puerto Rico
	The Prognostic Value of Cytology in Cancer of the Cervix-Uteri	1st. National Cancer Congress- 7th Radiological Workshop- August, 1961 Bogotá, Colombia
	Radiotherapy for Advanced Cancer: Cancer Control Program in Puerto Rico	1st. National Cancer Congress- 7th Radiological Workshop- August, 1961 Bogotá, Colombia
	Cancer of the Tongue	American Roentgen Ray Society Meeting- Sept. 1961 Miami, Florida
	Carcinoma of the Esophagus	7th. Interamerican Congress of Radiology- September, 1961 Sao Paulo, Brazil

<u>Author</u>	<u>Title</u>	<u>Place Presented</u>
Dr. Víctor Marcial (Cont.)	Teletherapy Isotope	7th. Interamerican Congress of Radiology September, 1961 Sao Paulo, Brazil
	Cancer Control in Puerto Rico, Twelve Years Experience	National Cancer Insti- tute of Guatemala- November, 1961 Guatemala City
	Treatment of Cancer of the Tongue	12th. National Congress in Medicine of the Col- lege of Physicians and Surgeons of Guatemala- November, 1961 Guatemala City
	Cancer of the Esophagus	12th. National Congress in Medicine of the Col- lege of Physicians and Surgeons of Guatemala- November, 1961 Guatemala City
	Carcinoma of the Penis, Therapeutic Problems	Annual Meeting of the Radiological Society of North America- Nov., 1961 Chicago, Illinois
Mrs. Irma Rieckehoff	Common Ion Effect on Solubility- A Demons- tration with Radioisotopes	Caribbean Chemistry Conference- April, 1961 University College of the West Indies Kingston, Jamaica
Dr. A.L. Rodríguez	The Role of Calcium on the Intestinal Absorption of Vitamin B-12 in Tropical Sprue	2nd. Annual Meeting of the University of P.R., School of Medicine- June, 1961 San Juan, Puerto Rico
Dr. Edwin Roig	The Thallous-Thallic Exchange at Various Acidities in Perchlorate Media	Caribbean Chemistry Conference- April, 1961 University College of the West Indies Kingston, Jamaica

<u>Author</u>	<u>Title</u>	<u>Place Presented</u>
Dr. H.H. Szmant	Chemistry in Latin America	1st. Interamerican Cong. of Chemical Engineers October, 1961 San Juan, Puerto Rico
Dr. Howard J. Teas	Application of Atomic Energy in Agriculture	In response to joint invitation of AEC and the Governor of Nebraska- Oct., 1961 Lincoln, Nebraska
Dr. José M. Tomé	Carcinoma of the Anterior Two-Thirds of the Tongue	Annual Meeting of the P.R. Medical Association November, 1961 San Juan, Puerto Rico
Dr. Mario Vuksanovic Dr. J.A. del Regato	Carcinoma of the Skin Overlying Cartilage	Annual Meeting of the Radiological Society of N.A.- November, 1961 Chicago, Illinois
<u>1962</u>		
Mr. Héctor Barceló	Comparison of Rod Worth by Period and Analog Computer Methods	Conference on Light Water Moderated Research Reactors- June, 1962 Oak Ridge, Tennessee
	Elimination of Control Rod Vibration Caused by Water Flow	Conference on Light Water Moderated Research Reactors- June, 1962 Oak Ridge, Tennessee
Dr. Antonio Bosch	Effects of L-Triiodo-thyronine in Altering the Response of Kidneys to Cobalt-60 Irradiation	48th. Annual Meeting of the Radiological Society of N.A.- November, 1962 Chicago, Illinois
Dr. Malcolm Daniels	Photochemistry of Thymine Solutions	Colloquium on Photochemical Transformation of Natural Products, 2nd. Int. Symposium- Sept., 1962 Prague, Czechoslovakia
Dr. Juan Facetti	Distribution of Radioactive Antimony Formed by Nuclear Transformation in Antimony Oxides	Eastern Regional Meeting American Chemical Society November, 1962 Gatlinburg, Tennessee-

<u>Author</u>	<u>Title</u>	<u>Place Presented</u>
Dr. Henry J. Gomberg	Utilization of Nuclear Energy for Civilian Purposes	7th Convention of the PAU of Engineering Societies- Aug., 1962 San Juan, Puerto Rico
Dr. Sergio Irizarry	Case Report of Patient with Carcinoma of Thyroid Treated with I-131	59th. Meeting of the P.R. Medical Association November, 1962 San Juan, Puerto Rico
	The Use of Renogram in the Clinical Evaluation of Carcinoma of the Cervix Uteri	4th. Interamerican Symposium on the Peaceful Applic. of Nuclear Energy- April, 1962 Mexico City, Mexico
Dr. Francis K.S. Koo	Polygenic Variability Induced by Thermal Neutron Irradiation	Annual Meeting of the Radiation Research Soc. May, 1962 Colorado Springs, Colorado
Dr. Duane B. Linden	Effects of Ionizing Radiation on Paramutation	American Society of Agricultural Sciences October, 1962 Mayaguez, Puerto Rico
Dr. Frank G. Lowman	Accumulation of Radionuclides in Marine Plankton and their Passage through Food Chains	3rd. International Symposium on Water Pollution- Aug., 1962 Cincinnati, Ohio
Dr. Víctor Marcial Dr. Pablo L. Morales	Prognostic Factors in Cancer of the Esophagus	Annual Meeting of the Radiological Soc. of P.R. and the American College of Radiology- Feb., 1962 San Juan, Puerto Rico
Dr. Víctor Marcial	Cancer Mortality in Puerto Rico	59th. Annual Meeting P.R. Medical Assoc.- Nov., 1962 San Juan, Puerto Rico
Dr. Andrew Maretzki	Aspects of Ascorbic Acid Metabolism in Acerola	American Society of Agricultural Sciences October, 1962 Mayaguez, Puerto Rico
	Ascorbic Acid Synthesis	59th. Annual Meeting Puerto Rico Medical Association- Nov., 1962 San Juan, Puerto Rico

<u>Author</u>	<u>Title</u>	<u>Place Presented</u>
Dr. Vicente J. Medina	The Influence of Copper, Iron, and Form of Nitrogen on Mo ⁹⁹ Uptake in <i>Cajanus indicus</i>	American Society of Agricultural Sciences October, 1962 Mayaguez, Puerto Rico
Dr. Eddie Ortiz	Inelastic Scattering of Iron Using a Neutron Source	Meeting of the American Physical Society January, 1962 New York
Dr. Edwin Roig	The Thallous-Thallic Exchange at Various Acidities in Perchlorate Media	8th. Latin American Congress of Chemistry September, 1962 Buenos Aires, Argentina
Dr. H. Harry Szmant	Scientific Documentation in the Field of Chemistry	Seminar on Scientific Documentation in L.A. sponsored by UNESCO September, 1962 Lima, Perú
	The Structure of Beta-Hydroxysulfides Obtained by the Oxidative Addition of Thiols to Olefine	8th. Latin American Congress of Chemistry September, 1962 Buenos Aires, Argentina
	The Synthesis of Intramolecularly Coordinated Boron Compounds	8th. Latin American Congress of Chemistry September, 1962 Buenos Aires, Argentina
	Scientific and Technological Resources of Latin America	Seminar on Chemical Industry of L.A. and the Common Market, 8th. L.A. Congress of Chemistry September, 1962 Buenos Aires, Argentina
	The Scientific and Technological Resources of L.A. and the Alliance for Progress	The Johns Hopkins University- April, 1962 Baltimore, Maryland
Dr. William Stucki	An Investigation of the Carotenoid Pigments of <i>Achiote</i>	American Society of Agricultural Sciences October, 1962 Mayaguez, Puerto Rico

<u>Author</u>	<u>Title</u>	<u>Place Presented</u>
Dr. Howard J. Teas	Keto Acids in Some Tropical Plants	Annual Meeting of the Society for Economic Botany- June, 1962 Washington, D.C.
	Inhibition of Banana Fruit Ripening by Gamma Radiation	2nd. International Congress of Radiation Research- Aug., 1962 Harrogate, England
Dr. José M. Tomé	Hodgkin's Disease: Our Experience at the Dr. I. González Martínez Oncologic Hospital	59th. Annual Meeting Puerto Rico Medical Association- Nov., 1962 San Juan, Puerto Rico
Dr. Jeanne Ubiñas	Carcinoma of the Tonsil	Annual Meeting of the Radiological Society of P.R. and the American College of Radiology February, 1962 San Juan, Puerto Rico
Dr. John Villella	Immune Responses to Irradiated Cercariae of Schistosoma Mansoni	American Society of Parasitologists and the Helminthological Society- June, 1962 Washington, D.C.
Dr. J.A. Wethington	Dosimetry from Photon Spectra and Pulse-Height Distributions	2nd. International Congress of Radiation Research- Aug., 1962 Harrogate, England
<u>1963</u>		
Dr. Ismael Almodóvar	A Neutron Diffraction Refinement of the Ca WO ₄ Structure	International Union of Crystallography- September, 1963 Rome, Italy
	Method for the Isolation of Thorium from Siliceous Materials	2nd. Caribbean Chemical Symposium- August, 1963 Río Piedras and Mayaguez, Puerto Rico
	New Results in the Search for Alpha Particles from the Thermal Neutron-Induced U ²³⁸ (n, α) Th ²³⁵ Reaction	Physics Department of the University of Bonn September, 1963 Bonn, Germany

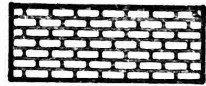
<u>Author</u>	<u>Title</u>	<u>Place Presented</u>
Dr. Ismael Almodóvar Rev. Ignacio Cantarell Dr. Helmut Bielen	Search for Alpha Particles from Thermal Neutron- Induced U^{238} (n,) Th^{235} Reaction	2nd. Caribbean Chemical Symposium- August, 1963 Río Piedras and Mayaguez, Puerto Rico
Dr. Helmut Bielen	Determination of Dis- sociation Vapour Pressure and Structure of Some Heavy Metal Sulfides	2nd. Caribbean Chemical Symposium- August, 1963 Río Piedras and Mayaguez, Puerto Rico
Dr. John C. Bugher	Nuclear Centers in Latin America: their part in Scientific Development	Study Group Meeting on Research Reactor Utilization
Rev. Ignacio Cantarell Dr. Julio A. Gonzalo	Transient Radiation Effects on Electron Emission of High- Resistivity Layers	American Nuclear Soc. November, 1963 New York
Rev. Ignacio Cantarell	Time-Dependent Schottky Emission in Photomulti- plier Tubes	American Nuclear Soc. November, 1963 New York
Dr. Malcolm Daniels Dr. Alec Grimison	Photochemistry of Thymine	2nd. Caribbean Chemical Symposium- August, 1963 Río Piedras and Mayaguez, Puerto Rico
Dr. B. Chalmers Frazer	Magnetic Ordering in Some Related Orthorhombic Cmcm and Pnma Structures	Symposium on Ferro- Magnetism and Ferro- electricity, June, 1963 Leningrad, Russia
Dr. Sergio Irizarry	Fat Absorption Study with $I-131$ Labelled Oleic Acid in Patients with Cancer of the Uterine Cervix Receiving Cobalt Radiation to the Abdomen	Thirty Second Annual Meeting of the P.R. Dietetic Association June, 1963 San Juan, Puerto Rico
Dr. Mortimer Kay	Neutron Diffraction Studies at the Puerto Rico Nuclear Center	International Collo- quium of Neutron Dif- fusion and Diffraction September, 1963 Grenoble, France

<u>Author</u>	<u>Title</u>	<u>Place Presented</u>
Dr. Francis K.S. Koo	Actions of 5-Bromouracil Deoxyriboside on Plant Chromosomes	11th. International Congress of Genetics September, 1963 Scheveningen, The Netherlands
Dr. Duane B. Linden	Effects of Radiation on Paramutation	11th. Annual Meeting of the Radiation Re- search Society May, 1963 Milwaukee, Wisconsin
	Radiation Induced Modi- fication of Paramutation Expression	11th. International Congress of Genetics September, 1963 Scheveningen, The Netherlands
Dr. Duane B. Linden Mr. José Cuevas Mr. Vicente Rodrí- guez	Uses of the PRNC Gamma Irradiation Facility in Agricultural Research	Fall Meeting of the American Society of Agricultural Sci- ences- Oct., 1963 Mayaguez, Puerto Rico
Dr. Frank G. Lowman	Activation Analysis Method for Scandium, Antimony, and Phosphorus	2nd. Caribbean Chem- ical Symposium August, 1963 Río Piedras and Ma- yaguez, Puerto Rico
Dr. Robert A. Luse Dr. Henry J. Gomberg	Resonance Radiation Ef- fects of Low-Energy Monochromatic X-rays on Catalase	11th. Annual Meeting of the Radiation Re- search Society May, 1963 Milwaukee, Wisconsin
	Resonance Radiation Ef- fects of Low-Energy Monochromatic X-rays on the Mettaloenzyme Catalase	2nd. Caribbean Chem- ical Symposium August, 1963 Río Piedras and Ma- yaguez, Puerto Rico
Dr. Robert A. Luse	Basic Mechanisms in the Radiation Chemistry of Proteins and Nucleic Acids in Aqueous Media	Conference on Basic Mechanisms in the Radiation Chemistry of Aqueous Media May, 1963 Gatlinburg, Tennessee

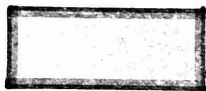
<u>Author</u>	<u>Title</u>	<u>Place Presented</u>
Dr. Víctor Marcial	Cancer of the Penis	9th. Congress of the Pan Pacific Surgical Association November, 1963 Honolulu, Hawaii
Dr. Víctor Marcial Dr. José Tomé	Radiotherapy in Carcinoma of Cervix Uteri	Annual Meeting of the Western Branch of the P.R. Medical Association- April, 1963 Mayaguez, Puerto Rico
Dr. Fausto J. Muñoz Ribadeneira Miss Milagros Miró	Effect of Copper Sulfate on the Ceric Dosimetry System	2nd. Caribbean Chemical Symposium- August, 1963 Río Piedras and Mayaguez, Puerto Rico
Dr. Eddie Ortiz Dr. Juan Facetti	High Energy Gamma Photons- Neutron Conversion Device for Half-Life Measurements	American Physical Soc. January, 1963 New York
Dr. H. Harry Szmant Mr. E.P. Olavarría	Base-catalyzed Formation of Imidates	2nd. Caribbean Chemical Symposium- August, 1963 Río Piedras and Mayaguez, Puerto Rico
Dr. H. Harry Szmant Dr. Edwin Roig Mr. Raúl H. Figueroa	Association Constants for Sulfoxide-Phenol Complexes	2nd. Caribbean Chemical Symposium- August, 1963 Río Piedras and Mayaguez, Puerto Rico
Dr. David Walker Mrs. Adela Alemañy	Longevity of Adult <u>Diatrea saccharalis</u> (Fab.) Crambinae, Pyralididae, Lepidoptera	Fall Meeting of the American Society of Agricultural Sciences- Oct., 1963 Mayaguez, Puerto Rico
Dr. David Walker	Mating Behavior and Fecundity of <u>Diatrea saccharalis</u>	Entomological Society of America Meeting December, 1963 St. Louis, Missouri
	Mating Behavior of the Sugar-Cane Borer, <u>Diatrea saccharalis</u> (Fab.) Crambinae, Pyralididae, Lepidoptera	Fall Meeting of the American Society of Agricultural Sciences- Oct., 1963 Mayaguez, Puerto Rico

<u>Author</u>	<u>Title</u>	<u>Place Presented</u>
Dr. David Walker Mr. Miguel Figueroa	Oviposition by <u>Diatrea saccharalis</u> (Fab.) Crambinae, Pyralididae, Lepidoptera	Fall Meeting of the American Society of Agricultural Sciences October, 1963 Mayaguez, Puerto Rico
Dr. M.P. Weinbren	Rift Valley Fever and Nairobi Sheep Disease	7th International Cong. of Tropical Medicine and Malaria September, 1963 Rio de Janeiro, Brazil
Dr. Owen H. Wheeler Mrs. E. Granell de Rodríguez	Acid-catalyzed Solvolysis of Some Substituted - γ - Butyrolactones and - γ - Valerolactones	2nd. Caribbean Chemical Symposium- August, 1963 Rio Piedras and Maya- guez, Puerto Rico
Dr. Owen H. Wheeler Mr. D. González	Oxidation of Primary Aromatic Amines with Manganese Dioxide	2nd. Caribbean Chemical Symposium- August, 1963 Rio Piedras and Maya- guez, Puerto Rico

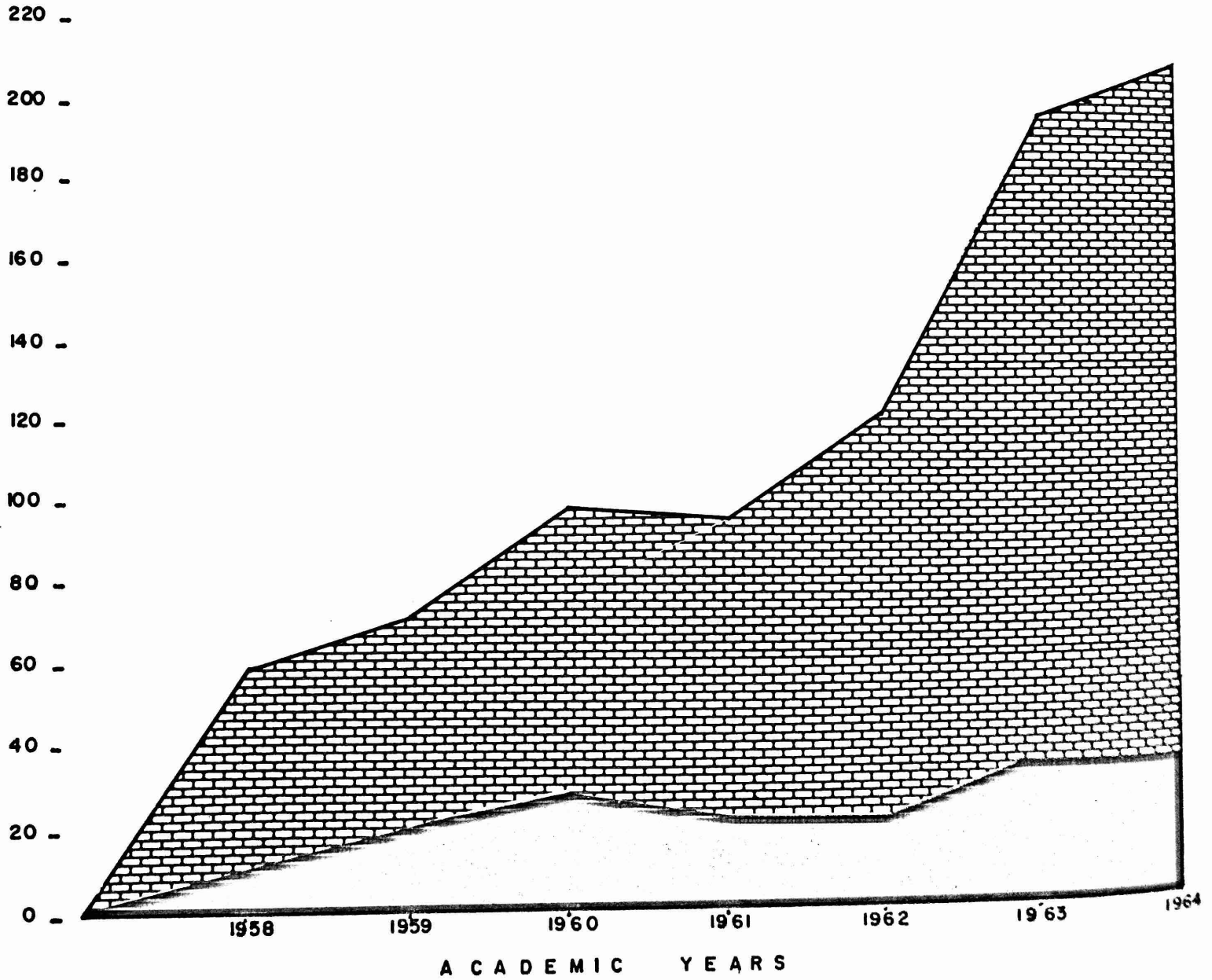
STUDENTS TRAINED AT PRNC



U. S.



NON-U. S.



Student Statistics

FY 1958 - FY 1964

COUNTRY	'58	'59	'60	'61	'62	'63	'64	TOTAL
Argentina	1	-	2	1	4	1	2	11
Bolivia	1	-	-	-	1	4	1	7
Chile	1	1	2	2	-	-	1	7
Colombia	1	5	3	6	3	6	7	31
Costa Rica	-	2	-	-	-	-	1	3
Cuba	-	1	3	-	-	-	3	7
Ecuador	3	-	1	1	-	-	1	6
El Salvador	-	-	1	-	1	1	2	5
Great Britain	-	-	-	-	1	-	1	2
Guatemala	-	-	-	1	-	1	2	4
Haiti	-	-	1	-	-	-	-	1
India	1	-	-	-	1	-	-	2
Japan	-	-	-	-	-	-	1	1
Mexico	-	5	1	1	2	1	3	13
Nicaragua	-	-	1	1	-	-	-	2
Panama	-	-	-	-	-	1	1	2
Paraguay	-	-	-	-	1	3	2	6
Peru	-	1	3	1	1	1	5	12
Philippine Islands	1	-	-	-	-	-	-	1
Santo Domingo	-	-	1	-	-	14	1	16
South Africa	-	-	-	-	1	-	-	1
Spain	-	1	3	3	3	2	1	13
Uruguay	-	1	1	1	-	1	-	4
Venezuela	-	3	4	3	2	-	-	12
<hr/>								
Total Non-U.S. Citizens	9	20	27	21	21	36	35	169
U.S. Citizens	50	52	71	74	101	161	176	687
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TOTAL STUDENTS	59	72	98	95	122	197	211	856

PRNC EXPENDITURES FY 1958-1964

Program 07 - Training and Education

Quarter	FY - 1958			FY - 1959			FY - 1960			FY - 1961		
	Operations	Equipment	Total	Operations	Equipment	Total	Operations	Equipment	Total	Operations	Equipment	Total
1st	-	-	-	\$ 40,290	\$ 3,274	\$ 43,564	\$ 82,340	\$ 29,992	\$ 112,332	\$ 148,249	\$ 4,276	\$ 152,525
2nd	\$ 30,267	-	\$ 30,267	59,253	31,651	90,904	91,699	15,513	107,212	165,737	3,360	169,097
3rd	43,097	\$ 16,094	59,191	76,401	4,251	80,652	107,163	12,065	119,228	173,633	14,934	188,567
4th	45,704	24,458	70,162	107,236	187,017	294,253	169,061	165,036	334,097	266,145	166,113	432,258
Total	\$ 119,068	\$ 40,552	\$ 159,620	\$ 283,180	\$ 226,193	\$ 509,373	\$ 450,263	\$ 222,606	\$ 672,869	\$ 753,764	\$ 188,683	\$ 942,447

Quarter	FY - 1962			FY - 1963			FY - 1964		
	Operations	Equipment	Total	Operations	Equipment	Total	Operations	Equipment	Total
1st	\$ 244,338	\$ 26,317	\$ 270,655	\$ 362,497	\$ 66,002	\$ 428,499	\$ 305,793	-	\$ 305,793
2nd	316,422	28,758	345,180	308,614	37,362	345,976	274,798	-	274,798
3rd	317,333	30,222	347,555	262,864	5,730	268,594	287,683	-	287,683
4th	330,500	12,108	342,608	247,067	116,301	363,368	237,723	\$ 70,000	307,723
Total	\$ 1,208,593	\$ 97,405	\$ 1,305,998	\$ 1,181,042	\$ 225,395	\$ 1,406,437	\$ 1,105,997	\$ 70,000	\$ 1,175,997

Program 06 - Biology and Medicine

Quarter	FY - 1962			FY - 1963			FY - 1964		
	Operations	Equipment	Total	Operations	Equipment	Total	Operations	Equipment	Total
1st	-	-	-	\$ 21,149	\$ 8,337	\$ 29,486	\$116,246	-	\$116,246
2nd	-	-	-	30,460	(1,561)	28,899	147,877	-	147,877
3rd	-	-	-	54,854	2,482	57,336	141,953	-	141,953
4th	\$31,503	\$67,146	\$98,649	111,384	166,312	277,696	118,922	\$78,000	196,922
Total	\$31,503	\$67,146	\$98,649	\$217,847	\$175,570	\$393,417	\$524,998	\$78,000	\$602,998

Program 05 - Physical Sciences

Quarter	FY - 1962			FY - 1963			FY - 1964		
	Operations	Equipment	Total	Operations	Equipment	Total	Operations	Equipment	Total
1st	-	-	-	-	-	-	\$ 23,241	-	\$ 23,241
2nd	-	-	-	-	-	-	24,786	-	24,786
3rd	-	-	-	\$15,033	\$ 28,663	\$ 43,696	57,630	-	57,630
4th	-	-	-	23,812	71,632	95,444	41,005	\$16,000	57,005
Total	-	-	-	\$38,845	\$100,295	\$139,140	\$146,662	\$16,000	\$162,662

EMPLOYMENT STATISTICS

Program 07 - Training & Education
 Program 06 - Biology & Medicine
 Program 05 - Physical Sciences

	FY-1958	FY-1959	FY-1960	FY-1961
Category	Program 07	Program 07	Program 07	Program 07
Scientific	19	16	21	25
Technical	12	23	31	37
Other	7	16	25	28
Administrative	5	8	10	30
Total	43	63	87	120

	FY-1962		FY-1963		FY-1964	
Category	Program 07	Programs 05 & 06	Program 07	Programs 05 & 06	Program 07	Programs 05 & 06
Scientific	48	1	33	21	45	16
Technical	71	3	71	21	62	24
Other	53	1	31	8	54	19
Administrative	41	0	41	0	40	0
Total	213	5	176	50	201	59