PRNC-211

SELECTED INFORMATION
on
PUERTO RICO NUCLEAR CENTER

for
Information Meeting
U. S. Atomic Energy Commission
Washington, D.C.
March 9, 1970

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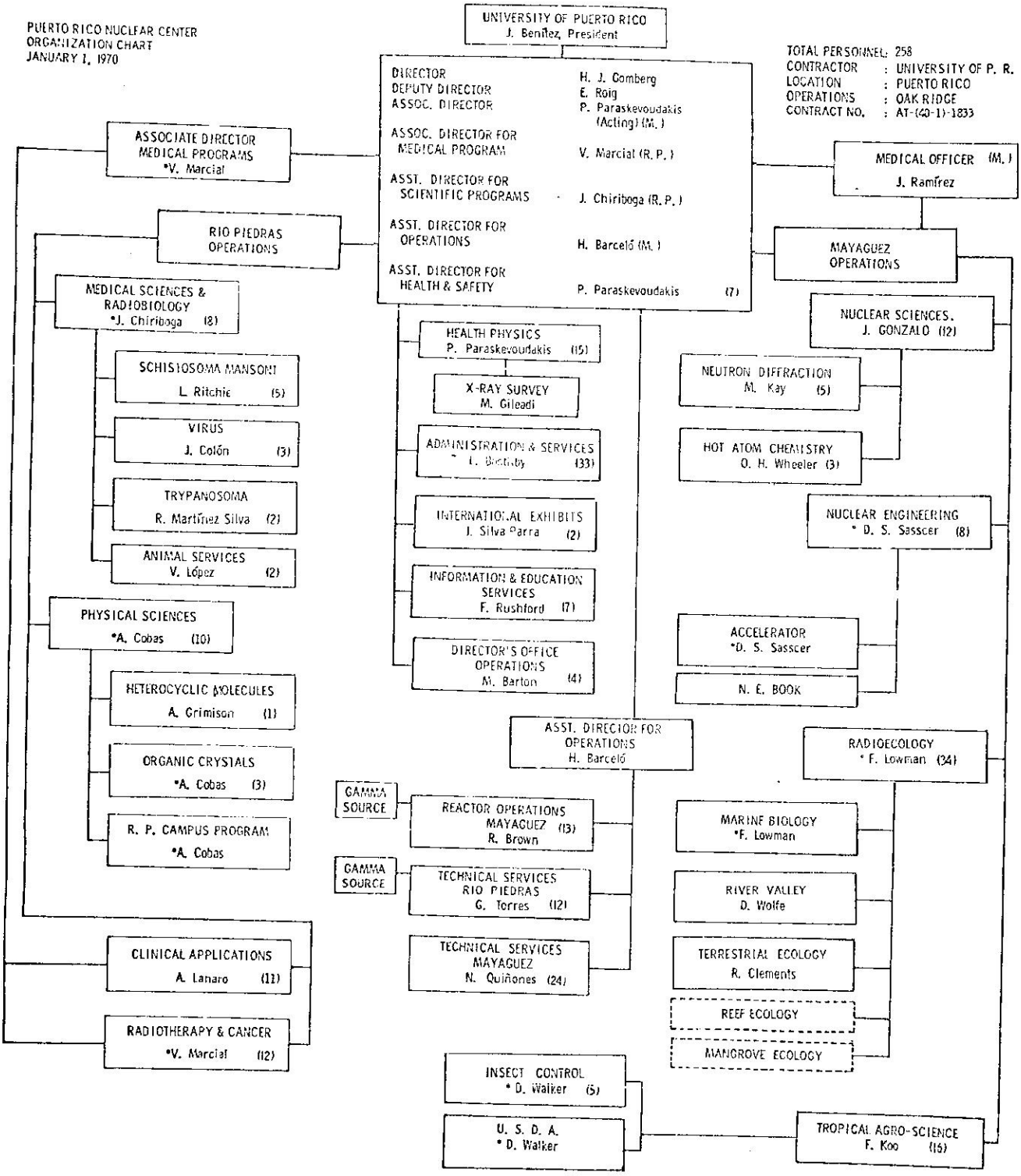
Abstracts

PUERTO RICO NUCLEAR CENTER
ORGANIZATION CHART
JANUARY 1, 1970



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AREA MANAGER
PUERTO RICO AREA OFFICE

* Multiple Function
---- Planned Projects

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DIRECTOR
PUERTO RICO NUCLEAR CENTER

PRNC EDUCATIONAL ACTIVITY — FY 1958 through FY 1970*

Fiscal Years	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Non-U.S. Students	10	18	27	17	21	32	35	13	32	37	46	50	50
U.S. Students	50	52	82	74	101	161	176	198	141	199	167	149	150
Total Students	60	70	109	91	122	193	211	211	173	236	213	199	200
Total Students Months	171	241	443	418	777	735	994	1505	1232	1493	1034	822	900
Student-Months for Non-U.S. Students	27	44	69	84	42	71	144	56	96	139	232	248	300
Average Residence time for Non-U.S. Students(months)	2.7	2.4	2.5	4.9	2.0	2.2	4.1	4.3	3.0	3.8	5.0	5.0	6.0

* estimated, February 26, 1970

TABLE SHOWING PRNC STUDENTS BY COUNTRY *

From FY—1958 through FY—1970 **

Country	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970 **	Total
Argentina	1	—	2	1	4	1	2	—	4	1	1	3	3	23
Barbados	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Bolivia	1	—	—	—	1	4	1	—	—	1	1	—	—	9
Brazil	—	—	—	—	—	—	—	—	—	1	1	1	—	3
Chile	1	1	2	2	—	—	1	1	2	4	4	3	1	22
Colombia	1	5	3	6	3	6	7	4	4	5	4	8	8	64
Costa Rica	—	2	—	—	—	—	1	—	—	2	1	1	1	8
Cuba	—	1	3	—	—	—	3	1	1	—	—	2	1	12
Dominican Republic	—	—	1	—	—	14	1	1	2	2	5	6	4	36
Ecuador	3	—	1	1	—	—	1	1	1	2	1	3	2	16
El Salvador	—	—	1	—	1	1	2	—	1	2	1	—	—	9
Formosa	—	—	—	—	—	—	—	1	3	2	6	—	—	12
Germany	—	—	—	—	—	—	—	—	1	1	—	—	—	2
Great Britain	—	—	—	—	1	—	1	—	1	1	1	—	—	5
Greece	—	—	—	—	—	—	—	—	—	—	—	—	2	2
Guatemala	—	—	—	1	—	1	2	—	—	—	2	2	1	9
Haiti	—	—	1	—	—	—	—	—	—	—	—	—	—	1
Hungary	—	—	—	—	—	—	—	—	—	—	1	—	—	1
India	1	—	—	—	1	—	—	—	—	3	4	—	1	10
Israel	—	—	—	—	—	—	—	—	—	—	1	1	1	3
Japan	—	—	—	—	—	—	1	—	—	—	—	—	—	1
Korea	—	—	—	—	—	—	—	—	—	—	—	2	—	2
Lebanon	—	—	—	—	—	—	—	—	—	1	1	—	—	2
Liberia	—	—	—	—	—	—	—	—	—	1	1	1	—	3
Mexico	—	5	1	1	2	1	3	2	—	1	2	1	2	21
Nicaragua	—	—	1	1	—	—	—	—	—	1	2	2	3	10
Panamá	—	—	—	—	—	1	1	—	—	—	—	1	—	3
Paraguay	—	—	—	—	1	3	2	—	—	—	—	3	2	11
Peru	—	1	3	1	1	1	5	—	1	—	3	2	—	18
Philippine Islands	1	—	—	—	—	—	—	—	2	1	1	1	—	6
South Africa	—	—	—	—	1	—	—	—	—	—	—	—	—	1
Spain	—	1	3	3	3	2	1	—	2	—	2	2	2	21
Thailand	—	—	—	—	—	—	—	—	—	—	—	2	—	2
Turkey	—	—	—	—	—	—	—	—	—	—	1	—	—	1
United Arab Republic	—	—	—	—	—	—	—	—	1	—	—	—	—	1
Uruguay	—	1	1	1	—	1	—	1	1	1	—	1	1	9
Venezuela	—	3	4	3	2	—	—	1	2	3	3	2	1	24
TOTAL NON-U.S CITIZENS	9	20	27	21	21	36	35	13	32	37	46	50	37	384
TOTAL U.S. CITIZENS	50	52	71	74	101	161	176	198	141	199	167	149	124	1663
TOTAL STUDENTS	59	72	98	95	122	197	211	211	173	236	213	199	161	2047

* A student is counted once each Fiscal Year he is in training

** Incomplete. Tabulated February 3, 1970 by the Information and Education Services Division

PUERTO RICO NUCLEAR CENTER
Thesis Research in Progress
February 1970

Medical Sciences and Radiobiology Division

1. Gualberto L. Borrero (Puerto Rico - USA), "The effect of ionizing radiation on the latency of Sinbis Virus Wild Type".

Tropical Agro-Sciences Division

1. Isabel Bulla (Colombia), Effects of gamma rays on isozyme patterns of malate and glucose -6- phosphate dehydrogenases in soybean seedlings.

2. Carmen Baerga Santini (Puerto Rico-USA), Combined mutagenic effect of soft x-rays and nucleoside analogues in histidine operon of *Escherichia coli* strain C.

3. Carmen Elena Cintrón (Puerto Rico-USA), The Effect of Temperature of the Mitotic Cycle in *Vicia faba.*

4. Aida Roca de Mari (Puerto Rico-USA), Effect of Gamma Radiation on the Peroxidase Effect Isoenzymes of Glycine Max (Soybean)

5. Oscar Aragón (Nicaragua), Complimentary Effects of Ionizing Radiation and the Lipoxidase Activity on Fatty Acids of Soybean.

Nuclear Science Division

Chemistry

1. Manuel Lagunas (Chile), Radiolysis of organic compounds in aqueous solution.

2. E. Lyons (USA), Radiation protection studies by ESR.

3. Nelson Peña (Panamá), Recoil Reactions of tritium in liquid organic acids.

4. José Sequeira Sevilla (Dominican Republic), Radiolysis of organic nitrogen compounds.

Physics

1. Genaro Coronel (Paraguay), Critical behavior of the specific heat anomaly in ferroelectric TGS.

2. Carlos Basora (Puerto Rico-USA), High frequency behavior of ferroelectric Rochelle Salt.

3. Luis C. Hernandez (Colombia), ESR spectra from ferroelectrics.

Physical Sciences Division

Physics

1. Julio Alberto Mainardi (Argentina), Annealing of singlet quenching centers induced by gamma radiation in anthracene crystals.

2. Leon Pereira (Colombia), Determination of free-hole trapped electron interaction rate constant in anthracene crystals.

3. Lisandro Vargaz Zapata (Colombia), Study of radiation induced electron traps in anthracene crystals.

4. Fernando Guerrero Vargas (Colombia), The Double Injections in Anthracene Crystals.

Chemistry

1. Elsa Gómez Audrines (Puerto Rico-USA), The relationship between quenching in liquid scintillation counting and chemical structure. (She uses ^{14}C as a β emitter)

2. Hilda Aledo (Puerto Rico-USA), The relationship between quenching in liquid scintillation counting and chemical structure (She uses ^{139}Ce as an internal conversion electrons emitter)

3. Sonia Vázquez (Puerto Rico-USA), Metallic complexes of heterodihydroanthracenes.

4. Agnes Costa (Puerto Rico-USA), Tritium recoil labeling of lithium organic salts: radiochemical yield and molecular distribution of the labeling.

5. Rafael Pereira (Colombia), Tritium recoil labeling of lithium salts: retention vs. inversion in hot atom substitution.

6. Juanita Freer Calderón (Costa Rica), A rearrangement in the chromic acid oxidation of arylethanes.

Nuclear Engineering Division

1. Rafael Alcalá (Puerto Rico-USA), Measurement of Reactor Shutdown Reactivities by the Asymmetric Source Method.

2. Antonio Castro (Puerto Rico-USA), Study of Gas Production in Irradiated Barytes-Boron Concrete as a Function of Temperature.

3. Braulio Mejía (Puerto Rico-USA), Instrumental Methods in Neutron Activation Analysis.

4. Fernando E. Plá (Puerto Rico-USA), Effect of Gamma Radiation on Organic Materials in Aqueous Solution.

Health Physics Division

Health Physics

1. Efigenio Rivera (Puerto Rico-USA), Measurement of Neutron Spectra of the PRNC IMW Reactor.

Radiobiology

1. Jorge Pérez Rivera (Puerto Rico, USA), Possibilities of the Existence of HRP(Horseradish Peroxidase) Molecule in a Partially Damaged Condition.

PUERTO RICO NUCLEAR CENTER — STUDENT ECONOMIC AID PROGRAM — FISCAL YEAR 1969 $10,000 Grant February 1st, 1970.

NAME	COUNTRY	TYPE OF TRAINING	DIVISION — LOCATION	INCLUSIVE DATES	AMOUNT ASSIGNED
1-Francisco Bernasconi	Chile	MS Degree in Chemistry	Physical Sciences - RP	Jan 1—Mar 31, 1969	$ 500.02
2-Isabel Bulla	Colombia	MS Degree in Biology	Agricultural Bio-Sciences - RP	June 15—30, 1969	100.00
3-Genaro Coronel Martinez	Paraguay	MS Degree in Physics	Nuclear Science - M	Jan 1-June 30, 1969	1,350.00
4-Francisco Hernandez	Dominican Republic	MS Degree in Electrical Engineering	Nuclear Science - M	" " "	1,000.00
5-Antonio Mock	Panamá	MS Degree in Physics	Nuclear Science - M	" " "	1,000.00
6-Laureano Niño	Colombia	MS Degree in Physics	Nuclear Science - M	" " "	1,000.00
7-Rafael Pereira Ramos	Colombia	Tritium Labeling Studies	Physical Sciences - RP	Mar 15-June 30,1969	700.00
8-Emilio A. Reyes Villar	Dominican Republic	Radioisotope Techniques Clinical Applications of Radioisotopes	Physical Sciences - RP Clinical Applications-RP	Mar 1-May 31, 1969	600.00
9-Juan B. Reñe	Argentina	Short Term Radiation Therapy	Radiotherapy and Cancer-RP	Mar 1-Aug 31, 1969	1,275.00
10-Reinerio Rodrĭguez-Fernandez	Spain	Radioisotope Techniques Clinical Applications of Radioisotopes	Physical Sciences - RP Clinical Applications - RP	June 1-30, 1969	225.00
11-Carlos Roldán	Argentina	Radioisotope Techniques Clinical Applications of Radioisotopes	Physical Sciences - RP Clinical Applications - RP	Mar 1-May 31, 1969	650.00
12-Angela Eugenia Vallejos	Paraguay	Hot Atom Chemistry	Nuclear Sciences - M	Jan 1-June 30, 1969	1,350.00
				TOTAL	$9,780.02

PUERTO RICO NUCLEAR CENTER — STUDENT ECONOMIC AID PROGRAM — FISCAL YEAR 1970 $10,000 Grant February 1st, 1970.

NAME	COUNTRY	TYPE OF TRAINING	DIVISION — LOCATION	INCLUSIVE DATES	AMOUNT ASSIGNED
1.Laureano Niño	Colombia	MS Degree in Physics	Nuclear Science — M	July 1-Aug 31, 1969	350.00
2.Antonio Mock	Panama	MS Degree in Physics	Nuclear Science — M	July 1-31, 1969	175.00
3.Reinerio Rodríguez Fernández	Spain	Radioisotope Tech., Clinical Applications	Physical Sciences — RP Clinical Applications — RP	July 1-Sep 30, 1969	675.00
4.Eduardo Rodriguez-Maisano	Argentina	Clinical Applications	Clinical Applications —RP	Jan 1-Feb 28, 1970	450.00
5.Nelson Peña Suarez	Dominican Republic	MS degree in Chemistry	Nuclear Science — M	July 1-Dec 31, 1969	1,200.00
6.Luis Carlos Hernández Pardo	Colombia	MS Degree in Physics	Nuclear Science — M	July 1-Dec 31, 1969	1,200.00
7.José E. Sequeira Sevilla	Nicaragua	MS Degree in Chemistry	Nuclear Science — M	July 1-Dec 31, 1969	1,200.00
8.Isabel Bulla	Colombia	MS Degree in Biology	Agricultural Bio-Sciences — RP	July 1, 1969 - June 30, 1970	1,775.00
9.Leo Moseley	Barbados	Neutron Diffraction	Nuclear Science — M	July 1-15, 1969	150.00
10.Ricardo F. Gerdingh Landin	Mexico	MS Degree in Radiological Health	Health Physics — RP	Aug 1-Sept 30,1969	400.00
11.Juan B. Reñe	Argentina	Radiotherapy Training	Radiotherapy and Cancer — RP	Sept 1-Oct 31, 1969	400.00
12.Alberto Palma Bonilla	Ecuador	Radioisotope Tech., Clinical Applications Renal and Brain Scanning,	Physical Sciences — RP Clinical Applications — RP	Dec 1, 1969 - May 31, 1970	1,350.00
		Pharmaceutical Labeling, Radiotherapy	" " " Nuclear Science — M		
13.Ana María Revollo	Bolivia	Radioisotope Techniques Clinical Applications	Physical Sciences — RP Clinical Applications — RP	March 1-May 31,1970	675.00
				TOTAL	$10.000.00

OAS REGIONAL SCIENTIFIC AND TECHNOLOGICAL PROGRAM * — Puerto Rico

February 1st. 1970.

NAME	COUNTRY	TYPE OF TRAINING	DIVISION — LOCATION	INCLUSIVE DATES
1. Manuel Lagunas	Chile	Radiolysis of aquatic solutions containing sulfurorganic compounds Chemistry	Nuclear Sciences — Mayaguez	July 1, 1969—
2. Angela Eugenia Vallejos	Paraguay	Hot Atom Chemistry Research	Nuclear Sciences — Mayaguez	July 1, 1969—
3. Oscar Aragón	Nicaragua	MS Degree in Chemistry	Nuclear Sciences — Mayaguez	July 1, 1969—
4. Genaro Coronel Martínez	Paraguay	MS Degree in Physics	Nuclear Sciences — Mayaguez	July 1, 1969 —
5. Julio Alberto Mainardi	Argentina	MS Degree in Physics	Physical Sciences — Rio Piedras	July 1, 1969 —
6. Rafael Pereira Ramos	Colombia	MS Degree in Chemistry -Tritium Labeling	Physical Sciences — Rio Piedras	July 1, 1969 —
7. Juanita Freer Calderón	Costa Rica	MS Degree in Chemistry	Physical Sciences — Rio Piedras	July 26, 1969 —
8. León Pereira	Colombia	MS Degree in Physics	Physical Sciences — Rio Piedras	August 6, 1969 —
9. Lisandro Vargas Zapata	Colombia	MS Degree in Physics	Physical Sciences — Rio Piedras	August 13, 1969—
10. Ricardo Gerdingh Landín	Mexico	MS Degree in Radiological Health	Health Physics — Rio Piedras	Oct. 1, 1969 —

* Present program is limited by OAS to physical sciences and biology.

Tropical Agro-Sciences Division

This division offers courses in agricultural research and biology at UPR Río Piedras and Mayaguez. In 1969, five graduate students were doing thesis research under the staff's supervision.

PRNC's special training--particularly in food irradiation--has attracted students and scientists from Thailand, Mexico and Guatemala.

The long-range research goal is to help improve diet conditions in tropical areas, such as the Caribbean and South America. A mutation breeding study of the soybean aims to obtain strains of high yield and protein content which adapt well to the tropics. Food irradiation studies are directed at prolonging the shelf-life of such diet and market staples as the papaya, mango and plantain. A sugarcane borer program explores methods to eliminate this pest from cane fields by mass releases of insects which have been sterilized by radiation (the present concentration is on inherited sterility effects). In studies of resonance radiation effect, target atom irradiation used in combination with other principles has been tested for possible control of mutation induction in higher plants(as of late 1969, results appeared to be affirmative).

Future plans include fertility studies in highly leached soils and the relation to crop production; livestock feeding and heat tolerance; low radiation dose effect on crop production; nitrogen fixation of leaf epiphytes of coffee, citrus, banana, plantain, guava, and pineapple plants.

On an international basis, planned programs include broadening cooperation with ICAITI of Guatemala, extending to food preservation other than fruits, insect control in hide cattle, and to organize programs in several areas with Guatemala's National Institute of Nuclear Studies. Soils studies and mutation breeding in the vast Llanos areas of Colombia are planned, in cooperation with Colombian scientists and the government.

Clinical Radioisotopes Applications Division

Located in PRNC's Río Piedras installation, this division trains physicians and allied medical personnel in the diagnostic and therapeutic uses of radioisotopes in humans.

During the past year, two types of courses were offered: a training course for Medical Technologists, with 43 students; a Clinical Applications Course, with 7 students. This training drew students from a broad geographic area.

Clinical research focuses upon the use of radioisotopes to study thyroid disorders, such as the application of minimum doses of I-131 to control hyperthyroid states, and the study of the effect of external irradiation on thyroid function. Work is also being carried out in the study of liver disorders, renal blood blow, tumor localization, and on the detection of pulmonary emboli.

Future plans call for the introduction of more advanced techniques to the study of clinical problems. New areas for teaching and research under consideration are: the more intensive use of short-lived radionuclides with high speed scanners and scintillation gamma cameras; the use of new radiopharmaceuticals that may be locally produced by PRNC's Chemistry Division; the use of radioactive gases to study pulmonary function and circulation; the search for improved diagnostic and therapeutic procedures which may result in better understanding of disease and management of the patient.

Health and Safety Division

This division has a triple role at PRNC: it provides educational and research programs; and it provides the services needed to safely operate the Nuclear Center, such as monitoring personnel and the area, calibrating equipment, waste disposal, and handling of radioactive materials.

An M.S. degree program is conducted in conjunction with the University of Puerto Rico School of Medicine. This program, in its second year, has six students, including one each from Colombia, Mexico and Israel. An eight-week course in Radiotherapy Dosimetry for 15 physicians from Latin America is now being organized, under the sponsorship of the IAEA.

Research efforts center upon maximizing information on dose ratio in Scintigraphic and Radiographic procedures. Basic studies in image formation, information transmission and assessment, and image-ing performance are being initiated. In addition to a recent paper on exposure slit modulation transfer functions, theoretical studies on the effects of screen phosphorescence on the temporal modulation transfer function, and the modulation transfer function of scanning apertures are near completion. It is hoped to establish a coherent optics laboratory facility to study image manipulation in Fourier space, and signature analysis as a diagnostic tool for screening procedure.

Medical Sciences and Radiobiology Division

This division offers training and research in fundamental nuclear energy aspects of biology, radiation biology, biochemistry, molecular biology, virology and medicine.

Research is directed in large part toward biological problems encountered in tropical areas such as Puerto Rico and most of Latin America.

The division has cooperative programs with different working groups in Latin America: with the Brazilian Group on Schistosomiasis of Belo Horizonte; and with the Veterinary Institute for Tropical and High Altitude Research, in Perú, especially in research on parasitic diseases. A cooperative program with the Bio-Medical Section of the Argentine Atomic Energy Commission is being considered.

Much of the research has centered on the effect of internal and external radiation in the host-parasite relationship in viruses, and in human and animal parasites.

A schistosomiasis project has studied the immunological mechanism and biological control of this disease, which is considered the number one health problem in many areas of the world, and remains a serious problem in Puerto Rico.

A new project studies Fasciola hepatica, a cattle liver disease which affects the wool industry and meat and milk production in much of Latin America.

A virus project studies the effect of irradiation on virus infections. Efforts in this project are directed to find the mechanism of the host parasite relationship, and in doing so to answer fundamental questions in virology, mainly dealing with the latency of viruses, especially arboviruses, the most common in the tropics.

The trypanosomiasis project deals with the effect of irradiation and host-parasite relationships at the cell and animal level. This parasite infects an estimated 7 million persons from the U.S. southward to Argentina. No preventive or curative agents are known. A new type of tissue culture cell line derived from a murine chondrosarcoma, more sensitive to the infection than any so far tested, was developed at PRNC's laboratory in FY's 1968 and 1969. This cell permits the cultivation of the parasite starting from one organism, and is also an ideal method for quantitative work.

Future plans include: more integration with the Puerto Rico Medical Center and Medical School, and with the Graduate Program of the University of Puerto Rico; participation in the planning of a multi-national center for parasitic diseases in Latin America; raising the level of radiobiological research, using electromicroscopy, and biophysical and molecular techniques.

Nuclear Engineering Division

This division teaches graduate courses at UPR, Mayaguez, and conducts research in nuclear engineering. The staff also directs thesis research of nuclear engineering students from the UPR and from other universities in the U.S. and Latin America. The division also offers short courses for scientists, engineers, and technicians, and for staff members engaged in individual research.

At Mayaguez, the UPR(in cooperation with PRNC's Nuclear Engineering Division) offers the Master of Science Degree in Nuclear Engineering. The UPR faculty for this field is comprised largely of PRNC staff members; the director of the UPR department heads the PRNC division as well.

In the past three years, 11 students have received their M.S. degrees, 6 others are working on their thesis, and 7 new students are engaged in course work.

Research is being conducted in the areas of reactor kinetics, Plowshare, pollution control, activation analysis techniques, and material irradiation.

Future plans call for the more intimate integration of computers in the program. Within two years it is hoped that a time-sharing computer terminal will be situated in the Division offices. Plans also call for a six week Plowshare Institute to be offered for professors from Latin American universities, possibly in February 1971.

A plowshare-type research project within the Nuclear Engineering Division is a study of in situ mining by nuclear devices. Studies have been focused on the hydrometallurgical aspects of chalcopyrite(Cu Fe S) in relation to underground mining. Chalcopyrite is one of the most abundant copper ores, but is also considered the most insoluble copper sulfide. Studies include the search for new leaching agents that may produce copper solubilization when long-term leaching time is applied. Recent research has uncovered a possible cheap, readily available solvent for chalcopyrite.

Nuclear Science Division

This division supports the graduate level programs at the UPR's Chemistry and Physics Departments in Mayaguez. It provides personnel to teach graduate courses and thesis research opportunities for M.S. degree students. Research facilities at the pre- and post-doctorate levels are available.

There are(late 1969) eleven graduate students from the Physics, Chemistry and Electrical Engineering Departments carrying out research under the supervision of PRNC's staff. Five former M.S. students are doing Ph.D. studies at schools on the U.S. mainland(U. of California, Santa Barbara, U. of Pennsylvania, Carnegie Tech, MIT, Harvard). Some former students who now hold academic and directive posts at various Latin American universities(Bogotá, Panamá, El Salvador, and in Ponce, Puerto Rico) have begun research projects along the lines of research performed at PRNC, and keep in close contact with the Center.

Research--The Electron Spin Resonance Spectrometer was set up in March 1969. Since then, data has been collected on y-irradiated single crystals of sodium, potassium, lithium and cesium tryhydrogen selenites. Work is also being done on radiation chemistry of aqueous solutions of organic sulphur compounds in order to determine the importance of sulphur as a radiation protective agent. Another scientist is investigating the mechanism of radiolysis of peptides in aqueous solutions. And another scientist's interests lie in the critical behavior of ferro and antiferroelectrics. Guest researchers include one from the United States and 2 from Latin America.

Two separate research programs are in the area of Nuclear Science. The Neutron Diffraction Program is generally concerned with ideal and imperfect arrangements of atomic nuclei and magnetic spin systems in solids. The scope of the project includes: the magnetic structures of inorganic salts, and the determination of the role of hydrogen in structures of importance in solid state physics and chemistry.

The Hot Atom Chemistry program investigates the products formed when an atom covalently bound to carbon undergoes nuclear recoil. The recoiling nuclei have included the transition metals and heavy metals, as well as non-metallic atoms. The carbon compounds employed have been phenyl derivatives, metallocenes and metal carbonyls. The purpose of these studies is to determine the mechanism of high energy reactions in organic compounds through a study of the products formed under different activation conditions. The possibility of directly preparing compounds and of obtaining radioisotopes of high specific activity by recoil methods is also being investigated. Joint research programs are planned with Mexico, Venezuela and Colombia.

Physical Sciences Division

The long-range objective of this division is to offer advanced training opportunities for Puerto Rican and Latin American trainees, primarily through participation in research projects which involve the use of high energy radiation and radioisotopes. Since this program is geared to regional needs, it includes an introductory training course in the use of radioisotopes, and PRNC's scientific personnel participate strongly in the academic activities, via joint appointments, of the natural science departments at the UPR campus in Río Piedras.

Education activities range from a four-week non-credit training course in the techniques of radioisotope applications, to research training at the Center's laboratories. In recent years, there has been a significant increase in the number of research participants, as well as in the ratio of persons who actually use radioisotopes in their professional work, following their training at PRNC.

Research is being carried out on: (1) Stereochemical effects in the gamma radiolysis of cis- and trans-1,2-dimethylcyclohexane; (2) radiation-induced addition of thiophenols to indene; (3) tritium recoil labeling of lithium phenylacetate; (4) matrix isolation studies of the gamma-radiolysis of heterocyclic molecules; (5) radiation damage in organic crystals; (6) oxidation of dianylethylenes; (7) influence of chemical structures on quenching in liquid scintillation counting; (8) calculation of C^{13} chemical shifts, and (9) molecular orbital calculations on lactam-lactim tautomers, and on aminophenols and aminothiophenols.

Two research groups are also involved in physical science studies.

The Solid State Physics Projects studies radiation damage on anthracene, phenanthrene and other organic crystals. It is felt that such studies on well-defined crystalline structures can provide a firm foundation for a later study of more complex materials, including those of direct biological interest. Present research works concern: (1) electron spin resonance(ESR) measurements in anthracene C_{14} H_{10} and deuterated anthracene C_{14} D_{10}; (2) the annealing of the triplet quenching radiation damage in anthracene; and (3) photoenhanced space charge limited currents.

Four students are engaged in thesis research at the laboratory during FY 1970, compared with 2 in FY 1969.

The Radiation Chemistry Project aims at trapping and subsequently characterizing the species formed by gamma-radiolysis of heterocyclic molecules which are of possible biological importance. Direct observation of labile intermediates formed following absorption of high-energy radiation is emphasized. This is made possible by using the matrix isolation technique, in which the molecule is irradiated in some form of rigid matrix, usually at low temperatures. Current research topics are : (1) absorption spectra of radiolytic intermediates at 77°K; (2) thermoluminesence following radiolysis at 77°K; (3) Thermoluminesence and ESR signals following radiolysis at room temperature; (4) photoionization in rigid glasses at 77°K, and (5) self-consistent field calculations on heterocyclic radicals and radical ions. A new project on energy transfer processes with emphasis on steric effects is planned. It is planned to augment the scientific staff by Latin American post-doctoral fellows within the next few years.

Radioecology Division

The Radioecology Division administers two major research projects: (1) the Terrestrial Ecology Program in the El Yunque Rain Forest, east of San Juan; and (2) the Marine Biology Program, from PRNC Mayaguez.

Terrestrial Ecology

This program, now in its seventh year, was designed to study the radioecology of a tropical rain forest, by installing a Cesium-137 source in the area, and making extensive follow-up studies. No similar study has been carried out in any tropical area of the world. The first four years were devoted to investigating the effects of gamma radiation on the forest's ecosystem. Beginning in 1966, emphasis was shifted to the second objective: the measurement of fall-out nuclides. This objective has since been modified to include the cycling of both radioactive and stable isotopes in the area. The cycling studies were further divided into four categories: (1) fallout measurements; (2) tracer experiments; (3) stable element analyses; and (4) water balance measurements. Since 1966, the movements of Cs-134, Sr-85, Mn-54 and Zn-65 in plants, animals and soil water have been studied and reported. Experimental work on the movement of tritium in plant and soils has been successfully studied. Current research includes studies on insect ecology, movement of selected isotopes through the animal food web, element input via rainfall, and its subsequent distribution in the forest, recovery in the irradiated area, movement and distributions of previously applied isotopes in the soil, plants and animals. Future work will be directed towards the systematic study of the movement of selected radioisotopes in both the biotic and abiotic components of the forest. Increased emphasis will be placed on the physical and chemical properties of forest soils, and the movement of macro- and trace elements via soil water to the streams.

A new field study station is planned for the Commonwealth Forest Reserve in Western Puerto Rico. This will deal with trace element movements in a tropical forest, and will be integrated with the Marine Biology Division's current lowland river and valley studies.

Marine Biology

Marine Biology activities studies trace element movements from a land mass into sea water, marine organisms, and bottom sediments, and investigates the cycling of those elements into the food webs and in the open sea environment.

This program is important because it directs itself to problems of marine contamination from nuclear-powered ships, nuclear power sources for marine and space applications, waste disposal, and plowshare-type projects.

A feasability study was completed two years ago for an Isthmus of Panama sea-level canal. Current research studies basic mechanisms which the canal studies program revealed to be essential in future work. These include precipitation and coprecipitation reactions in the areas of mixing river waters(with suspended sediments) and marine waters, coprecipitation of radionuclides by stable material in fallout from excavations with nuclear explosives, and other relevant data. A new research vessel is expected to be in operation by late FY 1971 or early FY 1972, which will increase the efficiency of field work and

Marine Biology (Radioecology Div.) Contd.

provide sea-going capability for future surveys and special research problems. During the past year, three new investigators joined the staff: one on a Bureau of Commercial Fisheries Training fellowship, to investigate physical and chemical mechanisms in the Añasco River; another from Oregon State University, to investigate the distribution patterns of carrier-free nuclides in solution and on bottom and suspended sediments in mixtures of whole river and sea water; and a third, from Oak Ridge Laboratory, to study mangrove forests.

In general, the emphasis of work in the Marine Biology program is directed toward immediate needs of the AEC in peaceful uses of nuclear explosives and in power reactor development. In FY 1972, plans call for a new study of radiation effects upon tropical reefs, or mangrove groves. A feasability study is now being prepared for this program.

Radiotherapy and Cancer Division

This division trains physicians and allied personnel in all aspects of the application of nuclear energy to the treatment of cancer. A residency program, approved by the American Board of Radiology, prepares qualified radiotherapists. The program functions at the Puerto Rico Medical Center, primarily at the I. Gónzalez-Martínez Oncologic Hospital(adjacent to PRNC, Río Piedras).

Cancer research centers on the use of radiation in treating the disease. The extensive facilities and patient load of the hospital(which treats medically indigent patients) are used for clinical studies related to the evolution of treatment results with different therapeutic methods, and to time-dose fractionation relationships in radiation therapy. Laboratory studies include work with cell cultures and irradiated animal tumors. Epidemiological studies on various forms of cancer of notable incidence in Puerto Rico are also conducted.

At present three doctors (two from Puerto Rico and one from Colombia) are being trained by the division. There are six clinical research projects underway, and the division also collaborates on four nation-wide cancer research projects.

The Reactor Division

The primary purpose of this division is to operate and maintain:

(1) a one MW pool-type research reactor;

(2) a 10W, aqueous-homogeneous L-77 reactor;

(3) a Co-60 gamma irradiation facility;

(4) a 1KW reactor, and

(5) high level hot cells.

The pool-type research reactor is to be converted to a 2MW thermal constant power reactor with a pulsing capability of 2000MW during 1970.

The division also supports PRNC's educational program, offering courses for reactor operators, and reactor supervisors.

X-Ray Survey Project

PRNC has engaged in a joint project with Puerto Rico's Health Department to survey X-ray equipment in Puerto Rico and evaluate average gonadal irradiation dosage in order to recommend how dosage may be diminished without diminishing the diagnostic value of the procedure. It was found that direct lead shielding can eliminate much potentially harmful dosage during abdominal X-ray diagnostics, and recommendations have been made that shielding should be required by law.