

# PRNC131

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PUERTO RICO NUCLEAR CENTER

ANNUAL REPORT 1968

?OPERATED BY UNIVERSITY OF PUERTO RICO UNDER CONTRACT

NO. AT (40-1)-1833 FOR U. S. ATOMIC ENERGY COMMISSION

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PRNC-131

(GENERAL, MISCELLANEOUS, AND

PROGRESS REPORTS. (T1D?1800)

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?at PRC during Fiscal 1967 and 1968.

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## INTRODUCTION

The Puerto Rico Nuclear Center, founded in 1957, is operated under contract for the U. S. Atomic Energy Commission by the University of Puerto Rico, whose student body of 34,000 (which has doubled in each of the past three decades) makes it the island's largest university.

The Nuclear Center engages in training and research in the peaceful use of nuclear energy, with special emphasis upon the needs of Puerto Rico and Latin America. The idea for a nuclear center on this Caribbean island stemmed from President Dwight D. Eisenhower's historic "Atoms for Peace" address before the United Nations General Assembly in 1953.

Since 1957, the Nuclear Center has grown rapidly. Its first year staff of 43 has multiplied to nearly 300, including 80 scientists. PRC's student enrollment last year was 235, four times the amount during its first year. About one-sixth of its 1,177 alumni are foreign nationals, from 18 Latin American republics as well as other nations,

The Center is small compared to major nuclear labs on the U. S. mainland, but its modern facilities are excellent.

One of PRC's two main facilities is at the University's Mayaguez campus on the west coast. There, it has three reactors (one pool-type research reactor and two training reactors), a subcritical assembly, a 10 MeV neutron generator, neutron spectrometers, a laboratory for work with high- and low-level radioactivity, a large gamma facility, a chemistry laboratory, and separate buildings for plant sciences, nuclear engineering and marine biology. The marine biology Program has a 100-ton oceanographic research vessel, fully equipped with laboratory.

The other main facility is the new Medical Center in Rio Piedras, on the outskirts of San Juan. The Bio-Medical building in Rio Piedras is equipped for research in several fields. Irradiation facilities include a cobalt-60 teletherapy unit, a 300 KVP X-ray therapy unit, and a cobalt-60 irradiator. An animal house next door is stocked with colonies of mice and snails for experimental use. A solid state physics laboratory is located at the University's College of Natural Sciences in Rio Piedras; terrestrial ecology laboratories are located in the Luquillo National Forest.

The Nuclear Center's academic program is closely integrated with the Master degree programs of the UPR in the physical and life sciences, agriculture and engineering. Students enroll at the University and receive academic credit through the corresponding University department. Their professors are scientists who have joint appointments at both PRNC and the University. Inroads are also being made at the doctoral level. New doctoral programs are now offered in biochemistry, microbiology and physiology; proposals for programs in sciences and chemistry are under study.

FRUC also gives non-credit training courses. It provides facilities for

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graduate research and offers courses in the nuclear field, with students receiving credit from the university they are attending.

The Center's bilingual policy--most formal lectures are in Spanish--has encouraged enrollment by Puerto Rican students and Latin Americans. Spanish-speaking scientists come from abroad to teach, or to take advanced level courses. For example, PHIC's Physics Sciences Division--in addition to Supporting the University's M.S. degree programs in chemistry, physics and biology--provides four-week basic courses in radioisotope techniques. Last year these courses were taken by--among others--a Uruguayan doctor, a Dominican engineer, and a Peruvian biochemist!

The Nuclear Center has also become known in Latin America by participating since 1965 in the US AEC's "Atoms in Action" exhibits, held twice yearly in « different South or Central American republic. The exhibit provide data on the Peaceful uses of atomic energy for scientists, teachers and the general public, PRNC's scientists lecture, work on graduate thesis projects with local students,

and cooperate with institutions in the country being visited. During 1967 in Ecuador, for example, research dealt with radiation preservation of agricultural products, including the banana, Ecuador's biggest money crop.

By far PRIC's biggest "growth area" in its first decade has been research, much of it aimed at solving problems germane to Puerto Rico and/or Latin America,

PRIC's marine biologists are playing a key role in determining how feasible it might be to dig a new sea-level Isthmus of Panama Canal with nuclear explosives. Its research ships spent seven months in the waters off Panama and Colombia, collecting tons of samples of water, sediment, phytoplankton, fish, crustaceans, etc. The results will be used to evaluate possible hazards caused by incorporating radionuclides into food webs leading to humans.

FRNC's terrestrial ecology specialists have radiated a small section of the Rain Forest in eastern Puerto Rico. Preliminary and follow-up studies show how radiation affects the total environment (plants, animals, insects, soil, water, mineral cycling, etc.).

The main thrust of FRIC's research in medicine and radiobiology studies

how radiation affects the relationship between the host and parasite in various parasitic diseases which cripple millions of persons, particularly in the South American and African continents. Studies are being done on Schistosomiasis (also known as Bilharzia), of Trypanosomiasis (also called Chagas' Disease) and of coxsackie virus. These parasites and viruses are being observed in ice, in snails, in human cells, and other host environments.

An insect called the sugarcane borer (*Diatraea saccharalis*) causes losses in Puerto Rico alone of \$2 to \$3 million a year. It is also a serious pest in the U. S. and Central and South America. A PRNG project begun in 1963 hopes to eradicate the sugarcane borer by breeding adults which have been sterilized by radiation and releasing them to mate with pests in the cane fields. The Center plans to release sterile insects on a 1,000 acre tract of cane land on the nearby island of Vieques to test the success of this method.

Food irradiation is another of PRIC's interests. Many areas of South and central America produce abundant fruits and vegetables, but poor roads slow delivery to distant markets and cause severe spillage losses. The technique of extending the shelf-life of tropical fruits by radiation, without damaging their nutritional value, is now being studied. Varieties of mango, banana, and plantain (a large cooking banana which is a food staple in many areas of the East Indies and Latin America) are now being irradiated.

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## NUCLEAR SCIENCE

?The Nuclear Science Division supports the M.S. degree programs in Chemistry and Physics of the University of Puerto Rico at Mayaguez by providing research Opportunities for graduate students and faculty to teach specialized advanced courses. Research facilities are also made available to graduate students of Nuclear Engineering and Electrical Engineering as well as for pre- and post-doctoral students of other universities interested in working at PRNC.

?The main facility incorporated this year has been a "Jeoleo" Electron Paramagnetic Resonance Spectrometer. The use of this facility by people within the Division from different groups (Radiation Chemistry, Solid State) will encourage cooperative research.

## EDUCATIONAL ACTIVITIES

### Graduate Courses

During 1968 six graduate courses were taught by PRNC personnel, with academic credit given by the UPR:

courses Professor Enrollment,

Nuclear Chemistry Dr. Owen H. Wheeler 20

Int. to Solid State Physics Dr. Julio A. Gonzalo 4

Radiation Chemistry Dr. Rupert A. Lee 3

Int. to Quantum Theory Dr. Baltasar Cruz 4

Graduate Seminar Dr. Baltasar Cruz 4

Solid State Electronics Dr. Florencio Vazquez 8

Thesis Research

The following students from Puerto Rico, Colombia, EL Salvador and the Philippines completed thesis research under Nuclear Science Division staff supervision

Thesis Title Student Advisor

A physico chemical study of

?the Chapman rearrangement. Fernanda Ronin Dr. Rosado

Effects of gamma irradiation

?on some components of

essential oils. Elba Diaz Dr. O. H, Wheeler

Radiolysis of peptides. Dolores Julián Dr. O, H. Wheeler

Neutron activation of aromatic

iodine compounds. Carmen Lecunberry Dr. O, H. Wheeler

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Dielectric properties of

alkaline trihydrogen selenites.

HCL Radiolysis in a

Nuclear Reactor.

W and G(H<sub>2</sub>) values for

CHAP and CHF.

F center formation at 78°K

An RbBr during exposure to  
monochromatic X-ray energy  
around the bromine and  
rubidium K edges.

Electroreflectance in silicon  
and germanium crystals

Lule C. Tilo

Lats Rivera oyola

José Mario Sace

Fernando Dfaz

Julio Marrero

Dr. J. As Gonzalo

Dr. R.A. Lee

Dr. R.A. Lee

Dr. B. Cruz

Dr. F. Vazquez

The following students from Puerto Rico, Colombia, Chile and Cuba are

doing thesis research under Nuclear Science Division staff supervision:

a

Title

Synthesis of Thlostercias.

Recoil labeling of aromatic  
compounds with halogen.

Radiation damage in XDP and  
ADP single crystals.

Synthesis of pyrinides

Labeled with radioiodine.

Incorporation of radioisotopes  
in pharmacological compounds.

Copolymerization of vinyl  
?compounds with crotonic acid  
induced by gamma radiation.

Mechanism of radioprotection  
of peptides.

Synthesis of radiopharmaceuticals  
labeled with short  
half-life isotopes.

Radiolysis of aqueous organic  
sulphur compounds

F center formation in potassium  
chloride at 76°K during exposure  
to monochromatic X-ray energies  
around the chlorine K edge.

Electroreflectance on (7 -)  
Irradiated silicon and germanium

crystals.

Student

Wilfredo Roarfguez

Hilda Lépez

Ivin Mazerio

?Teana Casanova,

Cénaida R. de Jess

Raquel Roar{guez

Gabriel Infante

Carmen Cecilia Motta

Manuel Lagunas

Laureano Iiiiio

Francisco Kerninde:

Avisor

Dr. O, Hy Wheeler

Dr. O, H, Wheeler

Dr. Js Ae Gonzalo

Dr. O. H. Wheeler

Dr. L, Felié

Dr. R.A, Lee

Dr. O. H. Wheeler

De. O, H. Wheeler

Dr. R.A. Lee

Dr. B, Cruz

br. F, Vazques

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Specific heat anomaly in ferro-  
electric transitions (763 and  
isomorphous compounds). AL Mock Dr. J. A. Gonzato

EESEARCH COMPLETED

Radiolysis of Gaseous Hydrogen Source: The Effects of Pressure, Temperature  
and Atmospheric Gases (Nitrogen, Oxygen, Water Vapor, and Carbon Dioxide) on  
the Radiolysis of Gaseous Hydrogen. (M. S. El-Agafy, A. M. El-Sayed, and  
S. H. El-Khatib, Al-Egyptian Journal of Chemistry, 1978, 21, 1-10)  
The radiolysis of gaseous hydrogen by cosmic rays has been obtained using the  
Elon chamber method. A G(H<sub>2</sub>) value of 9.0 at 90°C can be calculated from the  
kinetics for nitrogen bromide. Studies with added bromine and sulfur hexafluoride  
show that about 30 per cent of the hydrogen yield can be inhibited at scavenger  
concentration of about 1 mole percent, the remainder of the hydrogen is not  
easily suppressed, indicating the presence of two hydrogen forming species,  
one of which is not easily suppressed. The application of an electric field  
during radiolysis causes no change in the hydrogen yield. The  
ion recombination region is important in that ion recombination processes  
are unimportant in the formation of hydrogen.

Hydrogen Radiolysis in a Nuclear Reactor - R. A. Lee and Luis Rivera (W.S.,  
Nuclear Engineering, Sopenier TES)- Gascon hydrogen chloride: has been

Irradiated in quartz cells in a light water cooled reactor operating at 1 megawatt power. Irradiations were carried out in the pressure range 60-140 cm Hg of hydrogen chloride for times of 15 and 25 minutes. The method of dosimetry used was to compare the radiolysis of hydrogen chloride with that of nitrous oxide, irradiating one immediately after the other for the same time at approximately the same gas pressures. The Bragg-Gray theory of cavity ionization was used and corrections for the difference in stopping power of the two gases were made. A  $G(ip)$  value of  $6.1 \pm 0.1$  has been determined, in the PRC reactor, at a point where the neutron flux is  $5 \times 10^{10}$  neutrons per cm<sup>2</sup> sec., the gammas are the dominant source of energy deposition.

$W$  and  $G(Hg)$  values for  $CH_3F$  and  $CHF_3$ - R.A. Lee and Mario Saca (MS).

Paysse, October 1966). The gases methyl fluoride ( $CHF_3$ ) and fluoroform ( $CHF_3$ ) have both been irradiated with  $^{60}Co$  gammas. The cell used is in the form of a parallel plate ionization chamber having its parallel faces coated with graphite. This cell with its electrical components has been used to determine  $W$  (energy required to form an ion pair) and the ion pair yields from the decomposition of gases. The results obtained are not in complete agreement with the Bragg-Grey theory of cavity ionization chambers which predicts a constancy of the severe;

ton ionization current per unit pressure as the pressure is varied, The irradiations were carried out in the pressure range 20-60 mm Hg at 25 + 2°C. By a comparison method W values of 28.3 eV and 27.6 eV were obtained for polyethylene and Fluoroform respectively. G(Rp) values of 1.0 and 1.05 were determined from the measured W values and ion pair yields for these gases and CH<sub>3</sub>, respectively. Hydrogen formation may be due to the fact that the C-H bonds in these compounds are slightly weaker than the C-F bond

Thermal Hysteresis in Both Phase Transitions of NaAlF<sub>6</sub> (Se Jo =

J. A. Goniasio and L. C. Tito (N.S. Chentstay, April 1966) Dielectric constant and hysteresis loops measurements in NaAlF<sub>6</sub> show the existence of thermal hysteresis accompanying both phase transitions which appear at  $\approx 79^\circ\text{C}$  and  $10^\circ\text{C}$ . The most reliable values obtained from evs. T curves give estimates of 4063.2°C and 1-20.1°C, respectively. Assuming that a double potential well along the hydrogen bonds is responsible for the dipole ordering, it is possible to correlate the thermal hysteresis with the discontinuous disappearance of spontaneous polarization and the height of the potential barrier exceeded

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energies for the potential barriers in both transitions yield values which are reasonable for a short hydrogen bond.

Set\_of Experimental Critical Exponents for Ferroelectric Triglyotn

Sulfate - Jv A. Gonzalo. A series of curves of  $F$  vs  $B$  at various temperatures

Close to the transition temperature of triglycine sulfate have been used for determining the behavior of  $P$ ,  $(\partial P/\partial E)_{\text{pres}}$  and  $(\partial P/\partial T)_{E=0}$  with respect to field and temperature in the critical region. Log-log Plots of the polarization and its derivatives versus  $E$  and  $T$  allow the direct experimental determination of six critical exponents. All of these experimental values are consistent with predictions of the mean-field theory.

Electroreflectance Measurements on  $\text{MgSi}$ ,  $\text{MgGe}$ , and  $\text{MgSn}$  -

¥. véscuez, Richard A. Forman and Vanuel Cardona (ERIG and Brown University).

?The room-temperature electroreflectance spectra of the II-VI compounds  $\text{XeS}$ ,  $\text{MgGe}$ , and  $\text{MgSn}$  are reported in the energy region 1.5-4.5 eV. All measurements were performed using the electrolyte technique with « nonaqueous electro-

lyte. These materials crystallize with the antiferroite crystal structure and are small-band-gap semiconductors. In all of the materials, a large number of sharp peaks were observed; the spectra are interpreted in terms of the reflectivity spectra and existing energy-band calculations. Special mention should be made of a doublet observed (1.64~1.64 eV) in the spectrum of MgGe. This doublet appears to be due to the spin-orbit splitting of the  $\Gamma_1$  valence band.

F center formation at 76°K in RbBr during exposure to monochromatic X-ray energies around the bromine and rubidium K edges - Baltasar Cruz and Fernando Blase  
Measurements of the relative efficiency of formation of F centers in RbBr during exposure to monochromatic X-ray photons of energy either below, between, or above the bromine and rubidium K absorption edges were completed during the summer of 1968. This work verified similar research on KBr and verified calculations on the fluorescence during irradiation of alkali halide crystals.

#### [RESEARCH IN PROGRESS]

Improved statistical theory for ferroelectric 163 - J. A. Gonzalo. The inclusion of temperature dependent tunneling effects within the H-bonds, along the line recently suggested by Blinc and Svetina for KDP leads to an improvement of the agreement between the theoretical and experimental results for the spontaneous polarization and specific heat in the whole temperature interval up to the Curie point. This tunneling effect correction is formally similar to the "biquadratic exchange correction" used in the theory of magnetic transitions.

The Antiferroelectric Phase Transition in  $\text{CeFe}_3(\text{SeO}_3)_2$  - J. A. Gonzalo and L. C. Hilo, Careful measurements of temperature dependence of the dielectric constant perpendicular to the (100) plane have been performed on single crystal samples of  $\text{CeFe}_3(\text{SeO}_3)_2$ . The transition takes place at  $123^\circ\text{C}$ . The temperature interval between measurements was  $0.25^\circ\text{C}$ . Our results indicate no discontinuity in the dielectric constant at the peak temperature, strongly suggesting a 2nd. order transition.

Gamma induced copolymerization of crotonic acid and vinyl compounds - R.A. Lee and Raquel Rodriguez. The copolymerization of crotonic acid with (a) vinyl acetate and (b) methyl acrylate is being carried out using  $^{60}\text{Co}$  gamma rays. Since crotonic acid itself does not polymerize, it is hoped that the study of these two compounds would provide a comparison of the effect of the carbon to carbon double bond position relative to a carbonyl group in the

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formation of copolymers. Thermal copolymerization using benzoyl peroxide as a catalyst has been shown to occur via a free radical mechanism. In the case of radiation induced reactions it is known that both ions and radicals are formed initially, By introducing various scavengers and studying their effects, the mechanism, whether radical or ionic in these cases, would be determined,

find Manuel Togunas, Organic sulfur compounds have been shown to be extremely good protecting agents against radiation. Thioures in particular are exceptional. The reason for this is unknown; it is hoped that a complete study of the radiolysis of this compound in aqueous solution along with its methyl

analogues (tetramethyl thiourea) would shed some light on the subject. Aqueous solutions of these 2 compounds will be irradiated both in presence and absence of air,  $G(H_2O_2)$  will be determined and the effect of pH will be studied. By

using  $^{14}C$  labelled compounds a product analysis will be attempted to help elucidate the reaction mechanism,

Radiolysis of CHP, and Cig? in the presence of scavengers - R. A. Lee.

pretiniasy went on Uae ive jase bar alvandy Doon carried out,  $G(H_2O_2)$  and  $G(O_2)$

values were obtained. It is believed that  $H_2O_2$  formation is due to the reaction

of the H atom with either of these two compounds, since the C-H bonds are

weaker than the C-F bonds in either of these compounds. Scavenger effects

(both electron and H atom scavengers) on the G(Hp) yield will be undertaken,

along with product analyses to determine the mechanism of the radiolytic decomposition.

Electroreflectance from Semiconductor Crystals - F. Vazquez. Electroreflectance method is being used for T-radiation damage on germanium and silicon

crystals. It is also used to continue studying the band structure properties of these two semiconductors.

center formation in potassium chloride at 76°K during exposure to monochromatic X-ray energies around the chlorine E edge - Baltasar Cruz and Taureano Fito.

Equipment has been designed and built to irradiate KCl under vacuum during exposure to monochromatic x-ray photons of energy, either below or above the chlorine K absorption energy (2.82 eV). We are now trying to

develop means to obtain relative measurements of radiation beams in the energy range from 2 to 10 keV.

Equipment has been assembled and tested to investigate the energy of the fluorescence during irradiation of alkali halides as a function of sample temperature, purity, and incident photon energy. The thermal luminescence of alkali halides will also be studied. Basic information is sought on the re-

reactions involving vacancy and interstitial defects in alkali halides, and the effect of these reactions on present theories on the mechanism of the production of defects, "Through the study of the thermal luminescence of crystals it is hoped to improve present radiation dosimeters or develop new ones, particularly for photon energies from 5 or 6 eV through 4 or 5 keV ,

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## NEUTRON DIFFRACTION

The neutron diffraction group at the Puerto Rico Nuclear Center is working on two types of problems: (1) the chemical bonding of atoms in crystals and molecules; (2) the nature of ferromagnetism. Both are related to the spatial arrangement of atoms in molecules.

If either x-rays or neutrons are scattered from crystals, patterns can be analyzed that show the arrangement of atoms in the crystal. Since the amplitude of x-ray diffraction is proportional to the atomic number of the scattering atom, if both light and heavy atoms occur in the same compound, the

contribution of the light atom is very weak and its position can be determined only with great difficulty, Neutrons, however, are scattered by the nuclei of the atoms. Diffraction of neutrons by light elements compares favorably with that of heavier elements, and the coordinates of the lighter atom may be determined with greater precision than with x-rays. In compounds having atoms with unpaired electrons, a neutron-electron spin interaction is also present. Since the magnetic properties of substances are related to the way the electron spins are arranged within the crystal, determination of such spin arrangements by neutron diffraction provides information about magnetic structures.

## OVERALL PROGRESS

Several problems have been completed in the past year. An attempt will be made to briefly describe the results and give some idea of the importance of the investigation.

Z. Phenanthrene. Danask and Arndt have reported that phenanthrene undergoes a phase transition about 72°C as detected by heat capacity, electrical conductivity, and polarization measurements. Since the effect was found to be uniform throughout the crystal, the authors consider it possibly due to some type of ordering effect in the crystal, or perhaps to hydrogen atom motion, since no change in x-ray pattern was noted on heating phenanthrene through its transition.

We have not yet done any work on the high temperature phase. The room temperature phase, however, has been analyzed.

The structure of phenanthrene was solved in the 1950's by Trotter who reported the three rings (see Fig. 1) to deviate slightly from planarity. When we undertook the neutron work, Ys Oraya, then at IBM laboratories, took new X-ray data to obtain more accurate carbon position. Both x-ray and neutron data confirm the earlier results that the molecule is non-planar. Figure 1 gives the bond distances averaged over x-ray and neutron results; Figure 2 gives the angles; Figure 3 the distances of each atom from the average plane of the six central carbon atoms. Figure 1 shows the 2.04 XH (h) = H (5) distance. This distance, determined from neutron diffraction data, is well under the 2.48 Van der Waals distance. Because these two hydrogen atoms are so close, the molecule is forced to bend to try to relieve the repulsive stresses.

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It may be seen from Figure 3 that the top ring is bent down and the bottom ring is bent up with respect to the central ring, although the nature of the twisting seems to be somewhat different in the two rings. Each six membered ring is close to planar.

Why note that the carbon atoms determined from x-ray data are an average of 0.006 Å closer to the center of mass of the molecule than are the carbon positions determined from neutron data. Such systematic differences between data sets may be due to systematic experimental errors, but may also be consistent with differences between the position of the nucleus of the atom, determined by neutron diffraction data, and the average position of the electron density of the atom, determined from x-ray data.

Bond distances have been corrected for rigid body libration of the carbon atoms. The rigid body motions were determined by the Schonaker-Trueblood (1968) Acta Cryst. B 63 program. The carbon atoms fit a rigid body far better than do the hydrogens. The derived rigid body motion was subtracted at the hydrogen positions. The remainders of 25 of 30 diagonal tensor terms were positive, showing that the hydrogen vibrates on the phenanthrene carbon ring. The average uncorrected C-H distance was 1.076 Å after rigid body correction 1.082 Å.

The C(12) - C(13) distance is 1.46 Å as opposed to 1.43 Å derived from molecular orbital calculations, Coulson and Haigh (1963), Tetrahedron 19, 527 calculate that there should be an increase of about .02 Å due to the deformations, they did not, however, expect, the out of plane bending, proving either crystal forces, or higher order potential terms are important or the H<sub>1</sub> potential is harder than assumed. No clear-cut effects of over crowding show up in the H(4) or H(5) thermal parameters. Figure 2 shows that the angles in the ring formed by atoms C(4), H(4), H(5), C(5), C(13), C(12) are somewhat larger than

normal, Probably due? to the il fepwision.

IL, Thermal Vibrations of the Sulfate Group in Sodium Alun, Nah50}1210.

some alun aeractures were reported in PRODI On page 9 of that Tepore, we reported that three of the sulfate oxygens seemed to undergo a translational motion down the three-fold axis which is correlated with a rotation about the three-fold axis to avoid a near hydrogen neighbor. That is, the  $0, -8/3(02)$  (Guifate) group Ss on a three-fold rotation axis which passes through Grand 8. ?The three Op atoms are at the apices of an equilateral triangle. ?The spiral or translation-rotation motion described above consists of @ Potetion about  $\xi=0$ ) combined with e transiation parallel to the axi

PRNC-115 describes in detail the method of including such motion in the least squares refinement of structural parameters by means of a numerical integration of the scattering function and its derivatives. The usual method of treating small torsional oscillations is to assume linear harmonic motion and, from the amplitudes of such motion, try to guess the rotations that give rise to them. PRNC-115 on the other hand, describes a numerical method of directly putting the non-linear terms into the scattering expression which should be extendable to a wide variety of problems.

?At the conclusion of the above analysis it was discovered that on top of

the spiral motion described above, there was torsional or rocking motion. The numerical integration method could have been extended to include such a notion, however, by using some approximations. Kay and Behrendt (1963) *Acta Cryst.* 15 157 derived a function that describes torsional oscillations. This expression was used together with numerical derivatives in the least squares analysis of the x-ray data.

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Fig. 1. Phenanthrene: Wunbering system used to name atoms and bond distances averaged over x-ray and neutron results

Fig. 2. Phenanthrene: Bond angles

Fig. 3. Distances from least squares plane of central ring in Angotroz unite

Fig. 4. A representation of the crystal structure of  $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$  views along the b axis. Heavy Lined and dashed circles represent atoms in the mirror planes  $Y=0$ , and  $Y=1/2$  respectively. Thin Lined circles represent atoms at  $0 < Y < 1/2$ . Hydrogen bonds are represented by Lines

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The final results state that the sulfate group undergoes a spiral oscillation with a root mean square amplitude of 0.169 radians at a slope of  $59^\circ$  from the three-fold axis. The torsional oscillation is .278 radians.

One artefact of using an incorrect Linear vibrational function is that bond distances are artificially shortened and must be corrected. The functions used in the current work give correct distances (to the validity of the vibrational model) directly. The C-O, and S-O<sub>p</sub> distance increased from 1.461 Å and 1.459 Å to 1.479 Å and 1.454 Å, respectively, in the present work.

IIT. A Relationship between Incoherent Neutron Scattering and Nuclear Magnetic Resonance. The HOC antineutrino scattering experiment where a perturbation is applied to nuclear spin system, causing nuclear spin transitions in the system. In the IWR experiment these transitions are caused by the interaction of the nuclear spins with an applied radiofrequency field, while in the latter they are caused by the interaction with the neutron spins. We have derived the relation between the functions describing both types of experiments.

Using the established connection between generalized susceptibilities and fluctuations of dynamical variables, we find for a system composed of identical particles, the relationship between the spin dependent, or so-called incoherent scattering law and the susceptibility arising from the nuclear magnetism to be,

$$\chi''(\omega) = \frac{1}{2} \chi''(\omega) + \chi''(\omega)$$

$$\chi''(\omega) = \frac{1}{2} \chi''(\omega)$$

of the

ES, Ste Be EO>y,

Thus, "incoherent" neutron scattering and experiments on nuclear magnetism measure essentially the same function over different ranges of the same function over different ranges of the variables  $K$  and  $u$ .

By, The Crystal Structure of  $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$  at Room Temperature and at U.K. by Neutron Diffraction. In recent nuclear magnetic resonance experiments in the magnetic fields at the proton sites in antiferromagnetic  $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$  have been measured. Subsequent attempts to calculate these local fields on the basis of a simple dipole model, and thereby explain the results of the IR experiment, were unsuccessful. Since these calculations required the use of

several assumptions about the magnetic and crystallographic properties of the material, it was decided to experimentally determine the magnetic structure and spin direction in the antiferromagnetic state, as well as the crystal structure in the paramagnetic and antiferromagnetic states by means of neutron diffraction experiments before attempting another extensive calculation of the local fields. The magnetic properties have already been discussed in a previous report, while this work is concerned with crystallographic properties at room temperature and at 4.2°K.

The heavy atom structure at room temperature has been determined by Nis

using x-rays, space group  $C2/n$ , and contains

two formula units per unit cell. Cell dimensions determined by x-rays are

$a = 10.23$ ,  $b = 7.05$ ,  $c = 6.57$  Å, with  $\beta = 122^\circ 10'$ . The nickel ions are

---Page Break---

situated on  $2/m$  inversion centers of the  $ab$  faces, They are all octahedrally coordinated to four oxygen and two chlorine atoms, The oxygen atoms are slightly distorted square, with the nickel at the center, while the chlorines are located on the two normals to the oxygen plane. The remaining two water molecules of the formula unit are located in the mirror plane and are relatively free, but do take part in the hydrogen bonding scheme.

Unit cell parameters were determined by neutrons and found to be  $a = 10.24$ ,  $b = 7.04$ ,  $c = 6.58$  Å, and  $\beta = 122.1^\circ$  at room temperature, and  $a = 10.20$ ,  $c = 6.50$  Å, and  $\beta = 122.32^\circ$  at 4.2K,

Isotropic least-squares refinement of the intensity data gave the positions and isotropic thermal parameters given in Table I. The positions of the atoms measured at 4.2K are in good agreement with the room temperature results, indicating that the crystallographic structure of the antiferromagnetic state at 4.2K is the same as in the paramagnetic state at room temperature. A projection along the  $b$  axis is given in Fig. 4, wherein most of the atomic symbols are defined, and the hydrogen bonding scheme is indicated. Some bond lengths and angles calculated from the two sets of parameters are given in Table II.

Values calculated from the x-ray determination are also given.

The crystal structure is determined by hydrogen bridges of the type

$O_1-H_1 \cdots O_2$  and

$O_3-H_3 \cdots O_4$ ,

which link the  $NiCl_2 \cdot 2H_2O$  octahedra into a face centered two dimensional network

parallel to the  $ab$  plane, and bridges of the type

$O_5-H_5 \cdots O_6$

which bond together the neighboring two dimensional networks. Hydrogen atoms

from each  $O_1$  water molecule enter into two hydrogen bridges which are essentially

"parallel", while those from each  $O_3$  water molecule enter into bonds which are

essentially "collinear" in their effect on the crystal structure. Thus, there

are only half as many structural bridges along the (001) as along other direc-

tions, and this results in the perfect cleavage parallel to the  $ab$  plane.

In the hydrogen bonding system,  $H_3$  has a bifurcated type bond with  $O_7$  and

its mirror image  $O_7(2)$ , but it is interesting to note that  $H_3$  appears to be

hydrogen bonded to the point  $B$ , the midpoint between  $O_7$  and  $O_7(2)$ . The dis-

tances for  $H_3 \cdots B$ , and  $O_7-H_3 \cdots B$  of 1.7 and 2.70 Å, are essentially the same

as the corresponding distances of 1.60 and 2.72 Å, associated with  $O_7-H_3 \cdots O_7(2)$ .

Curiously enough, if the hydrogen bond is essentially electrostatic, having

effective point charge  $q$  on each oxygen atom, the  $O_z$  and  $O_r(2)$  may be replaced by an imaginary charge of  $1.5q$  at the point 8. This would seem to imply that the bifurcated bond is not necessarily a weak one. The apparent exceptional length of the O[1]-H1 bond is due to overlap in projection between Cl and Hh atoms in adjacent mirror planes. Other bonds and angles are in agreement with previously reported results.

Proton-proton vectors for  $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$  in the paramagnetic state have been measured by El Saffar, using the IMR method." Since this salt is isomorphous to  $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ , with respect to the heavy atoms, it was of interest to compare his results to those calculated from the hydrogen parameters presented above. Therefore, p-p vectors determined from the IMR and neutron diffraction experiments were compared and agreement was found to be quite good. Thus, within experimental error, it was found that these salts are probably also isomorphous with respect to the hydrogen atoms.

3B

---Page Break---

TABLE IZ

Interatomic distances and bond angles in  $\text{K}_2\text{C}_2\text{O}_4 \cdot 6\text{H}_2\text{O}$

at room temperature, and at 4.2K

7% 2.375 0;-0;(2) 2.86 (1)

B 19x( 2.936

io 2.05 (1) 2,098 clay 320 Q) 3.16

2.091 2333

HiL0; 3.90 (1) 3.932 hey" 3.7

\* 3.853 as

Srey) 293, 33.006 ca-c2(# 4.06 (2) 4.053

2.919 (5

on-#3 16 () orm + (2)

?5 @) n

ogy Lor (3 orm! 9h (2)

= + 8 s 3

3-H (1.63 (4) ?H-He" 1.48 (2)

ish (2) 1.55

-3 270 (1) 2.703 Op-Og3! 27% () ams

a 2b 6} a 2.67

ro" Bar (2) 3,128 ca! 3a Q) 3.96

a 3.109 @) \* csr

58 Lat (2) Oyy'-#a 2.80 (2)

1.700 (8) in

cu-it ean (3 cua 2.90 (2)

aus 8 2B S

04-3 2.27 (2) orn 3.05 (1) 3.072

H3-0;;-Hh 207? (2) Meow 10K (2)

ar aor) \* we

-H3-B 165 (2) M073" 17h (2)

Or % 8 een in

ec? 168 (1) Oy-H2"-cl' 16k (2)

Ons-B %@ & o ia

BeOyy-Cl" 124.7 (4) 2a. Oyy'=0y-c2" 89.5. (4) 90.7

12k (2) a

© Gpper number in each number set refers to room temperature, lower muaber to

4,2° bond or angle

> gona lengths and angles in these coluans were calculated from x-ray data

ae

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R.D. Spence, P. Middents, Z.Ms BL Gaffer, and Re Kleisbere, J. Aopl. Phys  
Suppl. 35, 65h (1964) oe Bip ee

2-R. Kleinberg, J. Appl. Phys. 38, 1453 (1967)

3.5, Mizuno, J. Phys. soc. Japan 16, 2574 (2962)

42, M. EL Sattar, J. Phys. Soc. Japan 17, 1334 (1962)

TABLE 1

?Comparison of parameters in HiCl2-6Hg0 detersined fron:  
anisotropic least-squares refinement of room temperature

x-ray data; isotropic refinement of room temperature

neutron data; and isotropic refinement of .2"K neutron

date

= y 5 2

x ° ° ° 12

act

cL 2708 sy ° 267% (3)

2591 (8 t 25 ( )

tr (5 ?1100 (7) 80)

O .omy ate (7) os (6)

20296 i +203, (2) 2k B

?oszo (3) ?ano aes

2825 (7 ° 7023 (32)

= ?696 23 (3

?eas (6) ?reo 3G)

moo (2) amp (3) 289 2 22 (3

107 (2) +8 2280 (1 2.2 (2)

2 a 2k) we 3G)

twa GQ) 1228 weet (1) 2.3 Q)

182 (4) ° +549 (5) 5.9 (7)

\* bh 3} ° 54g (2) 2.0 8

Hh +260 8 ° +839 (4) 1-2 {

261 (2; ° 828 (2) 1.7 (2)

In each heavy atom set of numbers the upper, middle, and lower number subsets

Correspond to positions determined by: x-rays at room temperatures neutrons

at room temperature; and neutrons at 4.2K, respectively

© In each hydrogen atom set of numbers

to positions determined by neutro:

y

© at h.°K, the y atomic paraneters for the water molecule in the sei

Position were selected to give reasonable molecular and hydrogen boris

tthe upper and lover subsets corr?

1s room temperature and 4.2K, res;

15

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## HOT ATOM CHEMISTRY

?The studies being carried out in the field of hot-atom chemistry involve the investigation of the products formed when an aton covalently bound to carbon undergoes nuclear recoil. The recoiling nuclei have included the tran- sition metals and heavy metals, as well as non-metallic atoms. The carbon compounds employed have been phenyl derivatives, metallocenes and metal carbon- yls. 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 @ifferent activation conditions. The possibility of directly preparing labeled compounds and of obtaining radioisotopes of high specific activity by recoil methods is also being investigated.

?The equipment available for handling unstable compounds includes vacuum systems and glove boxes. The experimental techniques used for separating the radioactive products include various methods of chromatography and electrophoresis.

## WORK \_In PROGRESS

Metallocenes - Solid solutions of nickelocene in cyclopentadienylthallium and in ferrocene, or solutions in indene, afforded an increased activity in the radioactive organic NiIII fraction. There was no increase, however, in the organic NiII activity, indicating that recombination results in the formation of organic NiII products.

Metal carbonyls = The retention of 2.56 hour <sup>65</sup>Zn in nickel carbonyl 1s

being studied by rapid vacuum distillation of the products, as a means of obtaining <sup>65</sup>Zn in high specific activity.

Carbonell ~ The recoil labeled products from glycine are being separated by chromatography on ion exchange columns, and on Sephadex and silica gel.

## WORK CoMPLETED

Metallocenes - Bicyclopentadienylosmium (osmocene) on activation afforded  
Sof oF the activity in the organic fraction of which about 10% was "retention."  
The inorganic Os activity was largely Os\*4, Bicyclopentadienylrhenium hydride  
gave only Wf activity in the organic fraction and If ?retention.? ?The inorganic  
ie activity consisted of Re\*3, Re\*# and Re\*?,

Molybdenum-99 - 99m has been prepared as a source of Pm, by activating  
K<sub>2</sub>MoO<sub>4</sub>·2H<sub>2</sub>O. The unchanged salt was precipitated with ethanol. From an  
elemental fraction, showing the same activity as the starting material

Silanes - The Si activities formed in the activation of tetraphenyl-  
silane, triphenylsilane and diphenylsilane were separated by chromatography on  
alumina from benzene, after washing out the silicic acid activity with sodium

Paraguayan woods

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## NUCLEAR ENGINEERING

The Nuclear Engineering Division teaches graduate courses at UFR, Yaguajay and conducts research in nuclear engineering. The staff also directs the research of nuclear engineering students from UPR and from other universities in the United States and Latin America. In addition, the Division offers guest courses for scientists, engineers, and technicians, and for scientists engaged in individual research,

## EDUCATIONAL ACTIVITIES

Master of Science Degree Program

UPR at Mayaguez, in close cooperation with PRIC's Nuclear Engineering Division, offers the Master of Science degree in Nuclear Engineering. The closeness of this relationship is illustrated by the fact that the faculty of

the UPR Department of Nuclear Engineering is composed largely of staff members of the PRIC Nuclear Engineering Division; the director of the UPR department is head of the PRIC division as well. The Division also provides the classrooms, offices, laboratories, equipment, and administrative personnel necessary for the education and training of UPR nuclear engineering students. The Masters degree in Nuclear Engineering requires 30 hours of graduate work and the satisfactory completion of @ thesis. A bachelor's degree in engineering is a prerequisite.

?The basic pedagogical method is the presentation of lectures, strongly reinforced by laboratory work with various types of radiation counting equipment, the subcritical reactor, the L-77 low power reactor, and the PRNC one-megawatt reactor. The student is encouraged to use both an analog and digital computer and to present a seminar on his research to the FRIC staff. Students are guided to choose research topics related to their specific interests and those of their sponsoring countries or organizations. A description of the courses included in the nuclear engineering curricula follows:

Nuclear Reactor Technology. Three lectures and one three-hour laboratory demonstration period per week Steady-state and transient thermal conduction in fuel elements; thermal convection in heat-exchanger design; liquid metal system; breeding and conversion; an introduction to the economics of reactor operations reactor engineering design problems.

Nuclear Measurements and Instrumentation. One lecture and two three-hour laboratories per week. Characteristics of operation and a thorough familiarization with the application of specialized techniques such as: coincidence and:

anticoincidence counting, pulse analysis, neutron spectrometry, and gamma ray spectrometry.

Elements of Nuclear Engineering. Four lectures per week include character-  
istics of SIERS, alpha and beta radioactive decay, interaction of radiation with  
matter, and basic neutronics.

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Grace Seiea mo

seven pine iar suas End SEEM rrr at etn og

Reactor theory, three

+ Three lecture =

quarter SSSStge cory "ures per week. Consist of neutron balance

periaset een eteorys and slowing down theory, bare homogenous reactor,

theory and transport theory, time dependent reactors portent

Advanced Reactor Theo,

. ?Three lectures per week. Advanced tr

?theory, reactor kinetics reactor theory Meee transport

?and heterogeneous reactor theory,

Reactor Laboratory. One lecture and one three-hour design per  
Laboratory problems involving the nuclear reactor. 3 Periods per week,

Nuclear Engineering Application of Wave Mechanics I. two lecture  
periods per week. | Thermal behavior and properties of reactor fuel- fission

Properties of fuel elements. Collision theory. Moderator temperature  
coefficient. Doppler Effect. \* 2 periods

Nuclear Engineering Application of Wave Mechanics II. two lecture  
periods per week. A continuation of the same topics covered in the "Wave Mechanics  
I" Course, including perturbation and control rod theory and the effect of an  
isotropic scattering.

Special Problems. One to three periods per week each semester related to  
the investigation of special problems in Nuclear Engineering.

Research, No credit. The student is awarded six credits for his thesis

upon satisfactory completion and presentation of a thesis. One to twelve  
Research periods per week. Research in the field of nuclear engineering.

Mathematics of Modern Science I. Three lectures per week in determinants  
and matrices, finite differences, Fourier series and integrals, and Laplace  
transformation.

Mathematics of Modern Science II. Three lectures per week. Partial  
differential equations, Bessel functions and Legendre polynomials, and complex  
variables.

#### Supplementary Courses

Nuclear Reactor Metallurgy. Two lectures and one three-hour lab session  
each week. An Introduction to elementary physical metallurgy of the principal  
reactor materials such as aluminum, zirconium, uranium, and high temperature  
alloys; mechanical properties; fabrication of nuclear fuels; radiation damage  
to reactor components,

Introduction to Nuclear Engineering. For advanced undergraduate and non-  
nuclear engineering graduate students three lectures each week in fission and  
chain reactions, elements of reactor design, utilization of nuclear energy for  
power, and radiation problems.

#### New Courses

wont

Peaceful Use of Nuclear Explosives. For graduate or advanced undergraduate engineers and Technicians were given Lectures on the basic engineering concepts of nuclear explosives, nuclear physics as applied to health and safety, structural mechanics and the application of nuclear explosives to large-scale engineering projects,

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During the Spring of 1968 a special problems course, Nuclear Civil Engineering, was offered jointly by the Civil and the Nuclear Engineering Department:

The course was taught by Dr. Luis Mora Faria of the Civil Engineering Department and Dr. Knud Pedersen of the Nuclear Engineering Department.

Although practical, peaceful applications of nuclear explosives have not yet been achieved, a large amount of research is being conducted in this field, and the results indicate that an introduction of this knowledge to civil and nuclear engineering students is advantageous.

Hon-Degree Program

In cooperation with the Reactor Division, a special five month course in Reactor Physics was offered for PRNC reactor operators in order to review and upgrade their knowledge in this area.

The academic aspects of the program were presented by the Division of

Nuclear Engineering. The applied aspects were obtained by on-the-job training in the Reactor Division.

## STUDENTS

During 1968, one student from Mexico, one from Nationalist China, and ten students from Puerto Rico participated in the M.S. Degree Program and a total of 18 students (five from foreign countries) in fields other than Nuclear Engineering took semester length courses taught by the staff of the Division of Nuclear Engineering. One graduate student of the Physics Department conducted her research in the Nuclear Engineering Division under the supervision of a PRIC staff member.

The 12 students in the Masters degree program are listed by name, country of origin, and sponsor in Table 1.

Six students had papers accepted for presentation at the Seventh Annual Student Conference of the American Nuclear Society at the University of Florida

(prin b-7):

1. Gilberto Vélez Delgado, "Measurement of Temperature Distribution in the Water Pool of PRIC Reactor"
2. Cho Fu lee, "Depletion Calculations on Several Reactor Models."
3. Fernando Lépez Carrasco, "Determination of the Transfer Function and Certain Neutron Kinetics Parameters of the I-77 Reactor.?"
- 4, Fernando Pérez Bracetti, "Use of a Gamma Ray Threshold Detector in Reactor Control.?"
5. Antonio Rivera Cordero, "Investigation of Gas Produced by the Nuclear Irradiation of Barytes Concrete Containing a Boron Additive.?"
6. tate Rivera Gyols, "Thiiclysis of Hydrogen Chloride in « nucleaz

Mr. Lee and Mr. Lépez Carrasco were unable to attend the conference and present their papers since both had finished their research and returned to their home countries before April, 1968.

Six students obtained the M.S. degree in Nuclear Engineering from UPR, Mayaguez during 1968. The list of students and their date of graduation is found in Table 2.

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The progress of students active in the Nuclear Engineering degree programs is shown in Table 3.

Mr. Lee, since returning to China, has been working in the Design and Planning Section of the Taiwan Power Company.

Mr. Lopez is now in a reactor supervisory position with the "Comité Nacional de Energía Nuclear" of Mexico.

#### TABLE 1

Students enrolled in Master of Science Degree Program

Name Country of Origin Sponsor

Cho-fu Lee Nationalist China IAEA

Fernando López Carrasco Mexico NEN

Fernando Pérez Bracetti Puerto Rico Self

Antonio Rivera Cordero Puerto Rico ABC

Enrique Rivera Oyola Puerto Rico EC

Rafael L. Ufret Acevedo Puerto Rico EC

Gitberto Vélez Delgado Puerto Rico FRARA

Francisco Roafríguez Perazza Puerto Rico UPR

Rafael Alcalá Quesada Puerto Rico ABC

Braulio Mejfa Avité: Puerto Rico ?ABC

José Castro Montalvo Puerto Rico ABC

Antonio Castro Rosario Puerto Rico Selt

SS

TABLE 3

Progress of Nuclear Engineering Students in 1968

eee

Students who received the M.S. degree 6

in Mclear Engineering during 1966

Students who have completed all course work L

for degree (presently working on theses)

students engaged Sn course work for M.S.

degree in lclear Engineering 5

ee

22

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Master of Sei

TABLE 2

ice Degrees in Nuclear Engineering 1968

- Research Graduation

a Director Date

Lee, Cho-fu "A Stuy of Computational Methods Dr. Gileadi, May, 1968

Used to Determine Fuel Depletion Aviva E.

in fuclear Reactors"

Lépez Carrasco, "Determination of the Transfer Dr. Gileadi, Nay, 1968

Fernando" Function and Certain Kinetics Aviva E.

Ferometers of the L-77 Reactor"

Pérez Bracetti, "Use of a Gamma Ray Threshold Dr. Ortiz, Eddie May, 1968,

Fernando? Detector in Reactor Control?

Rivera Cordero, "Investigation of Gas Produced Dr. Sasacer, Dec. 1968

?Antonio? by the Nuclear Irradiation of Donald 8.

Barytes Concrete Containing a

Boron Additive?

Rivera Qyola, "Radiolysis of Hydrogen Chloride Dr. Lee, Rupert Sept. 196

Tutorials in Nuclear Reactor"

Vélez Delgado, "Measurements of Temperature Mr. Berceld, Yay, 1968

Gilberto? Distribution in the Water Pool Héctor

of Puerto Rico Nuclear Center

Reactor"

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## RESEARCH PROJECTS

The research projects of the division, in process or completed during last year are as follows:

1, Determination of Reactor Transfer Functions and Certain Neutron Kinetic Parameters (A. E. Gileadi, F. Lopez Carrasco). The value of  $\beta/K$  was determined from the transfer function of the L-77 reactor by the use of a pile oscillator. Project completed in May 1968.

2, Population Models for Suppression of Sugarcane Borer (D. Walker, XK, Pedersen). Two population models for the suppression of the sugarcane borer *Dintraea saccharalis* Fab. (Crambidae, Lepidoptera) were investigated to determine if the release of irradiated adults would manifest sterility in the F<sub>1</sub> and subsequent generations. Project completed in December 1968.

3. Determination of Certain Neutron Kinetic Parameters by Means of Stochastic Methods (A. E. Gileadi). The applicability of stochastic methods including Rossi-alpha, variance to mean auto correlation to determine reactor transfer functions and certain neutron kinetic parameters, is studied, using a fast response time analyzer. The obtained data are processed on the 18M 360/40 computer. In progress.

4. Fuel Burn Up Studies (A. E. Gileadi, Cho-fu Lee). A computer code was written and used to determine the burn up in a water moderated reactor fueled with a mixture of <sup>235</sup>U/<sup>238</sup>U. To date this code has been used for two reactor models. Completed in May 1968.

## 5. Gas Evolution of Borated Concrete in a Neutron Environment

(D. 8. Sasscer, A. Rivers Cordero). The rate of gas produced as a function of the boron content in heavy concrete is determined by placing a sample of concrete in the pool of the PRIC reactor and monitoring the amount of gas produced as a function of time. In process.

## 6. Activation Analysis in Water Pollution Studies (K. B. Pedersen).

Determination of aluminum content by activation analysis has been used to measure the pollution of Mayaguez Bay. In process.

## 7. Calculation of Time and Space Dependent Neutron Densities Following a

Point Source in an Infinite Medium (H. E. Lisa, N. Rodrigues Feresza) The time and space dependent contaminant concentration due to a three dimensional block-shaped instantaneous source diffusing within an infinite medium is being computed. In process.

## 8. Initial Testing Program of the PRIC-TRIGA Reactor (A. E. Gilead).

The PRIC-TRIGA Reactor will be the first reactor of its type in operation. A testing program is, therefore, being designed to determine the pertinent characteristics of the reactor, In process,

9. Measurement of Fluorescent Radiation in Various Substances Induced by Radioisotope Gamma Ray Sources (E. Ortiz, K. Pagan de Ranirec). Gamma rays ?  
?Flom 8 Son soaies TANT oa Puatator, ekctidrg iva ehvonctersatic teray

spectrum. The X-rays are detected by a proportional chamber and the electric Pulses from the chamber are analyzed by a Multichannel Analyzer, In process.

10, Vertical Biological Transport in the Ocean (A. E. Gileait). A mathematical model of the vertical biological transport in the ocean 13 being to aid the work of the Marine Biology Division of PRIC. In process.

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Applied nuclear Power Engineering for Practicing Engineers (K. Pedersen), studies are being conducted with BF<sub>3</sub> the Glow and Di D. 3. Sasser for Entering to be used in a book to be published by the firm of Barnes and We'll aid the engineering understanding of nuclear power Plants. In process

12, Escape Peaks From a Proportional Chamber (B. Ort{z). When the energy  
By of the Incident radiation is Zero in the direction of the  
gas in a chamber, a spurious line appears in the spectrum. A study of the  
spurious lines is being made. In progress.

13. Effects of the Temperature and Time of Heating on the Leaching of a  
Copper Chalcopyrite Type Ore in Sulfuric Acid Solutions (- J. Maloa)  
Copper ore identified by X-ray diffraction techniques as chalcopyrite ( $\text{CuFeS}_2$ )  
was heated to different temperatures for various times. The heated samples  
showed an increased leachability of copper from samples heated up to  $350^\circ\text{C}$  as  
well as sharp reduction in its solubility from ore samples heated at higher  
temperatures. Completed September 1968.

24. Energy Deposition in Shock Wave in Media (Fausto J. Mufioz-Ribadenetra).  
The aim is to calculate the energy deposited by the shock wave in media and  
derive the relationships of this energy, with the possible induced vibration of  
atoms in the crystal of chalcopyrite or on its molecular rearrangement, or with  
the activation energy required for the desulfurization of this copper ore. In  
progress.

25. Technological Studies on the Leaching of Chalcopyrite (P. J. Mufioz).

Studies have been initiated as to its possible technological importance, using different concentrations of sulfuric acid, sulfuric acid plus oxidants, and other leaching agents, to the long-term increasing solubility of chalcopyrite when it has been heated up to 350°C. In progress.

#### 16. Development of Prediction Equations for Cratering from Models

(x, 3. Pedersen). By using distorted model theory in conjunction with properly designed models a method is proposed whereby it is possible to predict properties of craters whose variables fall outside the ranges of direct test experience. Completed October 1968.

#### 17. Computation of Time and Space Dependent Contaminant Concentration Due

to a Planar, Cylindrical, Spherical, or Point Source in a Three-Dimensional Block Shaped Instantaneous Source Diffusing within an

infinite Medium (open see) by A. B. Gilad, Prepared at the request of Drs.

F. Lowman and S. Barnes for the American Institute of Biological Sciences held

in Columbus, Ohio. September 4, 1968.

#### STAFF ACTIVITIES

Dr. Sack Gharnick, Toad of the Theoretical

prone nge amity Meet we eee i ae ae,

November. Dr. Chernick is advising the Siveion {in ite research projects,

ae .ctures to nuclear engineering st aden 8 and semins el ne ea

giving Lectures [? Using hie stay with PRI to complete a book on react

Trp sadiions Meat be at FRG wnt My 1959.

Dr. Aviva 5. Gi was @ Guest Research Collaborator with the tluclear

B. Gileadi was a Guest Reses

anginesring Division of the Brookhaven Tationel Laboratory from June 10 to

ingine

July 20, 1968.

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Dr. Knud B. Pedersen attended a short course (Nay 7-10, 1968) to fwattiar-  
ize nuclear engineering educators with the facilities of OR.

Dr. Eddie Ortiz attended The Small Accelerators for Teaching and Research  
Conference (April 8-11, 1968) at Oak Rlage, Tennessee, held to acquaint partici  
Pants with educational uses of a small aceølerator (Jess than 0.5 Nev).

Dr. Ortiz was a participant at the Institute in Small Accelerators (July 6-Aug 23, 1968) at Oak Ridge, Tennessee. The purpose was to acquaint the Participants with educational and research uses of various types of accelerators in the energy range from 150 Kev - 5 Mev.

Dr. Ortiz, Dr. Gileadi and Dr. Sasscer attended the Ninth Annual AUA-ANL, Nuclear Engineering Education Conference held at the Argonne National Laboratory (arch 25-26)

Dr. Federsen and Dr. Sasscer attended the joint meeting of the ANS-CUS held in Toronto, Canada in June.

Dr. Gileadi attended the American Nuclear Society Winter Meeting and conference on the Constructive Uses of Atomic Energy held in Washington, D. C. (ov, 11-15, 1968).

Dr. Sasscer attended the Conference on Abundant Nuclear Energy held at Gatlinburg, Tennessee from (August 26-29, 1968).

ADDITIONAL, INFORMATION

During the year the Division has

sn becoming engaged in a new, major

area of teaching and research, called "plovehare", or the peaceful uses of

nuclear devices. ?The research has been conducted by F. J. uloz Ribadeneira,  
and K. B. Pedersen and the teaching by Dr. Pedersen,

Taree publications (See appendix) have resulted from this research. ?The

research projects pertain to : (a) in situ mining by nuclear devices, specific-  
ally, the leachability of chalcopyrite ( $\text{CuPeS}$ ,) in sulfuric acid solutions and,  
(b) applications of distorted model theory topredicting cratering dinenaions,

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(1) De. Amador Cobas, deputy air  
alio heads the Physical Sc

(2) Dr. Manfred Eberhardt works at an IBM card pu

preparation for molecular orbital calculation:

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## PHYSICAL SCIENCES

The long range objective of the Physical Sciences Division is to offer advanced training opportunities for Puerto Rican and Latin American trainees primarily through participation in research projects involving 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 requires heavy participation of the scientific personnel in the academic activities of the natural sciences departments of the University of Puerto Rico, Rio Piedras campus. The latter cooperative effort is encouraged through joint appointments. The Division also participates in the AEC "Atoms in Action" exhibits.

## EDUCATIONAL ACTIVITIES

The educational activities of the division range from a four-week non credit training course in the techniques of radioisotope applications to research training in the laboratories of the Center.

a) The Radioisotopes Techniques Course was offered four times during 1968.

The distribution of the fourteen trainees by geographical origin (Table I) shows seven from Puerto Rico, one from Spain, two from U.S.A., one from China, two from Colombia, and one from the Dominican Republic.

b) A course in Radiation Chemistry (PRNC 505, two credits) for M.S. students in Health Physics was taught by Dr. Alec Grimison and Dr. Manfred Eberhardt, with the participation of four students,

c) University courses:

1. Advanced Physical Chemistry (Chem. 6h, three credits). A one-semester graduate course, taught twice by Dr. Alec Grimison, with a total of thirty students.

2, Photochemistry and Radiation Chemistry (Chem. 660, three credits)  
A one semester graduate course, taught by Dr. George A. Simpson, with three students,

3. Undergraduate Inorganic Chemistry (Chem. 311, three credits). A one semester course, taught by Dr. Nariel muir, with thirty students.

4, Advanced Inorganic Chemistry (Chem. 521). The second semester of a two-semester graduate course, taught by Dr. Mariel Muir, with ten students.

5. Graduate Research (Chem. 599 or Phys. 501, one to six credit). Graduate students supervised by PRNC personnel and their geographical origins are shown in Table II.

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6, Undergraduate Research Training. Three senior science students took advantage of FRIO's research training opportunities during 1968; José Marrero and César Cordero with Drs. A. Cobas and 8. Z. Weisz; Janice Petrovich with Dr. J.P. A. Casterton.

#### PARTICIPATION IN THE "ATONS IN ACTION" HaTBITS

Dr. Alec Grinizon participated in the "atone in Action? exhibit in

jela (April 27-May 5, 1968). He presented two lectures in

"Radiation Chemistry of Organic Glasses" at the Instituto Venezolano de Investigaciones Científicas (IVIC), and "Uses of Radioisotopes in Scientific Research" at the Central University, Caracas. A special project was initiated on the thermoluminescence of gamma-irradiated uracil and cytosine, coupled with electron spin resonance measurements in conjunction with Dr. Benski, of the Physics Department, IVIC.

Dr. José Castrilién participated in the "Atoms in Action" exhibit in Córdoba, Argentina (October 26 - November 2, 1958). He presented three lectures to the Institute of Chemical Sciences, University of Córdoba on "The Use of Radioisotopes in Organic Chemistry", and two seminars for the Biological Chemistry Group at the University of Córdoba on "Liquid Scintillation Counting".

Research projects were initiated on the tritium labelling of sphingosine and dihydrosphingosine, using the catalytic technique, and on the use of tracers in the study of the oxidation of aldehydes with *n*-bromosuccinamide

## MESTEING LECTURERS

During 1968 the following visiting lecturers presented conferences of particular interest to the division staff:

February 23, Dr. G. J. Dienes, Hea Solid State Physics Group, Brookhaven ational Taboratory. "The Properties of Suall Substitutional Impurities in the Alkali Halides."

April 10, Dr. Allan Maccoll; Reader in Physical Chenistry, Untversity Coliege London, London, England. "Mass Spectroscopy".

May 28, 29: Dr. Martin Pope, Solid State Physics and Radiation Laboratory, Dept."of Piytlce, How York University, \*autctonsvation ia see son at "Photoconductivity as a Spectroscopic Adjunct."

June 12, 13, Dr. Marvin Silver, Organic Crystals Solia State Physics Project, Dept. of Physics, University of Worth Carolina. "Stuly of quasi Free Electrons in Liquid Heliun by Electron Injection,? ani "Determination of Electronic States in Anthracene from a Study of the Texperature Dependence of ?the Recombination Coefficient.?"

July 11, Dr. Gabriel Chuchant, Head Chemistry Dept., Instituto Venezolano de Investigaciones Científicas (IVIC), Caracas. "The Effects of Amino Groups in Aromatic Electrophilic Substitution."

July 18, Dr. Michael Barfield, Chemistry Dept., University of Arizona.  
"Theory of Nuclear Spin-Spin Coupling."

August 8, Dr. D. A. Armstrong, Chemistry Dept., University of Calgary, Canada, Madhwalyste of Aqueous Solutions of Selenite Coe

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ing November 6) Dr. David Skelly, General Electric Research Laboratory.  
"A Novel Photographic Process: Photoplastic Recording."

STAFF CHANGES,

Dr. Harry Szmant, Division Head, who had been on leave of absence in the Dominican Republic, resigned from PANC in August 1968. Dr. Senant has accepted position as Chairman of the Chemistry Department, University of Detroit.

Two of the graduate students working with Dr. Senant, A. Birke (Chile) and A. Yata (Costa Rica) will shortly join him at the University of Detroit. The

remainder have transferred to work under the supervision of Dr. Castrillón.

Mr. Gerardo Molina, Research Associate, resigned from the Division in September, 1968, and has entered the graduate school, Duke University, to study for the Ph.D. degree in Chemistry.

Miss Dolores Julian has joined the Division staff as Research Assistant. She completed the research for her M.S. thesis in Radiation Chemistry under the direction of Dr. Owen Wheeler, PRC, Mayaguez. Mica Julian will soon present this thesis for the M.S. degree.

#### SCIENTIFIC MEETINGS AND COURSES OUTSIDE PUERTO RICO

March 17-20, 1968: American Physical Society Meeting, University of California, Berkeley. Attended by A. Cobas and S. Z. Weisz.

March 31-April 5, 1968: American Chemical Society Meeting, San Francisco.

The following paper was presented: "Steric Effects in the Radiolysis of Cis- and Trans- 1,2-dimethylcyclohexane;" by Manfred Eberhardt.

April 6-9, 1968: American Chemical Society Short Course, San Francisco, Dr. Manfred Eberhardt received special training in Molecular Orbital Theory.

April 20-25, 1968: second Inter-American Conference on Radiochemistry, Mexico City. The following paper was presented: "Radiation Effects in Organic Glasses," by Alec Grimison.

May 4, 1968: Instituto Venezolano de Investigaciones Científicas (IVIC),

Caracas, f- Rize Grintson delivered a lecture entitled "Radiation Chemistry of Organic Glasses."

4, 1968: Central University, Caracas. Dr. Alec Grimigon delivered @ lecture entitled "Uses of Radioisotopes in Scientific Research.?"

June 28, 1968: Hebrew University, Jerusalem, Israel. Dr. 8. Z. Weisz delivered @ lecture entitled "Radiation Damage in Organic Crystals."

July gle, igéts Mth Motecuter crystal Sympostun, Enschede, etheriants,  
?The following paper was presented: "Radiation Induced Paramagnetic Centers in Anthracene and Deuterated Anthracene" by 8. Z. Weisz, J. Castellanos, A. Cobas, and G. A. Simpson.

August 20-23, 1968: Loyola University, Chicago, ILincis. Dr. George A.  
?Simpson Attended an International Conference on Molecular Luninescence.

Septenber 26, 1968: University of Montreal, Montreal. Dr. Alec Gr:  
delivered a lecture entitled "Blectron Attachnent to Fyridine aud the Diasine

---Page Break---

September 27, 1968: McGill University, Montreal. Dr. Alec Grintson delivered a Lecture entitled "Electron Attachment to Pyridine and the Diazines: Experimental and Theoretical Considerations."

October 2-23, 1968: Buck Hill Falls, Penn. Dr. S. Z. Weisz attended a Conference on Electrical Insulation and Dielectric Phenomena,

## RESEARCH

Division research can be classified under the following headings

Radiation Effects, Radioisotopic Studies, and Supporting Research. The projects are described briefly below, with the senior investigators and graduate student trainees.

Radiation Effects. These projects study the effect of high-energy deposition in chemical systems. Some of the projects emphasize the initial, or primary, products of radiation; others emphasize the final products subsequent to secondary chemical reactions. However, the aim is always to trace the detailed mechanism by which radiation-induced changes occur.

a) Stereochemical Effects in the Gamma Radiolysis of Cis- and Trans-

1,2-dimethylcyclohexane (M. K. Eberhardt). The gamma radiolysis of cis and trans-1,2-dimethylcyclohexane in the liquid phase was studied from  $2 \times 10^4$

ev/ml to  $16 \times 10^6$  ev/ml at a dose-rate of  $8.3 \times 10^{17}$  ev/ml hr<sup>-1</sup> using a <sup>60</sup>Co source,

The main products are H<sub>2</sub>, 1,2-, 2,3-, 3,4-, and 1,5-dimethylcyclohexene, cyclohexene-2, dimeric products, and isomerization. The trans compound shows a greater decrease in G(olefin) with increasing dose than the cis isomer. Iodine ( $2 \times 10^{-4}$ s) reduces G(H<sub>2</sub>) in the trans-1,2-dimethylcyclohexane from 3.54 to 2.36 (He) = 1.8, but in the cis isomer the G(H<sub>2</sub>) is only reduced from 3.70 to 3.05 (He) = 0.65. Our results suggest that the difference of unscavengable hydrogen between the two isomers  $3.05 - 2.36 = 0.69$  is due to molecular hydrogen elimination in the cis-1,2-dimethylcyclohexane, and that tertiary axial hydrogens lead preferentially to the formation of scavengable hydrogen atoms. A similar behavior was observed with cis and trans-decalin.

(b) Radiation-Induced Addition of Thiophenols to Indene (I. H. Szman and M. K. Eberhardt), The gamma-radiation induced addition of p-substituted thiophenols to indene in cyclohexane follows first order kinetics with respect to both the thiol and the olefin. In the case of p-thiocresol the bimolecular rate constant is  $1.2 \times 10^{10}$  l/mole<sup>2</sup> s at 25°. The rates give a linear Hammett Plot when sigma plus values are employed and the large, positive rho value of 2.29 is obtained. The G-values for the disappearance of p-thiocresol from an equimolar (0.5) mixture with indene is strongly solvent dependent: 720 in carbon tetrachloride, 512 in cyclohexane, 219 in benzene and 131 in 1,2-dimethoxyethane. In a competitive reaction of p-thiocresol with 1-octene and

Andene the latter olefin is more reactive. These and other observations:

Suggest a mechanism that involves the olefin and a thiol residue, and a rate-determining step favored by electron-withdrawal in the sulfur-containing moiety.

Graduate student trainee: Irma Y. Zea Ponce.

ϕ) Tritium Recoil Labelling (J. P. A. Castrillén). The analysis of samples of Lithium phenylacetate following neutron irradiation is well advanced. An alternative method of analysis via the nitration of the labelled acid 42 being studied.

Work has begun on the steric aspects of recoil labelling, and for this purpose p-phenylbutyric acid 1s being resolved into its enantiomers. Graduate student trainee: Agnes Costa.

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4) Matrix Isolation Studies of the Gamma-Radiolysis of Heterocyclic

Molecules (A. Grinson and G. A. Simpson). This project receives support from

the ABC Division of Biology and Medicine, and studies the nature of primary

species formed by gamma-irradiation of heterocyclic molecules. The work is

described fully elsewhere in this Annual Report under the 06 Program, Graduate

student trainees: Myrta Trujillo Sanchez, Francisco Bernasconi, José Revuelto

e) Radiation Damage in Organic Crystals (A. Cobas, 8. Z. Weisz, G. A. Simpson). This project receives support from the AEC Physical Sciences Division. Radiation damage in well-defined crystalline organic materials is studied by conductivity and spectroscopic measurements. The work is described fully elsewhere in this Annual Report under the 05 Program. Graduate student trainees Jaime Castellanos and Eva Arzola.

Radioisotope Studies, These projects include the use of incorporated radioactive tracer atoms, as a diagnostic aid to the study of reaction mechanisms, as well as studies of counting techniques.

fa) Oxidation of Diarylethanes (J. P. A. Castrillón). The individual steps in the synthesis of 1,1-diphenylethane have been examined in an effort to improve the yields. The synthesis of the labelled compound was later performed successfully. Oxidations of inactive samples have been carried out in preparation for the tracer experiments. Graduate student trainee: J. Colón.

b) The Influence of Chemical Structure on Quenching in Liquid Scintillation counting (J. P. A. Castrillén). To measure more accurately the quenching caused by the displacement of the C1  $\beta$ -spectrum toward lower energies, a variable Gieseler counter was calibrated using several internal conversion electron emitters. Several compounds of chosen structure have been synthesized: p,p-diacetyldianino benzophenone, p,p'-dianinobenzophenone, p-noniode benzophenone, p,p'-diiodo benzophenone. p,p'-diiodo diphenyl sulfoxide is currently being synthesized.

No clear relationship between quenching constant and chemical structure has yet been established. However, the quenching seems to be additive in the sense

that the quenching of p,p'-dihalo compounds is double that of corresponding monohalo compounds. Work using terphenyl as a scintillator has been initiated, Graduate student trainee: Elsa Gonez

Supporting Research. The projects described under this heading do not affect the use of radiation or radioisotopes. However, they exist to provide support for the previous projects by producing essential information on the systems of interest.

a) Molecular Orbital Calculation on Lactan-Lactim Tautomers (M. K. Eberhardt). Huckel MO calculations have been made on a series of lactan-lactim tautomers. These results can be related to the ability of these compounds to undergo an acylation reaction (Mannich reaction).

b) Molecular Orbital Calculations on Aminophenols and Axino thiphenols

(4. K. Boerbardt and A. Grinison, in collaboration with Dr. Gebriel Chuchant, IVIC, Caracas, Venezuela). Huckel MO calculations have been made on *o*-, *m*-, and *p*-aminophenol, and *o*-, *m*-, and *p*-aminothiophenol to explain the differences in electrophilic substitution with triphenylmethyl carbonium ion.

cc) Thioxanthone and Related Compounds (J. P. A. Castrión), to improve the method of preparation and isolation of thioxanthone sulfoxide, its ability to act as a ligand in metallic complexes was investigated. Thioxanthone

sulfoxide form stable, crystalline compounds with the group IIB metals. This led to the unexpected discovery that thioxanthone itself yields less stable complexes with these same metals. The structure of these two new families of

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compounds are being studied. Graduate student trainee: Sonia Vazquez.

Sonia Vazquez and W. Adan).

Nuclear Spin-Spin Coupling Constants (A. Grimtzon and

Castro) have been studied of the nuclear spin-spin Coupling constants in various small molecules. Only the dominant Fermi contact term was computed, using the complete perturbation expression, as well as various approximations. The best available self-consistent field wavefunctions were used. Graduate

student trainee: Philip Sprangle.

ations of C<sup>13</sup> Chemical Shifts (A. Grinison and W. Adan). The carbon 15 chemical shifts of the N-membered ring heterocyclics pyrazine, pyrimidine, pyridazine, s-triazine, s-tetrazine, and their cations and dications, and of the S-membered ring heterocyclics pyrrole, imidazole, Pyrazole, and their anions and cations have been calculated from various approximate perturbation theory expressions. The diamagnetic contribution to the shielding tensor was calculated exactly. The paramagnetic contribution was calculated using (i) individual transition energies in the full perturbation theory expression (ii) the Karplus-Pople approximation (iii) the Karplus-Das approximation, and (iv) from n-electron densities. Valence electron wavefunctions computed by the extended Huckel theory (EET) were used, in non-orthogonal and in orthogonal form. The detailed perturbation expansion fails badly; this failure can be linked to the limited basis set used in BHT calculations. The neglect of orbitals on vicinal atoms, or the use of actual orbitals, does not improve the results significantly. Good agreement with Ciseri-Bent 18 obtained by the judicious use of the average excitation energy. areca dustion and orthogonal wavefunctions. A normalized  $\xi$  parameter calculated from the EET energy values reproduces (a) the displacement of the chemical shift to higher field in the s-electronic series Gripts Celies Colise, (b) the displacement of the chemical shift to lower field on successive nitrogen substitution, and (c) the displacement of the chemical shift to higher field on excitation of the nitrogen lone pairs. The use of the x-electron approximation does not permit the latter correlation to be made with experimental data.

Graduate student trainee: Gladys Rodriguez.

£) Hetaryne Intermediates (& Grimicon and W. Adam, in collaboration with R. Hoffmann, Cornell University). The electronic structures of al) or sre Possible 1,2-, 1,3-) and 1,4~ didehydroaronsitic intermediates derives fey Pyridine and the diarines (hetaryne intermediates) have been calculated wing the extended Huckel theory (BHT). The didehydroxyridine is the Sost stabioe and the 26-didetydropyridine the least stable. Great relative statiiten se also predicted for 4,5-didehydropyrazine and 4,6-didehydromriedanes tte complex computational trends in the hetarye stabilities car be nevione zed very well by simple molecular orbital considerations of the orbiter teenies ons among non-bonding radical lobes and lone pair orbitals. ?A dearecer smreracts shown to bea nitrogen lone pair destabilization of nearby raiser tone ne calculated stability sequences and total electron aistrivutions promec an excellent correlation of the available experinental data on relative stability and orientation effects in the hetaryne intermediates,

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TABLE 1

Participants in Basic Course in Radioisotopes Techniques, 1968

Field of | Finaetat

country Tnterete =~ Sponsor

1. Martiner-S., Rey WD. Spain Mercbioleoy FRC
2. Jordan, C.F., Ph.D. United states Eeclory FETC
- +3. Ramos-S., MA. Puerto Rico (USA) Hematology felt
- 4, Ramfrez-8., C., M.De Puerto Rico (USA) Surgery ?UPR
5. Pothler, Led. United states Elochentstry Self
- 6 Riveracti., Fe Puerto Rico (USA) Odontology Self
- T. Lu, Litteyuan, Ph.D. China Blolesy self
8. ger? Rfo-R., M. Puerto Rico (USA) Mereblelogy Self
- 9 Rodriguez-A., D.C. ?Donnican Rep. ?Nuclear

Medicine elt

20. Osorions., Rit. Cotesbia Muarsacology WO
- Ui. Masger-R-, J.A., M.D. Puerto Rico (UGA) Fadiclogy UR
- 1B. ColdneL.y Joke Bierto Rico (Ust) Bloleey Pac
  
13. Soto-G., C.Hs, MaDe Puerto Rico (USA) ? Radiclogy P, R. Medical

Genter

Pade Puerto Rico (USA) ?Bioleey P. Re Health

Department

vette, c.0. corenbia Marnacclosy ? TKIA

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?Thesis Research Supervieed by Division Personnel During 1968

Student Country of Ortain supervisor

1. Arzola, Eva Puerto Rico 8. 2. Weisz, Ae Cobas

21 Bernasconi, Francisco chile ?A. Grinison, G.A. Simpson

3. Birke, Arnoldo chite H. H. Semant

4B caneio, zathh Puerto Rico 5. PL Castritién

5: Castellanos, Jaine\* Colombia 1 21 Welae, A, Cobas

6! colén, Jaine Puerto Rico 3: P. Castriniéa

7: costa, Renes Puerto Rico 3. Ps Castritién

8. Fernndez, les cube, x. war, .

9: Génez, Fite Venezuela 31 Ps Casteitién

10. Mata,? Alfonso Costa Rica Hs H. Smant

11. Rechant, Flo Puerto Rico NM. Mite

12, Riqueine, Ida cuba Hi Be Samant

1s. Rodrguer, Gladys Puerto Rico ?A. Grimison |

ab, Revuelta, José Cuba Ki Grimteon, G.A. Sinpeon

351 Trujillo, Wyrthe cuba Ki Grimieon, G.A. Einpeon

36. gprangle, Philip United states 1K. Grinizon?

V7. Zea Ponee, Irna\* Gustenaia HLF Senant, M. Poerhardt

Les egres awarded during 106.

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RADIATION CHEMISTRY PROJECT: MATRIX ISOLATION  
STUDIES OF PRODUCTS OF GAMMA-RADIOLYSIS OF  
HETEROCYCLIC MOLECULES.

\* me project aims at trapping and subsequently characterizing the spe-

Species formed by  $\gamma$ -radiolysis of heterocyclic molecules which are of possible biological importance. Emphasis is placed on direct observation of labile intermediates formed following absorption of high-energy radiation. 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. Under appropriate conditions, radicals and radical ions can be stabilized by using this method for extended periods of time and studied by spectroscopic techniques. An important part of the program involves the quantum-mechanical calculation of electronic properties of heterocyclic radicals and ions. These results are used in conjunction with the experimentally measured properties to help identify unknown intermediates.

A description of the current research topics follows:

1. Absorption Spectra of Radiolytic Intermediates at 77K. The previous Annual Report mentioned the observation of electron attachment to pyridine and the diazines by  $\gamma$ -radiolysis in 2-methyltetrahydrofuran (THF) glass at 77°K. This has now been confirmed for pyridine, pyrazine, pyridazine, and pyrimidine by studies of bleaching effects, solute concentration effects, and addition of electron scavengers. The spectra of the radical anions obtained in this way are in excellent agreement with the assignments of other workers. Hush and co-workers (Hush and H) (University of Bristol) have reported the radical anion spectra produced by chemical reduction with metallic sodium in methyltetrahydrofuran at room temperature. Kinzel and Strauss (Kinzel and Strauss) (University of California) produced the same species by electrolytic reduction in liquid ammonia. The results are shown in Tables 1-4, together with the theoretical predictions

(see later). This work has been presented for publication.

2. Thermoluminescence following Radiolysis at 77°K. Thermoluminescence following  $\gamma$ -radiolysis of biologically significant compounds has been detected by several investigators. Some qualitative observations are summarized in Table 5. After irradiating the listed compounds at 77°K to a dose of approximately  $3 \times 10^7$  rads, luminescence can be observed visually on warming in the dark. For adenine, cytosine, DNA, guanine, thymine, and uracil, these observations confirm earlier work. While 2, 4, 5 triphenylimidazole gave a yellow emission, all other luminescences were blue. Triphenylimidazole 4s known to have yellow phosphorescence bands. The previous Annual Report mentioned a blue (450 nm) thermoluminescence of DNA in irradiated 3-methylpentane glasses. The blue phosphorescence bands of unirradiated DNA and the pyrimidine bases are well known.

A rationale of the observed luminescence bands (which is confirmed by more detailed studies) is that the observed thermoluminescence is due to re-

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normal phosphorescence of the unirradiated molecule,

### 3. Thermoluminescence

BSR Signals following Radiolysis at Room

Benge

tite, «fa conjunction with Dr. Gesdki (Instituto Venezolano de. Tnvestig ee

Tientiticas) comparative studies were maie of the ESR signal and the:

science following Toon temperatare radiolyste of blotosteetiy nace ye

cemgouids. Figure 1 shove the ESR epestrim Gaignd fon arisen

porter ie rAlcal aavoiated with thio anoymctical tn enencin ol

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The absence of detail is characteristic of powdered samples. The g-value Cai |

the Wath suggest ?a neutral raitcey with the ipaired deciror toetig |

a carbon ator joined to two fydropen atonsy A siatiar speceton iorelsed

from irradiated uracil, the prevalence of these radicals is approximately  
{yettsent following Srjagation, the efficiency of production of Talat Sag,  
Loot the order of  $10^{10}$  radicals per 100 eV absorbed?

saturation of the reaction, at room temperature, |

|

Following irradiation of thymine, cytosine, alanine, purine, guanine, or ?  
uracil to doses up to  $6 \times 10^4$  rads at room temperature, @ thermoluminescence. ie  
Produced with a yield approximately one-tenth that from @ reactions  
Frosted sample of lithium fluoride, and 46% linear with dose in the range cited, |  
For cytosine and uracil the maximum thermoluminescence is obtained free 6a |  
 $155^\circ\text{C}$ , which suggests a trap depth of about 1 eV. |

if it is assumed that the trapped species giving rise to the thermolumi-  
nescence is associated with the free radical center observed by ESR, then the  
luminescent process can be attributed to chemiluminescence resulting from  
radical diffusion and annihilation in the crystalline matrix.

4, Photosensitized Several mechanisms of photo:

Sensitization have the most significant of these for

biological systems appears to be the low energy, or biphotonic, process which involves absorption of Light by the triplet state of the molecule. However, little direct evidence has been presented for the occurrence of biphotonic photoionization in heterocyclic molecules.

A test for photoionization is the occurrence of recombination luminescence subsequent to photolysis. This may be observed as thermoluminescence, optical stimulated luminescence, or prolonged isothermal luminescence. Table 6 reports on observed prolonged isothermal luminescence for a variety of aromatic amines and heterocyclic compounds in glasses at 77K, after brief exposure to an intense UV source. This isothermal luminescence may last as long as 3 hours. The table lists the compounds in order of efficiency of production of prolonged luminescence, together with the normal phosphores

Predicted by the biphotonic mechanism. Moreover, in the cases where we have obtained the photolysis intensity dependence of the luminescence, a squared dependence is obtained, as required by the biphotonic mechanism?

Jong. | Farise-Farr-Pople calculations have been carried out for the photoionization of neutral molecules and their radical anions and radical cations: pyrrole, furan

Hutophene, ryridine, pyrinidine, pyrazine, and pyridazine. These eeleslat io  
included limited Configuration Interaction, and used the couputer program des  
erived in the previous Annual Report.

The agreenent obtained with the well-characterized absorption spectra of

Spe antral molecules vas very good. In harrony with recent theories, the  
of a very Limited configuration interaction woreens the acreemont with exper=®

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?ranestion Bnergies (eV) For Toe Pyridine Anion

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3.6 (.25)

898 (205) 5.21 (2) 5.22 (123) 5.54 (28)

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Thermal Values of Irradiated Vals

Transition Energy (eV) For The Pridasiee Anion

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52 ose) 2.66 (085) 33 ee

5.3 (Ba) 3B (3

Sins sragS wise

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TABLE 5

Compounds Irradiated at T7°K Giving Thernolusinescence

Compound ?Observed Intensity

Aeridine Strong

?Adenine Strong,

Anthracene ewe

?Ascorbic acsa Weak

Benzinsdazole Strong

Benzotriagole Wear

Strong

Strong

Strong

Woae

Tone

one

oak

Henatoporphorin ous

L, hetidine eae

Indole wear

Teidercie Wea

Indasole eax

Senethyleytosine eax

Lplo-phenanthroLine eax

Pirine Strong

Pyrazcle eax

Byranine 3 one

Byronine ¥ Strong

Sodium chloride oak

Sucrose Weak

Tetrapheny) pyrrole

Talonine

Triphery2 anine

2yk5-tréphenyl imidazole (TPr)

Thysine

Ursesi

Xanthine

GY geppunie iad Wise easton, exept HPT Wich appeared Blu. dove aprox.

'3 X10" rade).

?ABLE 6

Compounds Undergoing Phototontzation At TIX In MIKF

?In Order OF Decreasing Bffickency

Compu Liretie (Seconds)

Indole

?ripbenylanine

Indacole

Tetrapherylpyrrole

?Frotused one second exposures to « 1000 watt high procure cerouy INAp:

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SOLID STATE PHYSICS

STUDY OF RADIATION DAMAGE IN ORGANIC CRYSTALS

The primary interest in this project is to study the effects of radiation on 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. Anthracene was chosen as the initial material to be studied because: (1) large, very pure anthracene crystals can be obtained; (2) much is known about its electrical and optical properties; (3) radiation damage due to high doses of neutron and gamma irradiation in anthracene has been studied.

Radiation damage in anthracene after gamma irradiation in the high dose range (larger than 10<sup>5</sup> rad) was studied by measuring the degradation of its fluorescence. Radiation damage due to neutron irradiation was studied by measuring the changes in the photoconductivity properties

## ACHTEVEEITS

### 1. Electron Spin Resonance (ESR) Measurements in Anthracene C<sub>10</sub>H<sub>8</sub> and

Deuterated Anthracene C<sub>10</sub>H<sub>7</sub>D. Several types of damage centers are introduced

Ty iivaliating enthvacene with gusma rays. These defects are detected by  
Girterent methods such ast delayed fluorescence, fluorescence, optical absorp-  
tion, space charge Limited currents (A description of detecting radietion

?by these methods is given in PRIC-58 and PRIC 107.) and electron spin resonance.

Crystals irradiated with doses up to 10Y rad were dissolved and analyzed by

thin layer chronstograply but m0 traces of impurities could be found. In spite

Of the extensive stuly of the radiation damage in anthracene Until now, only

the nature of the paramagnetic centers could be revealed. Tt became possible

to Identity these centers by stuiying the ESR spectra of gama irradiated

anthracene and deuterated arthracene. Doses up to  $7 \times 10$  rad were measured.

The spectra of the gamma irradiated anthracene was found to be that expected

from three equivalent spin  $1/2$  nuclei coupling with an unpaired electron. The

incenstty rutioo and hyperfing, goiteings are approxisately the sane as for the

methyl radical. Blum et. al.(1) suggested that the spectra results from the

hyperfine interaction of 3 equivalent protons on a Linear segment of a dinerte

anthracene radical. It was anticipated that 1f the proposed cross-linking

between the anthracene nolectles is indeed produced, then the spectra of the

paramagnetic centers produced on irradiation of deuterated anthracene will be

considerably narrovers They would be less than  $1/3$  of the methys radical ant

have a7 Line structure with intensity distribution of 1:3:6:

spectra obtained in ganna irradiated deuterated anthracene was very close to

the predicted one. A small excesa in the width of the spectra 18 thought to

be due to the partially deuterated anthracene Cy,DgH which is noninally presest

in the sample. Since the Cyidolf has only one hydrogen, at low concentrations all the nearest neighbors in the crystal lattice would be fully deuterated and the Temultant radical could have no more than one hydrogen. Hence, the spectrum

1. Blum, et. al. Mol. Cryst. 3, 269 (1967).

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obtained is that of a mixture of deuterated and partially deuterated radicals

Studies of ESR spectra produced by irradiation of selectively deuterated anthracene should provide even greater insight into the nature of the gamma ray induced paramagnetic centers in anthracene.

2. Annealing of the Triplet Quenching Radiation Damage in Anthracene.

has been described in HACE on PREDICTIONS of irradiation induced triplet quenching centers in anthracene. Due to the long diffusion length of the triplet excitons in pure crystals, concentrations of damage centers as low as  $10^{10}$  W/cm<sup>2</sup> can be detected. From transient delayed fluorescence measurements it was found that these damage centers shorten the monomolecular lifetime of the triplet excitons. These centers are stable at room temperature for more than one year. Annealing the crystal at 120°C, the change in the monomolecular lifetime is restored by approximately 30%. The ability to anneal these centers at relatively low temperature suggests that these defects are physical ones. Measurements now in progress of the lifetime of the triplets in anthracene grown from irradiated powder can reveal more about the nature of these centers.

3. Photoenhanced Space Charge Limited Currents. Several authors reported recently on observation of interactions of triplet excitons with trapped and free electrons, respectively. Our calculations indicate that radiation damage measurements on the photoenhanced electron space charge limited currents in anthracene can distinguish between the two processes. The measurements are made on solution grown crystals. Sodium amalgam is used as the electron injecting electrode. It is found that electron traps are induced in anthracene by gamma rays. For radiation doses higher than 10<sup>18</sup> rads the changes in log J vs log V curves are similar to those for hole currents. The trap filled limit voltage is shifted toward higher voltages. A change in the slope of the curve is also observed. The sodium amalgam is oxidized very rapidly in air. To obtain quantitative results and to perform the photoenhanced current measurements, an electrode system is built so that the measurements may be performed in vacuum.

## LABORATORY. SPACE

?This project is housed in the Facundo Bueso Science Building at the U.P.R. Rio Piedras Campus because of the space shortage in the PRIC Bio-Medical Building. The project began in January 1962, in a 360 square foot room. In February 1965, the project was moved into a room with approximately 900 square feet of floor space. Two offices with a combined area of approximately 240 square feet were also provided. The increase in space has made it possible to set up the equipment more advantageously and to add to the staff.

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## CLINICAL RADIOISOTOPE APPLICATIONS

?The Clinical Division of Radioisotopes teaches physicians and allied personnel to handle and use radioisotopes in nuclear medicine, This consists

primarily of the diagnostic aspects of the various applications of radioisotopes to the study of human diseases

A basic course is offered twice annually for medical personnel wishing to qualify for a radioisotope license to engage in this type of medical practice. Activities offered to other trainees include extension of training, special projects or specialty courses.

The Division participates in teaching nurses, medical students and technologists by organizing visits to the Laboratory, clinical conferences, consultations and clinic rounds and teaching courses.

## EDUCATIONAL ACTIVITIES

The Division offers the following courses:

### Basic Clinical Radioisotope Application Course

This week course consists of clinical conferences which stress the

usefulness of radioisotopes in the resolution of a diagnostic problem. Therapy with internal emitters is also included. Laboratory procedures are keyed to the clinical material which is selected to provide a wide variety of clinical states which come into the trainee's consideration, to cover general presentation of the various applications available in current practice in nuclear medicine.

Subject matter treated in this course includes: thyroid disorders, cardiovascular system, liver and kidney function, gastrointestinal absorption, hematological applications, analysis of fluid compartments and electrolyte turnover, tumor localization, organ visualization, and radioisotope therapy of thyroid disorders.

Trainees and teaching staff correlate points of clinical interest with the various tests performed. Teaching is based on demonstrations, laboratory performance of tests, discussions of results, conferences and audiovisual Presentations.

The course is satisfied when the student completes at least 60 adequately performed diagnostic procedures and evaluates and treats 3 patients with thyroid disorders (Table 1).

Nuclear Medicine Course for Medical Technologists

This course, offered this winter for the first time to students of the Medical School of the University of Puerto Rico, consists of 9 sessions, of

hours each, in which clinical conferences and laboratory procedures of the major areas of diagnosis in nuclear medicine were presented. The Medical

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technology student is thus offered the opportunity to learn about this discipline and encouraged to extend training in this field.

#### Informal Courses

acquire practical, laboratory experience working with patients under the guidance of more, clinical and laboratory experience are available in thyroid

See also the localization studies,

there were 43 participants in the nuclear medicine course for medical technicians. Thirty-two participants were also participants in our other courses, they were 16 (47%) and those professional backgrounds and countries of origin appear in Table 1 & 2.

The various teaching and diagnostic or therapeutic procedures done for or by

See also the following table

See also the following table

## RESEARCH IN PROGRESS

Evaluation of antithyroid effect in hyperthyroid patients with Radioiodine

Seetharam

During the past year 13 new patients were included in this study. The radioiodine uptake at 24 hours averaged 77%, which under tapazole administration fell to 35.8% at 3 hours and to 17.4% at 24 hours. There were 12 patients under the effect of tapazole whose residual uptake values at 24 hours were above one fourth of the 3 hours value. By this criterion, only one patient would have been predicted sensitive to the drug. However when the 24 hour values post tapazole were compared with the 24 hour pre-tapazole uptakes, only 3 patients showed residual 24 hour uptakes above one fourth of the baseline values at 24 hours. When the KCNS discharge test was given to 7 patients, significant discharge of iodide was observed in all of them. By this approach all 7 patients showed considerable blockade of thyroid hormone synthesis and consequently, they are expected to respond well to drug therapy.

Thirteen patients were studied with propylthiouracil. 24 Hour baseline Radioiodine uptake, compared to 3 and 24 hour uptake values under propylthiouracil effect, showed depression of radioiodine uptake by the thyroid gland, but not as marked as in the cases under the influence of tapazole. The patients had average baseline radioactive uptake values of 75.043 under propylthiouracil. The 3 hour and 24 hour uptake values averaged 46.0% and 39.9%, respectively. None of these patients could have been judged responsive to the drug on the basis of a comparison of the 2 hour uptake value under propylthiouracil with 3 hour uptake, also under this drug, or with the 24 hour baseline values. When the EERE Glseinzge toet was given to 6 patients medicated with propylthiouracil, a strong response was observed in 3 of them. The detection of response by the HOIS discharge method is related to the fact that the degree of thyroid blockade by the antithyroid medication is maximal at the time of the test (3 hours) and is much less at 2 hours. The medication is not suspended during the day for the performance of the 2 hour test so that a greater amount of organification may occur at this time. By reproducing the clinical situation with the administration of antithyroid medication throughout the 24 hour period, one would anticipate a similar effect as that observed at the 3 hour setpoint. The next group of patients will be studied with this procedure.

## Organ Scan and Tumor Localization

Radioisotope localization of thyroid, brain,

Liver and kidney constitute

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The major organs studied, with the exception of lung scanning studies which were done primarily to detect pulmonary embolism. Clinical and histopathologic correlation of the scan pattern, when Positive or non-contributory, has been good in patients coming to operation, or in whom final diagnosis has been confirmed at autopsy, laboratory procedures or by clinical observation,

Effect

of external irradiation on thyroid

Eight patients were followed after their thyroid glands were irradiated during the course of radiotherapy for extrathyroidal carcinoma. Radioiodine studies of uptake,  $^{131}\text{I}$  Conversion Ratios and  $^{131}\text{I}$  Plasma levels were

performed several times during the period of observation which was of 1 year

in 5 patients and 2 years in the remaining three. The 24 hour thyroid uptake of radiotodine showed a consistent tendency to depressed values except in two patients who had no change. Both the PBI 131 Conversion ratios and PSI 131. Flasma levels ehoved lov values before and after radiation, with some depression in the majority of patients, which does not seem significant. The average values of the tests before radiation and at the tine of last observation were fs follows:

Before Last

Radiation Observation

2 Hour Uptake i. ne

FBI 131 Conversion Ratios 5.4% 37%.

PBI 131 Plasma Levels 0.036 per liter of 0:025% per iiter of

plana plassa

Results in this group would indicate that after the initial phase of

depression reported in last year's annual report, there follows @ rebound phase in which nearly pre-radiation values are approximated, which apparently is followed by another phase of moderate depression in most of the patients. Further follow up should prove helpful in establishing whether this depressed phase of thyroid function will eventually lead to a hypothyroid state or to recovery.

rinantal,

otoxicity in dogs with Thioacetanide (Dr. A. Ri  
eros

During the past year the early lesion induced by thioacetanide in the Liver of dogs was investigated by various tests. It was found that with the battery of tests of Liver function the earliest biochemical alteration could be detected by the ESP test (Bronosulphthalein test) and by I-131 Rose Bengal Liver scanning. Electron microscopy at this early stage of toxicity was also carried out and demonstrated the ultrastructural changes at the subcellular level, particularly the mitochondrial system, which is damaged early after the administration of thioacetanide and upon breakage is responsible for the release of liver transaminases.

## Study of Renal Blood Flow:

Clearance studies of renal blood flow by the classical method using the well-

known standard technique of the paraaminohippuric acid clearance test have not

been widely used in clinical medicine routinely as a diagnostic test of renal

function because it is cumbersome and laborious to perform; yet, because of its

exact nature, it remains the method of choice as a standard reference. Recently

since the advent of radioactive labelled substances appropriate for renal works

a group of clearance techniques have been proposed for the determination of renal

blood flow. Diatrizoate and Hippuran labelled with radioactive iodine ( $^{131}\text{I}$ ) have been

described as effective tools for this determination. Three techniques have been

(b) infusion method without catheterization; and (c) a single injection technique.

technique which requires no catheterization, but which may be carried out either by multiple blood sampling or by assay of two blood samples and an externally detected blood clearance curve. The methods for the determination of the effective renal plasma flow (ERPF) and for the glomerular filtration rate (GFR) based on the multiple sampling procedure were referred to in Schedule 189 of the Public Health Act of 1968. In any of these methods, the blood activity curve is divided into two components which are analyzed in terms of the two compartment formula,

Effective renal plasma flow is being studied at this laboratory with I-125 hippurate using the method proposed by Blaufox et al. Patients with renal disorders are being referred by and studied in collaboration with the Nephrology unit of the University Hospital. The group also includes patients with normal renal function as controls and patients with a variety of thyroid disorders from our laboratory to assess the effect of thyroid dysfunction on renal circulation. A total of 112 patients have been examined; of which 15 are patients with normal renal function as controls, 27 are patients with varying degrees of renal dysfunction and 40 are patients with thyroid disorders (9 hyper and 31 hypothyroid individuals). Clinical and laboratory correlation of the degree of renal impairment detected by the radioisotope determination will follow. The study of additional clinical material will also continue.

## STAFF

Dr. J. O. Morales terminated his one-year period as a Joint appointee of the Division and the School of Medicine.

Dr. Pedro Juan Santiago, Pediatrics, resigned as joint appointee of this Division and the School of Medicine. He continues on our staff as Chief Scientist Ad Honorem, specializing in pediatric hematology.

Dr. A. Rodriguez Clieros, Professor of Pharmacy at the University of Puerto Rico and the School of Medicine, was appointed Chief Scientist Ad Honorem of this Division.

## SCIENTIFIC MEETINGS

Dr. Sergio Irizarry attended the Annual Meeting of the Society of Nuclear Medicine, St. Louis, Missouri, June 1968,

Dr. Aldo E. Lanaro attended the Second Latin American Congress of Biology and Nuclear Medicine, Mar del Plata, Argentina, November 1968. At this meeting Dr. Lanaro presented a talk on "The Teaching Programs of this Division and its Relation to Training in Latin America,

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Ba

Two Month Training Program on

Clinical Applications of Radioisotopes

WOTS OF STUDY "AVERAGE GER OF PROCEDURES

PER TRATES

?\_?e ies

Thyroid Function %

Routine uptake measurements (as)

Assay of radioactive thyroid

hormone levela in blood as)

Modified tests of thyroid

function (5)

Dynanie functions of the hepatic, 2

Fonal, and vascular eysten

Honatelogic applications of radioisotopes 5

Tumor Localtzation studies 20

Gastrointestinal absorption 5

Electrolyte and fluid balance e

?Therapeutic procedures 3

?TOTAL &

SS

?ARLE 2

Basie Course in Clinical Applications of Radioisotopes

January 2 to February 23, 1968

1. Zobeida de Jess Malpas Venezuela

2. Marfa de les M. Thiguae Tos. Rep.

3. Ricardo Socoleky argentina

4! Jocé R. Mariacn Bolivia

July 15 to Septenber 7, 1968

2. Dinorah Cc. RodrSeuez Don. Rep.

2. Gerhard B. Ranfrez Puerto Rico

?Special Training Tumor Localization and Organ Vieuelization

September 1-30, 1968

1, Rodrigo Fierro Benitez Ecuador

Medicine

Ruerto Rico

Puerto Rico

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(Orientation in Huclear Nedicine, continued)

3. Cabrera Rivera, Olga Puerto Rico

¥! colén Veldzquez, Carlos M. Puerto Rico

5. Correa Colén, Wanda 8. Puerto Rico

6. cruz Coléa, Gioria Marfa Puerto Rico

7, De Arnas Vazquez, Lillian Puerto Rico

8. Fernindez Vives, Aida Doxinican Rep.
9. Garefa Zabala, Elba Puerto Rico
- 10; Gonzalez Véequez, Julia Puerto Rico
- 31! Hernandez Yolina, Ana Nilea Puerto Rico
- Ye! ginénez Santiago, Ana Puerto Rico
- 33, guldd Reichard, Hora C. Puerto Rico
- ik, Nacaraig, Vilma Puerto Rico
15. Martinez Robles, Elba Puerto Rico
36. Nedina Aguayo, Ana Celia Puerto Rico
- U7! Medina Rivera, Ana Milagros Puerto Rico
38. Méndez Rosa, Ileana Puerto Rico
39. Monegas Acosta, Huguette Puerto Rico
20. Nieves Lépez, Noelia Puerto Rico
21. Ojeda Reyes, Gladys Puerto Rico
20. Ortiz Cruz, José L Puerto Rico
- 23, Padilla Berrfos, Ius Marine Puerto Rico
- Bi, Pagén Lépez, Alba Griselle Puerto Rico
- 25, Pérez Cronot, Gilda Theane Puerto Rico
26. Quifiones Ranos, Wilda Paula Puerto Rico
27. Ranfrez Acevedo, Rosa I. Puerto Rico
- 28, Renfrez Diaz, Ivelisse Puerto Rico
29. Ricart Quintero, Olga Puerto Rico
30. Rivera Ferrer, Avilds Puerto Rico
31. Rivera Lamberty, Wyre Puerto Rico
- 30, Rivera Ortiz, Margarita Puerto Rico
33. Rivera Rivera, Milagros Puerto Rico

3h, Saldafia, Irma Josefina Puerto Rico

35, santiago Becerra, José Buerto Rico

36, setlés Herndndez, José Puerto Rico

37, sobrino Fortezs, Wonda Puerto Rico

38. Tapia Cruz, Gladys Puerto Rico

35, Texidor Carmona, Migdalia Puerto Rico

3g, trinidad Salgado, rma Buerto Rico

IQ! Yetlectiio Euanvelli, Priscilla Puerto Rico

12, verges Ronos, Wilda Puerto Rico

Puerto Rico

43, Urdaz Alvarez, Vivian

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TABLE 3

Munber of Trainees

Te oF Taber

xD. 5

Nedical Technicians 2

Neaical Technologists B

3

ee \_

Puerto Rico 43

Latin serica 7

argentina (2)

Bolivia? (2)

Dom. Rep. (3)

Ecuador = (1)

Veneruela (1)

w

TABLE

Procedures completed, observed or discussed by students

TAADEE cours aef~~ya~~ pone GEfS'SeesShe ToAL

Zobeida de Jess alpas Clin. Applic. Red. 11h 139139 392

Nala M. Tizuez se "i 13 139 ho

Ricardo Socolsiy 0 2 "995 15139 359

José 3, Neriace o 9 "al? 309139 35

Dinorah C. RodrSguez 5 9 " "8 1352 385

Gerhart 5. Ranfrez es "8 1% 62 383

Rodrigo Fierro Benftez Sp. training Tmor = ? 97 - 7

Loc. and Organ Vis.

TOTAL, aso am

## TABLE 5

Bingnostie and therepeutic procedures Carried Out During 1968

Thyroid Studies 1938

Liver Studies 132

Heart Studies 31

Kidney Studies 2h

Gastro-Intestinal Studies a

Blood Studies 18

Tumor Localization un

Training Procedures sone 2591

TOTAL

3B

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## RADIOTHERAPY AND CANCER

The adlotherexy and Cancer Division has a three-fold objective: elucati  
research, and service. anemia

{he Division functions as part of the radiotherapy departaent of the I.

González Martinez Oncologic Hospital, adjacent to the Sionedical Building av the  
Puerto Rico Medical Center. The Oncdlogic Hospital provides sone of the para  
medical personnel, equipment and space, operating rooms, hospital beds, out  
patient facilities, clinical laboratories, end medical services essential to the  
care of cancer patients,

?The hospital renders services to over two-thirde of Puerto Rico's indigent

cancer cases. Since May 1966, it has also provided the radiotherapy services  
to patients of the Puerto Rico Medical Center.

At the academic level, the Radiotherapy Division operates as the radiotherapy section of the University of Puerto Rico School of Medicine. It also

works closely with the Cancer Control Program of the Puerto Rico Department of Health.

Partial support for this program is obtained from the National Cancer Institute training grant through the University of Puerto Rico School of Medicine.

## EDUCATION PROGRAM

The educational program includes the radiotherapy residency program (long term training), short-term radiotherapy training course, in-service cancer training for medical students, in-service training for radiological physicists and radiotherapy technicians, and a series of lectures in radiotherapy and cancer offered to third-year medical students.

The radiotherapy residency program, designed to prepare qualified radiation therapists, meets the requirements of the American Board of Radiology.

The trainees are physicians with a year of internship or equivalent clinical experience. The training period is three years, but trainees are required to take an additional fourth year of supervised practice (preceptorship) before admission to the specialty examinations. Diagnosis of cancer, determination of

the extent and radiosensitivity of tumors, selection of appropriate treatment, and the planning and conducting of radiological therapy are included in the curriculum. Residents acquire background in clinical oncology through supervised work with new, follow-up, and hospitalized cancer patients. Radiation therapy experience is acquired by working with roentgen therapy machines of various voltages, cobalt and cesium teletherapy units, and the internal application of radioactive material in solid sources (needles, tubes, wire), such as radium, strontium, cobalt, iridium, and cesium.

The short-term radiotherapy training course is prepared according to the needs of the individual requesting the training; the person must have had

3

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previous radiotherapy experience. Participants may engage in research to, first, to the division; however they are extended the privilege of patient responsibility. "A man of one word is a tag to use?"

In-service cancer training for medical students acquaints future physicists with clinical problems and current research in cancer and radiation therapy. The minimum length for this course is one month.

In-service training for radiological physics personnel and radiotherapy technicians is provided as the demand calls for it. These persons are allowed

supervised practice in the division's facilities.

The radiotherapy of cancer lecture course for third year medical students is offered yearly as part of the medical school curriculum. Twelve lecture hours highlight epidemiology of cancer, radiological physics, radiobiology, clinical radiotherapy, and radioisotopes in therapy.

## EDUCATIONAL ACHIEVEMENTS

Formal programs and courses were offered regularly to physicians and medical students. These included lectures, seminars, demonstrations, and patient care under supervision with rotation through the various sections of the Division (PRNC treatment area, Oncologic Hospital treatment area, Curiotherapy and hospital in-patient area, follow-up, and radiological physics). Resident physicians in the program also rotated through the Pathology Department of the Oncologic Hospital, the radioisotope courses of PRIC, and the Medical Sciences and Radiobiology Division for radiobiology training. See Table 1 for the regular activities of the Radiotherapy Division, Table 2 for the list of trainees, and Table 3 for service activities

The following former trainees of this division are heading, or participating in, radiotherapy teaching programs in their communities: Dr. Mario Vaksanovic, University of Miami; Dr. Bfrein Navarro, National Cancer Institute in México City; Dr. Modesto Rivero, National University in Caracas, Dr. Juan Reusehe, Instituto de Radiología Cayetano Heredia, Lima; Dr. Oriel Alva, Roffo Cancer Institute, Buenos Aires, Argentina. Drs. Guillermo Géuez, Alvaro Ariza, and Alvaro Rosas participate in the training program at the Instituto Nacional de Cancerología in Bogotá, Colombia. Dr. Silvio A. Aristizébal participates in the training program at Vanderbilt University in Nashville, Tennessee.

Dr. Stephen Brown participates in the training program at the University of Vermont in Burlington, Vermont. The following former trainees are directing radiation therapy programs; Dr. Ernesto Anadey, Corrientes, Argentina;

Dr. Lucas Di Rienzo, Córdoba, Argentina; Dr. Arturo Valencia, Pereira, Colombia

Dr. Apoleén Matos, Lima, Peru; and Dr. Andrés Peralta, Santiago, Dominican Republic.

The radiotherapy staff also participated in the teaching programs, of OUT. divisions of PIE and in the weekly Tumor Conference of the Hesies! school, in weekly Tumor Conference of the San Juan City Hospital, and in the New Patients Conference of the Oncologic Hospital (Monday through Friday). The radiotherapy

of cancer lecture course for third year medical students was? presented avait  
?this year. "

## STAFE

At year's end, the Radiotherapy Division had four radiotherapists, on?  
physicist, an assistant physicist, and a biostatistician.

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?The services of @

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research medical records Librarian, three graduate nurses, three clerical per-  
sons, and photographer-electronic technician, were also available. Personne  
ig still insufficient for the needs of the division, particularly at the radio-  
therapist level; the present patient and teaching load requires at least six  
radiotherapicts,

## TRADES

Short-term Radiotherapy Training

1, One month training for residents in Radiology at the Veterans Administration Hospital in the Bronx, New York by special arrangement with Dr. B. Roswits Chief of Radiation Therapy Service at that Institution,

#### Nene Country Date

Dr. David A. Chastanet United Kingdom January 1968

Dr. Justo M. Gonzales Puerto Rico February 1968

Dr. Bernard Gheinan Brazil March 1968

Dr. Po-Young Li Formosa April 1968

Dr. George Aranenata Argentina May 1968

Dr. Danuta Montorfano Argentina September 1968

Dr. Jong Ok Park Korea October 1968

Dr. Inook Song Korea November 1968,

Dr. Randn Acosta Puerto Rico December 1968,

2, Dr. G. Stephen Brown, U.S.A., fourth year resident at Penrose Cancer Hospital Colorado Springs, Colorado, spent March to June 1968 training in our program. Doctor Brown is a member of the faculty of the University of Vermont School of Medicine.

#### Long-term Training

Dr. Ildefonso Arenas-Bueno, from Spain, a fourth year radiotherapy resident who spent the first three years of training at the Penrose Cancer Hospital, Colorado Springs, Colorado, trained in this program from January 1 to December 31, 1968.

Dr. Silvio A. Aristizbal, from Colombia, spent three years of training as  
resident in radiotherapy at our Institution, from July 1965 to June 1968.

Doctor Aristizbal is in his fourth year of training at the Radiotherapy Dept.,  
Vanderbilt University Hospital, Nashville, Tennessee, where he also holds a  
position as Instructor in Radiotherapy.

In-service Cancer Training for Medical Students

Name country Date

Yorenzo Tigard Puerto Rico January 1968,

Aa T. Laén Valiente Puerto Rico January 1968

?Tomis Hernandez Puerto Rico April 1968

Sonia, Dones Puerto Rico June 1968

Arturo A, Yarach Puerto Rico June-July 1968

Jerome Igangane Nigeria June-July 1968

Char Salazar Cuba June-July 1968

José M. Sobrino Puerto Rico June LAS

Sous F. Irizarry Puerto Rico June-Aug 1968

José R, Hernanides Puerto Rico Sune=July LS

Prank Rodrfauetz Puerto Rico Sune-luly LOS

Francisco Robert Puerto Rico Suneaginy 1008

Noraina M. Laniraa Puerto Rico Suneonay D8

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(In-service Cancer Training, continued)

José victor Figueroa Puerto Rico duty Sent. 1969

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Irving Kapp

## RESEARCH PROGRAM

### A. Current Research Projects at Ent of Year

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enh tnt ttn exe cranaton of ersten oe

2, Fractionation in radiation therapy of carcinoma of the uterine cervix:

3 ve 5 fractions per week (See annual report 1967, page 62).

3. Fractionation in radiation therapy of inoperable breast cancer:

fractions per week (See annual report 1967, page 61).

4, Surgical adjuvant breast project (National Study) (See annual report

1967, page 63).

5. Radiotherapy for carcinomas of the prostate - Stage C (National Study)

(See annual report 1967, page 63).

Lvs

6. Study of the incidence of leukemia in patients with cervical cancer

treated with radiation (National Study). (Discontinued-See annual report 1967,

page 63).

7. Study of Optimal irradiation in carcinoma of the esophagus:

of irradiation 2 weeks post-radiotherapy.

A boost,

8, Fractionation in radiation therapy of post-surgical breast cancer:

3 vs 5 fractions per week.

9. Study of tumor regression in carcinoma of the cervix.

#### B, Projects Terminated During the Year

1. Fractionation in radiation therapy of head and neck cancer: 3 vs

fractions per week, this project, previously described the local and distant effect

of irradiation of head and neck cancer using two

fractionation regimens of the same weekly dose (3 vs 5 fractions). The study of

the accumulated data will be carried out when the clinical experience of the

individual tumor sites is analyzed. Over 300 cases were randomly included in the

study.

2, Pilot Study of Split-Course Irradiation in Carcinoma of Base of Tongue.

This project aims at a comparison of two radiation dose fractionation schemes

for advanced carcinoma of the base of the tongue (lesions where the primary or

metastatic tumors measured 5 cm or over). A total of 48 cases were randomly

distributed for the following treatment modalities: 3000 R in 2 weeks, followed

by a 2 or 3 weeks rest period, then a repetition of the irradiation (4000 R in

2 weeks) utilizing fractions of 500 R 3 times per week, 3000 R in 2 weeks,

followed by a 2 or 3 weeks rest period, then a repetition of the irradiation

(3000 R in 2 weeks) utilizing fractions of 300 R 5 times per week; 6000 R in 7

weeks with 170 R fractions 5 times per week and 6000 R in 7 weeks with fractions

of 285 R 5 times per week. The study was analyzed concerning tumor control and

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normal tissue damage and the results will be presented at a national scientific meeting in Philadelphia in April 1969. me ce

3, Review of Clinical Experience with Carcinoma of the Uterine Cervix =  
 Year 1962, This is a retrospective clinical study of tumor control and normal tissue damage among the patients with carcinoma of the cervix treated with irradiation at our department in the year 1962. The results of this study will be subsequently reported.

4, Study of Results of Treatment Techniques in Adenocarcinoma of Endometrium. This is a retrospective study of treatment results of adenocarcinoma of the endometrium patients treated at the Radiotherapy Department of the I. González Martínez Hospital during 1955-1965. The combination of external irradiation followed by intracavitary curietherapy followed by surgery has given outstanding curability, particularly in Stage II patients where the disease has invaded the cervix. A scientific paper based on this work was presented at the Annual Meeting of the American Radiology Society at Miami in April 1968, and it will be published soon in the American Journal of Roentgenology, Radium Therapy, and Nuclear Medicine.

5. Review of Clinical Experience with Wilms' Tumor - Years 1941-1966.

This is a study of the clinical experience with Wilms' Tumor at the I. González Martínez Oncologic Hospital during 1911-66. The best results were obtained by nephrectomy followed by irradiation to the tumor bed. A scientific paper based on this work was presented at the Annual Meeting of the Puerto Rico Medical Association and it will be published during the year 1969 in the Boletín de la Asociación Médica de P. R.

6. Review of Clinical Experience with Patients with Brain Tumors - 1911-66,

This is a retrospective study of the clinical experience with brain tumors at the I. González Martínez Hospital conducted by Doctor Arietizébal, a trainee, who is expected to prepare a paper for publication based on this work.

7. Review of Clinical Experience with Cases of Carcinoma of the Pyriform Sinus

1955-67. This is a retrospective study of the clinical experience with carcinoma of the pyriform sinus at the I. González Martínez Hospital during 1955-67 conducted by Doctor Arenas, a trainee, who is preparing a paper for publication on this work.

SIAFY POSITION,

1. During the year Dr. Victor A. Marcial held the position of Associate

Director for Medical Programs while acting as Director of the Radiotherapy and Cancer Division. In addition, he was member of the Safety Committee of PRIC and Chairman of the Committee for Human Uses of FRNC. He held the following other appointments in Puerto Rico: Chief, Radiotherapy Department, Oncologic Hospital, Consultant for Professional Education of the Cancer Control Program of the P, R, Department of Health; Member of the Advisory Board of the P.R. Radiation Protection Program; Member of the Subcommittee for Clinical Services of the Puerto Rico Medical Center; Representative for PRNC at the Medical Policy Committee of the P. R. Medical Center; Member of the Medical Board of the University Hospital; Member of the Executive Committee of the Oncologic Hospital; President of the Medical Staff of the I, González Martínez Hospital; Member of the Cancer and Utilization Committee of the University Hospital, Member, Planning Committee, P. R. Regional Program for Heart, Cancer and Stroke; In addition, he held the following overseas appointments: Counselor for P. R. to the Interamerican College of Radiology; Counselor for P, R. to the Radiological Society of North America; Member of the U. S. Committee for Radiation Therapy Studies;

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Member of the Task Force for Cancer Data Coding Member of the Cancer Commission, American College of Radiology; Member of organizing committee of the Tenth

Interamerican Congress of Radiology to be celebrated in San Juan, May 1971;  
Co-chairman, Conference for Radiobiology as Applied to Radiation Therapy to be held at Cernel, California in September 1969  
Project Director of the Split-Course Radiotherapy of Cancer = Clinical Trial - @ national study,

2. During the year Dr. Joos M, Toné held the position of Chief Scientist 1 at the Radiotherapy and Cancer Division of the Puerto Rico Nuclear Center, he was also a Member of the Board of Examiners of the Radiology Technicians; Member of the Library Committee of the I. González Martínez Hospital; Member of the P. R. Gastroenterology Society; and Member of the Education Commission of the Interamerican College of Radiology.

3. Dr. Jeanne Ubifias held the position of Chief Scientist I at the Radiotherapy and Cancer Division of the Puerto Rico Nuclear Center. She was Member of the Planning Committee on Cancer and Heart Stroke, P. R. Department of Health she also acted as Director of the Cancer Control Program of the Puerto Rico Department of Health.

4, Dr. Antonio Bosch held the position of Chief Scientist I at the Radiotherapy and Cancer Division of the Puerto Rico Nuclear Center and was Member of the Emergency Committee of the Puerto Rico Medical Center.

5. Dr. Guillermo Génez-Cirdeñas held the position of Visiting Radiotherapist at the Radiotherapy and Cancer Division until May 1968.

## VISITING scrawrusTs

Yarch - Dr, Harold B. Johns, Director of the Biophysics Department of the University of Toronto, Canada, acted as consultant to the program under the Training Grant.

1961 = Dr. Chahin Chabbasian, Radiotherapist from the Penrose Cancer Hospital, Colorado Springs, Colorado = Consultant under the Training Grant.

1962 = Dr. George Lajtha from the Christie Hospital and Westman Institute, Manchester, England = Lectured on Stem cell kinetics at the Paterson laboratories in Manchester.

1963 ~ Dr. Ruberi Peres Tamayo, Chief of the Radiotherapy Department, Ellis Flavel State Cancer Hospital, Volusia, Manour! = Consultant under the Cancer Control Program, Federal Department of Health,

1964 ~ Drs John Z. Utterback, Associate Professor of Medicine, University of Chicago, formerly with the Francis and Taylor Foundation, as a Consultant under the Training Grant

## SCIENTIFIC TRIPS OF STAFF

1. Dr. Jeanne Ubifins: April 1.8, Visiting Professor at Ellis Fischel state Cancer Hospital, Colubia, Missouri. Four lectures were presented. November 20-23, Houston, ?Texas - M.D. Anderson Hospital and Tumor Institute. Attendance of "Symposium on Carcinoma of the Breast."

2. Dr. Antonio Bosch: November 20-23, Houston, Texas - N.D. Anerson Hospital and Tunor Institute, Attendance of "Symposiu on Carcinona of the Breast".

3. Mrs. M. M. Palacio: : January 7-13, Visit to the Ratiolo, Physics Department of the M.D. and Turor Institute, Anderson Hospital, Houston Texas; Novenber 30-December 5, Attendance at the Annual Meeting of the Radioe

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logical Society of Worth America, Chicago, Tilinois; Decesber 6-14, Visits to

Tae Mayo Clinic (Rochester, Minnesota); University of Rochester (Rochester, N.Y.)s

Cornel University (Ithaca, N.¥.); Brookhaven Laboratories (Kew York, N.Y.

Naval Medical Center, Walter Reed Hospital and ational Institute of? Health

(Washington, D.C.)-

4, Miss Zenaida Frias: May 17, Attendance and participation in a necting of  
perficiants in the Split-course Project, National Cancer Institute, Bethesda.

5. M.D. José M. Tord: Novenber 14-17, Presentation of a paper at the Annual  
Mecting Of the P. R, Medical Association; Decenber 1-6, Attendance of the Annual  
Meeting of the Radiological Society of North America, Chicago, Illinois.

6. M.D. Victor A, Marcial: April 1-7, Visiting lecturer at the Hospital  
Sen Jorge, Pereira, Colombia, with presentation of two lectures; April 6-13,  
Attendance of the Annual Meeting of the American Radiun Society in Mian,  
Florida, with presentation of a paper} Sept. 25-30, participation in the "DX  
Jornadas Radiclégicas Colombianat", Nedelifa, Colorbia, with presentation of  
four papers and two round tables; Oot. 12, Presentation of a paper at the  
"Convencién Anual del Colegio de Farnacéuticos de P. R.", Hotel Dorado Hilton,  
Puerto Rico; Oct. 31 to Nov. 4, Attendance of Annual Yeeting of the Association

of American Medical Colleges, Houston, Texas; Dec, 1-6, Attendance of the Annual Meeting of the Radiological Society of North America, Chicago, Illinois.

Other Activities:

Mrs, M. M. Palactos de Lozano participated in the Course for Students in Radiological Technology offered by the Division of Radiology of the P.R. Medical Center.

Dr, Victor A. Marcial was named Member of the Advisory Committee for the Regional Cancer Program organized by the Tumor Institute of San Francisco.

Association of the He Cane Reated = January to December 1968

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## AGRICULTURAL BIO-SCIENCES

The purpose of the Agricultural Bio-Sciences Division remains two-fold: first, to train students in agricultural and biological research with emphasis upon nuclear science applications in these investigations; and second, to continue basic research programs which are particularly concerned with problems in tropical agriculture that can uniquely be studied by nuclear techniques.

## EDUCATIONAL AND TRAINING ACTIVITIES

During 1968, the emphasis on training continued to be directed toward the graduate and post-graduate level. Such training was frequently related to the Division's basic research activities, which are outlined in a later section.

As honorary members of the various science departments of the University,

Division staff offered the following courses during the year:

Cytogenetics - Dr. F. K. S. Koo, Taught in the Biology Department in Rio Piedras, ?The cytogenetic effects of radiation was one of several subjects emphasized in lectures and laboratory exercises.

cytogenetics - Dr. J. Ferrer-Monge. Serves as core for one of the three areas BE igectaitation chosen for anphaste in the graiuate progren by the Biology Department in Mayaguez.

Food Chemistry - Dr. N. Deshpande. A new course, designed to initiste in the College a Food Science curriculun which may interest graduate students in research of radiation preservation of food.

Nuclear Techniques in Biological Research - Dr. J. Ferrer-Monge, Dr. N. Deshpande, Mr. J. Cuevas, and Dr. F. K. S. Koo. Covers the use of radiation and radioisotopes as tools in biological research.

Nuclear Techniques in Agricultural Research - Dr. N. Deshpande, Mr. J.

Cuevas, Dr. J. Ferrer-Nongs and Dr. F. K. S. Koo. Covers the use of radiation and radioisotopes as tools in agricultural research.

Special Studies in Biology - Dr. J. Ferrer-Monge. Provides supervised reseccith- le spacial toples of thology.

Biology: Research and Thesis - Staff. For students doing M.S. thesis

research in biology

Agronomy: Research and Thesis - Staff. For students doing M. 8. thesis

research in agriculture:

In addition, the staff contributed lectures and laboratory sessions to the

PRNC basic course in radioisotope techniques, the University's course in radio-chemistry, and PRNC courses in radiation biology and tissue culture,

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Graduate Research

A number of graduate students were active in thesis

research in thesis research for 4,

degrees in biology or in agriculture under the supervision of Divicien sec

ae Research topics reflected the broad interests of the Division. .

uring 1968, five graduate students completed their theses. .

A. Thesis research completed

1. Combined effects of chemicals and gamma rays on the production «

chromosomal aberrations in *Tratescantis paluors* ?aalth Re Le Tae,

Rico). Three chemicals (G-ethonycaffeine, 5-antnouracil, kinetin) and gamma rays radiation have been used separately and in combination to produce, ease aberrations in Tradescantia paludosa root-tips. When the chemicals alone were applied in combination, a synergistic effect was observed in the production of chromosome breaks and interchanges. It is of special interest to note that the increase in chromosomal interchanges in the combination treatment is attributable to either an increase of interaction between chromosome breaks produced by two agents or an increase of number of breakages per cell, thus resulting in more interchanges. Research was performed under the direction of Drs. F. S. Hoar

2, Effects of ionizing radiation on Q-diphenol: oxygen oxidoreductase -

Aida G. de Fournier (Puerto Rico). Determination of the molecular weight of this enzyme, which may be a monomer or tetramer, has been made from the radiation sensitive volume and found to agree well with the tetrameric weight. Research was directed by Dr. R. A. Luse.

### 3. Effect of radiation on ripening of banana fruits - Joaquin Oliver-

Campos (Puerto Rico). The extent of delay in ripening of Johnson and Montecristo variety bananas given low doses of gamma radiation has been determined.

The interaction of radiation delay with subsequent artificial ripening by chemicals has also been studied. Thesis was directed to completion by Dr. R. As Inse.

### 4, Preferred host plants of the sugarcane borer, *Diatreea saccharelis* (¥)-

Victoriano Quin\*aria (Puerto Rico). Seasonal surveys of infestation by the sugarcane borer in field crops and the University's world grass collections have been made. Corn was found to be the host plant that most nearly satisfies the total requirements of the sugarcane borer. The other species in their relative order of general suitability as a host are teosinte, milo, sugarcane and Nerker grass. The remaining species rank relatively low in overall suitability as hosts. Research was directed by Dr. D. W. Walker.

### 5. Cytogenetic effects of chronic gamma radiation on microsporogenesis at

other inherent cytological anomalies in *Panicum riparia* ~ Robert ?. VenstOr (Puerto Rico). This under-story tree species was studied cytologically following a short term chronic gamma irradiation in the rainforest at #1 Verde. In general, the results show that the meiotic abnormalities increased with dose and these aberrations decayed with time. Pollen abortion was found to be relatively low, presumably due to the small chromosomes and polyploidy nature of this species. Also uncovered in this species were several inherent cytologic

anomalies such as cytomixis, binucleate sporocyte formation, and polyspory-

Research was performed under Dr. F. K. 8. Koo's supervision,

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B, Thesis research in progress

1. Effect of temperature on the mitotic cycle of *Vicia faba* - carmen 2.

cin ten Gusto Rice) Tie ose Sigiticane Heiings todsee ere: (i) with

emperature increase from 0°C to 40°C, there is generally an increase in

Mitotic rate, (2) at higher temperatures certain cells are severely affected,

thus lowering the mitotic index, and (3) at least for the *Vicia faba* Long Pod

variety used, there is a high degree of variability in the mitotic index among

the rest (seeds) at given temperature, ?Completion of this study is expected

September, 1969. (Advisor «Dr. d« Ferrer-Hionge)

2. Influence of ionizing radiation on methionine utilization

Escherichia coli as a model organism for the study of the effects of ionizing radiation on

ned to various doses of gamma irradiation are being studied as to their  
ability to incorporate  $^{35}\text{S}$ -labeled methionine into cell constituents,  
Meats is expected to be completed in 1969. (Advisor = Dr. R. A. Luse)

### Special Training

The Division participated actively in technical and scientific training  
programs. Training in radiation preservation of food was provided for an  
International Atomic Energy Agency Fellow, Miss Vachira Jiravatana of Thailand;  
technical assistance was given to Instituto Centro Americano de Investigacion  
y Tecnologia Industrial (ICAITI) of Guatemala. These are further examples of  
training offered by the staff to five other trainees (sponsored by ORAU, IAEA,  
the Peace Corps, and OAS) since 1965. Miss Jiravatana, a scientific staff  
member of the Office of the Atomic Energy for Peace in the Ministry of National  
Development in Thailand, joined the Division in August and will be with us for  
one year. She first received a technical orientation and studied all phases of  
fruit preservation by irradiation, including selection and pre-treatment of  
fruits, experimental design, irradiation operation, dosimetry, post-irradiation  
storage, visual observation and testing by instrument, biochemical analysis-

ses, etc. She was then assigned to conduct independently specific research problems closely related to the needs of her homeland. By the end of 1968, Miss Jiravatena amassed extensive data on the shelf-life extension and biochemical changes in irradiated papaya fruit; she is to continue her studies of radiation effects on fruit respiration, flavor, enzymes, etc.

The second program, which receives financial support from the USAID, is the Technical Assistance Program specifically planned for ICAITI. Dr. Pedro Solé and Mr. Carlos Rolz, both Research Engineers at ICAITI and Professors of Chemical Engineering at the National University of San Carlos, spent three weeks each at PRNG in November to study the effects of radiation on papaya fruits. They investigated changes in respiration, flavor, and pectic enzymes using infra-red spectrophotometry, gas chromatography and other analytical methods. During the current fiscal year (FY 1969), PRIC staff members will travel to ICAITI to assist in establishing new food irradiation preservation programs, to serve as consultants, and to review progress. In addition, a feasibility program for Central America will be planned, taking into consideration the needs of Guatemala and other Central American and Caribbean countries.

The Division staff continued to serve as Scientific Advisors at the USAEC "Atoms in Action" Exhibit in Latin America. In April-May 1968, three staff members participated in the Exhibit in Caracas, Venezuela. Their activities were as follows

Name Subjects covered

R.A. Iuse Food Preservation by Radiation and

Radiosotope Techniques

D. We Walker Insect Control by Radiation

Sterilization

Carmen Asencio Food Preservation by Radiation

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The time and effort spent encouraging scientific research in Latin America

has brought positive results; agricultural and biological investigations

initiated during the Exhibits have been continued and further developed in EL

Salvador, Guatemala, Costa Rica, Nicaragua, Ecuador and others. Work on numer-

ous theses, originally outlined and supervised by our staff, has brought both

students and faculty members into contact with nuclear techniques. It is felt

that, such research promotion in Latin American countries, and cooperation with

these scientists, will continue to foster application of nuclear techniques in

Central and South American agriculture.

## ?RESEARCH ACTIVITIES

Basic research activity may be discussed under four main categories:

2, Sugarcane improvement. By means of automated analytical techniques, a mass screening continued for variants having increased sugar content in the gamma land neutron irradiated and vegetatively-propagated progenies. Selected individual cane seed pieces have been grown in the field to provide material for confirmation analysis for sucrose content; the final selections will be evaluated in the Sugarcane Improvement Program of the University's Agricultural Experiment Stations. It is anticipated that induction of mutations of high sucrose content by gamma rays and neutrons offers one solution to declining yields in sugarcane, still the most important crop in Puerto Rico's economy.

the induction of mosaic

Another project to increase sugarcane yield with virus resistance by radiation in several selections susceptible to this disease, but otherwise promising in many agronomical characteristics. In 1968, an improved method for artificial inoculation of mosaic virus was tested, but only a limited amount of material was screened for virus resistance, as the project was shelved in order to develop other programs in line with the Division's limited funds and personnel.

2, Environmental adaptation of crops by mutation breeding. The main objective of this new program is to adapt crops to tropical environmental stresses by mutation breeding. In the summer of 1968, preliminary tests for regional adaptability of chickpeas and a group of soybean varieties and selections from high protein crosses were made. In December, the first generation of gamma-ray-treated soybeans (three varieties) was planted in isolated plots with supplemental lighting. This group of material is expected to provide the first massive source from which to select desirable mutant types (adaptive, day-length neutral, high yielding, high protein content, disease resistant, etc.) beginning in the summer of 1969. Other subjects for investigation in the near future include the physiology of environmental stresses as presented by high temperature, high rainfall and humidity, high and low light intensity, etc. This program has been carried out in cooperation with the University of Puerto Rico Agricultural Experiment Station.

3. Radiation Preservation of Tropical Fruits, Considerable effort was directed to the underlying processes associated with radiation preservation of tropical fruits. To continue the previous year's work on characterization of flavor components, mango and papaya nectarates were extracted for the volatile For mangoes, solvent extraction with chloroform was attempted. The papaya, nectarates, on the other hand, were subjected to extraction by means of the Copey apparatus for isolation of the volatiles. This essentially utilized the principle of flash evaporation and vaporization from a continuous thin bedded sheet. Water and vaporized food constituents were recovered by condensation in a

series of cold traps cooled by Liquid nitrogen, dry ice and ester

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Studies of the ionizing radiation effect on the kinetics and molecular

structure of pectin methyl esterase and its relation to mango fruit softening

have been reported previously. In 1968, a group of selected subjects was

again investigated with papaya fruits, ?It has been suggested that pectin methyl

esterase may be present in a concentrated form, Increasing doses of radiation

may cause disruption of cellular components, thus liberating the enzyme and

increasing its activity, Results with papaya strongly suggest that ionizing

radiation increased activity of the enzyme pectin methyl esterase} in the irradiated fruits after storage, the increase of enzyme activity was even greater. These results again support the view that cellular degradation caused by radiation and ripening liberates the enzyme and results in its higher activity. For the characterization of the pectic constituents, the papaya pulp was determined for total uronic acid content and methoxy content.

Financial support to the Radiation Preservation of Tropical Foodstuffs

Program provided by USAEC Division of Isotopes Development was terminated in September. Since then, the Division has carried on research on papaya shelf-life extension, radiation effects on its nutritional components and respiration.

Preliminary results indicate that a considerable retardation of ripening was attainable by gamma ray treatment at 25-50 Krad levels. This delay in ripening, coupled with the insignificant loss of vitamin C, suggests a very favorable response of papaya fruits to radiation preservation. Other results of the AEC-DID supported program are presented elsewhere in this Report.

4, Radiation Sterilization of Sugarcane Borer. Research carried out by Dr. D. W. Walker, with primary financial support provided by the USAEC Division of Biology and Medicine, is reported elsewhere in this Annual Report.

In addition to the Agricultural Bio-Sciences Division's basic research in

agriculture, two projects of fundamental radiobiological importance are incorporated within the Division:

1, Resonance in Radiation Effects. Previous work with metalloenzymes indicates an energy dependence of damage (inactivation) related to the constituent metal. At equal dose, catalase shows a ten-fold increase in inactivation at 7.1 Kev, the K-edge of iron, compared with damage a few Kev above or below this energy. To determine more precisely the nature of damage produced by x-irradiation at the iron K-edge, a very pure preparation of bovine liver catalase was irradiated and studied by the latest techniques of protein chemistry to determine the structural changes in the enzyme induced by such radiation. Results indicate that there was an energy dependence in the inactivation mechanism with maximum effect slightly above the K-absorption edge of the target atom. The inactivation of the catalase molecule was mainly due to the effects on the iron centers, resulting in the release of free iron from the inactivated molecule and the impairment of the integrity of the heme molecules. Data from the spectrofluorometric analysis and iron release studies strongly indicate that the energy absorbed by the iron atom transferred to other linkages in the porphyrin molecule. The amount of iron released followed the total dose of irradiation, but the fluorescence for porphyrin was not detectable until the dose reached 500 Kilorads. The gamma irradiated samples increased in optical density in the protein absorption region, indicating a molecular aggravation different in nature from the monochromatic x-ray irradiated sample.

or

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Further studies of the low-energy monochromatic x-ray effect on gonetsg  
Esterial lsteled with S-tronodecsyruine again confirm that photons wit go  
K-absorption edge energy of the target atom broaine are capable of dnduet

tations at a much enhanced rate not know with a1y other Tadiationa toes,  
Rish-energy photons. In the past year emphasis has been placed on the const  
thon of the astion spectrum etulies for mitation iniuction in Bechertsaiy et  
get Conmetastertun equi. The vorkability of teradiating bactefls Were  
intensity Ey peuns of Tluorescence Line irradiation bas been investigate  
allation aceion on tolecaiar lesion induction tas aldo boon stalled Tt 1,

nerelly believed that, among the x-ray induced DIA strand breaks, only ise  
Eiigie strani breaks an anensble to ferairy double strand Drente tre cata  
lethal, ani the repair efficiency for the x-ray induced lesion is very iene  
comparcd vith that for the Ueinluced lesion. These generalizations ae tet  
investigated with Lowenerey nonochronatic x-rays.

2, Eallobiological studies of seeds, To further a world-wide program on seed  
irradiation organized by the International Atomic Energy Agency, the Diviston tay  
begun investigations of the ganna radiation effect on soybean seeds with differ:  
ent moisture contents. Apparatus for attaining the moisture equilibrium in the

seed at any desired levels has been constructed. Preliminary results indicate that soybean is relatively sensitive to radiation as measured by its growth inhibition at the seedling stage. Studies with soybeans and other seeds using neutrons will await the completion of the remodeling of the neutron irradiation facility.

In addition to its own research activities, the Division has promoted cooperative investigations with scientists of other institutions. Several programs were initiated in 1968, including (a) differential adsorption of C-14 labeled herbicides by different types of Puerto Rican soils; (b) H-thyridine labeling study of chromosomes treated with radioactive chemicals; and (c) breaking of dormancy and mutation induction by radiation in the root crop yautias (*Xenopus atrovirens*).

## STAFF

There were many changes in the Division's roster in 1968. In July, Dr. Luse departed (on leave of absence for two years) for Vienna, Austria, where he assumed his duties of First Officer in the Genetics and Plant Breeding Section of the FAO/IAEA Division of Atomic Energy in Food and Agriculture and the responsibility for the mutation breeding program for high protein crops and the neutron irradiation program. Also in July, Dr. Kamath resigned to take position at the University of Iowa, Iowa City, as associate professor. In December, Dr. Walker was granted a one-year leave of absence to serve as an

international Atomic Energy Agency Technical Expert assigned to the Atomic Energy for Peace Program at the Nuclear Center in Bangkok, Thailand, to investigate rice stem borer sterility. On the plus side of the balance, Miss Angelica Nuliz joined the Division in September and participated in resonance radiation effect studies in genetic systems. She received her M.S. degree in Biology at the University of Puerto Rico in the summer of 1966,

Dr. Ferrer and Dr. Deshpande were granted joint appointments by the Geology of Agriculture and Mechanical Arts, U.P.R. in Mayagüez. Dr. Meerer, 18 Professor of Biology in the Biology Department and Dr. Dockertie, Professor of Chemistry in the Chemistry Department. Also, Mr. Cuevas received an Ad Eminent appointment as Assistant Professor of Entomology and Plant Culture, CAAM in Mayagüez. Mr. Hart

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Two Division members completed graduate studies at the University of Puerto Rico, Mayagüez. Mrs. Edith Irizarry received her M.S. degree in Biology in June and also her promotion to Research Associate I at FRIVG; Mr. Victoriano Quintana passed his final examination for an M.S. degree in biology in October and left for Spain to enroll in the School of Medicine at the University of

Dr. Luse was elected Chairman-Elect 1968 of the Puerto Rico Section of the American Chemical Society. Mr. Cuevas was appointed Permanent Secretary of the Sociedad Americana de Ciencias Agrícolas.

on April 28, Dr. Inse accompanied Dr. Gouberg and Mr. Barcelé to Colombia to conduct an on-site survey of the humid, lowland area lying directly east of the Andes (the Line Orientales) to determine what research required highest priority for the development of Llanos agriculture. The second trip to the area was made on July 22-28, Discussions were held with the scientists at the Colombian Institute of Nuclear Studies (IAN) and the Colombian Institute of Agriculture and Animal Husbandry (ICA) and with staff members of the USAID Mission in Bogotá on the feasibility of agriculture development in the Llanos

On October 6-10, Dr. Koo visited the Instituto Centro Americano de Investigación y Tecnología Industrial in Guatemala City, Guatemala where he made final plans for the ICAITI staff training program in food irradiation preservation at FRIC and our staff visit to ICAITI.

Several Division staff members attended scientific and technical meetings during 1968. Dr. Luse was an invited participant in a Panel on "Sociological Aspects of the Application of Ionizing Radiation to Food Preservation" sponsored by the Joint PAO/IAEA Division of Atomic Energy in Food and Agriculture in Vienna, Austria (April 8-12), delivered a paper on "Radiation inactivation of enzymes important in fruit ripening," and served as chairman of the group drafting recommendations on Food Irradiation, He also attended the IAEA Panel on

Mey Approaches to Breeding for Plant Protein Improvement? at Svalof, Sweden on June 17-21. On July 7-12, Mr. Cuevas traveled to Trinidad to participate in the 6th Annual Meeting of the Caribbean Food Crops Society. He presented a paper entitled "Preservation of tropical foodstuffs by irradiation," Dr. Koo was invited participant to the Conference on Food Production and Economic Development held in August at the University of Puerto Rico, Mayaguez, and presented a paper on "Soybean protein production improvement in the tropics." This Conference was sponsored by the University and Dr. Graham served on the Organizing Committee. Dr. Graham attended the 8th Annual AEC Food Irradiation Program Contractors' Meeting on October 16-17 in Washington, D. C. Dr. Koo participated in the meeting of the Working Group for the Study of Food Preservation by Radiation sponsored by the Inter-American Nuclear Energy Commission of the Organization of American States in Montevideo, Uruguay during the period December 16-20, and presented a paper on "Puerto Rico Nuclear Center participation in food irradiation program development in Latin America." In December, Dr. Walker attended the Annual Meeting of the Entomological Society of America at Dallas, Texas, where he presented a paper on "Inherited sterility in the sugarcane borer. \*

Dr. Deshpande attended an intensive short course on "Molecular characterization of polymers" offered by the American Chemical Society at Vassar College, NY. on June 3-7.

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## SUGARCANE BORER CONTROL PROGRAM

(Fob.) (Crambidae: Lepidoptera)

causes direct destruction of plant tissues, often completely destroying young Plants, as well as causing sugar inversion in cane stalks. This pest also allows? secondary invasion by fungi and bacteria, which reduce sucrose yield, This pest is of major importance in most. sugar producing areas of the world; it causes an estimated annual loss of 2.5 million dollars to Puerto Rico's

Sugarcane crop alone.

?The sugarcane borer, Distr

Principal research objectives include determining whether *Diatraea saccharalis* can be rendered sterile by gamma irradiation and studying the Bionomics of this species with reference to phases of the life cycle that are applicable to the development of a program of mass-release of sterile adults in Puerto Rico. This project is part of a cooperative effort with the UPR Agricultural Experiment Station,

Since the previous report (Annual Report, PRI, 1967), work has been concentrated in two main areas: (1) developing of the island test in Vieques, P.R.

and (2) inherited sterility.

Approximately 300 adults are harvested daily in the Mayaguez insectary, This line was obtained from the Louisiana State University laboratory in Baton Rouge from Dr. S. D. Hensley. This strain has undergone more than 100 generations in the laboratory on a wheat-germ diet developed by Hensley, Long and Yadov as a modification of the original wheat-germ diet developed by Vanderzant and Adkisson. Adults are vigorous, and of long life. The females lay approximately 350 eggs each, and are well adapted to a laboratory rearing regime, larval life-span is approximately 25 days and the pupal stage requires 6-7 days for completing development. Larval and pupal mortality is low, and the frequency of diapause in our laboratory has been less than 5 percent. These factors taken together have given us the assurance that we will be able to produce a sufficient number of sterile adults to complete an island test involving 1000 to 2000 acres of sugarcane.

Scales of total rearing costs of insects to be released on a mass-scale will be seen in the next few years. Thus we are very interested in achieving the pre-emptive strategy, (70m) Our release methods, Inherited sterility is a potential solution to this problem,

Inherited sterility is being investigated in the laboratory and in field cages. The ultimate objective of this work is to achieve a permanent method of releasing sterile insects. This might be possible by liberating

gularic numbers of P generation sub-steriles that outbreed with the wild  
Population and produce a large number of F<sub>1</sub> larvae that survive to adulthood  
as fertile FL adults, | The application ratio is expected to be ten times the

number of 10 times, i.e. ten times as many as were set

order of 10 times, 3.6, ten times as many sterile F<sub>1</sub> adults as were released

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factors are heritable through

continuous outbreeding.

8 cage.

) gravid female to test oviposition

rot stage larvae as measured by

tionally the best plant

rd stage larvae

oviposition response

2 that corn

n overall suitability of hosts,

sources of larval food.

to

Preparing for liquid scintillation counting, Miss Angélica, Muiiz is delivering fractions onto paper discs following sucrose density gradient centrifugation of B. 80

in a study to determine

effect of low-energy.

?the x-rays on DIA st

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## PRESERVATION OF TROPICAL FOODSTUFFS BY GAMMA IRRADIATION

ten of radiation preservation of fresh mango fruits were continued, the Elon, Buty Sensations fruit varieties, considered to have high marketing potential in the near future both locally and on the U.S. mainland,

were obtained from the Fortuna Substation of the University of Puerto Rico Agricultural Experiment Station. Measurement of shelf-life extension (retardation of ripening) and biochemical assays of changes in food quality were made for these exotic varieties.

As described in previous reports, mature green mangoes (physiologically fully developed, but green) were picked the day before irradiation. They were selected to exclude those which were bruised or otherwise defective and were then gamma irradiated at 25, 50, 75, 100 and 150 kilorad doses.

The irradiated and non-irradiated fruits were stored in a constant temperature room at 68°F and 60% relative humidity. At appropriate intervals, depending on how the ripening of the fruits progressed, individual fruits were withdrawn and assayed for sugar, starch, ascorbic acid, total carotenoids, and titratable acidity. The progress of ripening was also noted and observations made for rotting or other deteriorative processes. On cutting the fruits, observation was made for blackening or pithing due to the irradiation treatment.

Eldon mangoes treated with 50-150 kilorads of gamma radiation showed a delay in ripening of about 5 days as compared to the non-irradiated controls. After the 7th day in storage, only the 75 kilorad level effected a delay in fruit ripening. At 150 kilorads, the fruit showed skin discoloration. Ripening and softening seemed to have been accelerated.

Sensation variety mangoes treated with 50-75 kilorads showed a storage life extension of 7 days as compared to the non-irradiated controls. After 12 days of storage, fruits treated with 100 and 150 kilorads doses seemed to ripen faster than the controls. Those treated at a level of 150 kilorads were soft and revealed no significant loss of ascorbic acid (vitamin C). There was some decrease in the level of total carotenoids at the 75-150 kilorads levels and after 11 days of storage the sugar to acid ratio of fruits treated at 50 and 75 kilorads was appreciably lower than that of the control.

At doses of 50 and 75 kilorads of gamma radiation, Ruben mangoes showed a ripening delay of five days. Generally, the biochemical characteristics of this variety showed the same trends as for the Sensation variety.

Keitt variety showed a delay in ripening of 6 days, even at the 25 kilorads level of irradiation. The Kent variety showed a delay in ripening &

days at doses of 50-100 kilorads.

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photometric set-up

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## MEDICAL SCIENCES AND RADIOBIOLOGY DIVISION

The Medical Sciences and Radiobiology Division offers training and research opportunities 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. Facilities include a tissue culture unit, an animal house containing a mouse colony and a snail colony, a biochemistry laboratory and other modern equipment and laboratory facilities.

This report covers educational, training and research activities involving

Division personnel. Also included are projects sponsored by the AEC Division of Biology and Medicine:

1, Studies on the host-parasite relationship in Schistosonlasis manson

Radiation effects and application of radioisotope technique

2, Radiation activation of latent virus in wild arthropods and vertebrates

3. Radiation effect on the host-parasite relationship in Trypanosoma cruzi

Anfections (Proposal in study in the DM)

## EDUCATIONAL ACTIVITTES

The following courses were offered during 1968:

1. Tissue culture and radioisotope techniques at cellular level. Offered under the direction of Dr. Ramiro Martines-Silva, Farticipants were: Miss

Rachelle Evenchick (7/22-8/30/68,)U.8.A., and Dr. Abdel Arandia Patraca (ufi9-8/27/68), Mexico.

2. Graduate Course in Virology. Sponsored by the UPR School of Medicine's Department of Microbiology. Offered at PRIC under the direction of Dr. Julio I. Colón, Associate Scientist (ad hoc) & Professor of the School of Medicine.

The participants were:

Kane Country and country.

Felicita Gotay Puerto Rico Carlos Roberto Lau Puerto Rico

Victor M. Gotay Puerto Rico José A. Licha Puerto Rico

Héctor Gotay Puerto Rico Enrique Reynold Lépez Puerto Rico

Angela 7. Hernández Puerto Rico Rachel Lépez de Suárez ?Puerto Rico

Oristibal Jiménez Puerto Rico Agapito Lépez Rivera Puerto Rico

Citrajanes el Guyana Charles Lowry Phillips United States,

3. Radiation Biology (PRINS 510). Given for academic credit by Doctors

Jonge. See also literature, and José Ne Correa, member of this

Division. ?The following students attended: Aquiles Santana, from Colombia,

Tale A, Rodríguez, from Ecuador, and Renán Cruz Ortiz, Daniel Torres Ortiz,

and Keriberto Torres Castro, from Puerto Rico.

---Page Break---

4, Special Training. The following persons received training in the topics

listed?

None Country, Field Training Dates

Dr. Qecar Juliao Colosbia Viroidgist et the Mlcrouutogrpty 7/3 8

Tational Institute,

of Health in Bogoté

Marcela Estrena- Pert Med. Technologist

doyro de Rendén

Misewe culture 5/582

Radloteotepes 10/18/68

techniaues ws

Breil MD. Sehistorona ransont 10/7-

Hostal Hate Use of radiciso- 11/18

topes for testing aruge)

5, Speckal Training in Radiodtology for Rudiotherapicts. Special training

in basic radiobolog, with lectures ani laboratory exercises, vas offered to

Dr. Silvio Aristizabal of Colombia by Division staff mexbere Dr. Ramiro

Martinez-Silva, Dr. Julio I. Colén, Dr. Jorge Chiriboga and Dr. José N. Corres,

6, Orientation on PRIC Program in Tropical lhelear Biology and Medicine

Course? ?The Tollowing postgraduate fellows wno-sttenied a Trorieal Nedisiog

Course at Louisiana State University were given a special orientation:

David . Dennis, N. D.; Gerald V. van der Viugt, M. D.j Clarence A. Parker,

Ph, D.5 Clayton?R. ?Page, Ph, D.; John W. Rippon, Ph. 5.

7, Orientation in tissue culture and radioisotope techniques, Given to the following professors from the Faculty of the Ceatral University in Venezuela:

Mise Mercedes U. de Montalvo, Miss Hosaura Belto, and Mrs, Mireys de Gugig.

8, Sumer studies. Gerald M. Kidder and Roger Arnold Pedersen from the Graduate Frogram of the Biology Department of Yale University studied molecular Diclogy here in the sumer, using radioisotopes of marine specinens. They were referred to PRIC by the School of Medicine (UPR).

## 9. Thesis research

The following students continued their thesis research:

Hane Country Degree s

Source of Sponsorship Title

Carmen Rivers ?FP. R, Master Ta Effect of irradiation

Microbiology on interferon levele

Roger Fanos Per Ph. D. in PAHO and FRNC Labeling of cocaine

Aliaga Biochemistry and metabolic studies

COOPERATIVE TRAINING AND RESEARCH

COOPERATIVE TRAINING AND RESEARCH

2. Division staff members assist in the teaching activities of the follow-

ing divisions: Physical Science, Health Physics, and Clinical Applications,

2. Rateah cooperation with Agricultural scientists, and

for analyzing both the density and the density of the

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relent it then be unt a sopee On atacl® EAL Ok, Scrae ently

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substitution.

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3+ School of Medicine UPR,

a, Department of Microbiology = Dr. Julio I. Colén, Virologist, continues

as an "ad honoren" nesber of the PRIC staff

b, Department. of Parasitology - The interchange of Snformation and blow

Jogical material with this departtent has been continued.

c. Department of Biochemistry and Nutrition - Dr. E. Toro Goyco, Associate

Professor of Biochenistry and Nutrition, continued to study the biochenistry of

Schistosora mansoni eggs} he 12 receiving help from the Division.

4, Dr. Jorge Chiriboga, Professor of Biochentetry (ad honoren) at the UPR

School of Medicine, has lectured at the Doportnent of Biochentstry.

fe. Garrido Annex: An agreement has been made between Dr. Ranos Morales, Head and Director of the Schistosoma Program of the Department of Medicine, and Dr. Chiritoga, through which the bilharzia laboratory of the Department of Medicine will be used for PRC research programs. In return PRIC will provide antigens for clinical and epidemiological studies of bilharzia,

4. U.S. Public Health Service, Cooperation on Schistosomiasis research with the group headed by Dr. Frederick Ferguson, has continued. Schistosoma cercariae in large numbers were labeled with  $^{35}\text{S}$  to study the cercariophageic activity of guppy fish under laboratory and field conditions. It is hoped that these studies will eventually contribute to the better understanding of the ecology of this disease, Mrs. Wilda B. Knight of USPHS is assigned to PRN.

5. Veterans Administration Hospital. A project on the resistance of mice to Schistosoma mansoni has terminated; the results have been presented for publication. Dr. Rafael Yenédez Cortada, Associate Chief of Staff of the Veterans Administration Hospital, and members of our Division, have begun @

time lapse cinematography project on the penetration and development of T. cruzi in Dep cells developed in our laboratory. Dr. P. Crosby, of the V. A. Hospital, is conducting research on xanthine-oxidase levels in mice infected with normal and irradiated cercariae provided by PRIC.

6. Schistosomiasis Laboratory. Dr. Neftale Katz, the Universidad Federal of Minas Gerais, Belo Horizonte, Brazil, spent two months with PRIC with the Schistosomiasis group.

7. Walter Reed Army Institute of Research. Dr. Lawrence 8. Ritchie of the Waiter Misi Ana Tnstiowe, who had been assigned to the Schistosontasis group of PRIC until June, was appointed Chief Scientist in the Medical Sciences and Radiobiology Division.

8, Medical Research Center. The Division engaged in a cooperative program with Miss Encarnite Conde, from the Medical Research Center, in the mechanism of action of hemolymph of *Bicmphalaria glabrata* in *Schistosoma mansoni* parasite in vitro, using radioactive techniques. The Division also provided biological materials for the *Schistosoma* research of the Medical Research Center.

9. Visiting Scientist from Oak Ridge National Laboratories. Dr. Raymon A. Brown, visiting scientist from the Biology Division of Oak Ridge National Laboratory, arrived in May 1968 to work with the Medical Sciences & Radiobiology Division.

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[RESEARCH ACTIVITIES

[RESEARCH ACTIVITIES

activities offered

atopological training acti ae

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animal, cell, and subcellviay, oor st-parasite relations various bigicey

ety be radiation on the os lationship 49 variou i ?

the effects of redietrTeure, arthropods, snails, and other Fs

systems we rescarch, organized by sections,

-DEETHNTATION OF COCAINE AND NUERITEOUAL, STATUS

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ocaine metabolite in mice live

ogrephic differentiation of © in oe

Guronmtographis Gitserentle Toh, SF Symtic system Wien cocaine ye

inteptinee Bue UE Grraction + 9000 x g soluble supernatant along with

ewbaved with microsouay {yeti ye presence of Op» stoichenetrie anounte op

Trini, regenerating tYignyde were found as the only wetabolites in the liver,

Feat ts coe abing the cane system, bensoblecgonine ? not norcocaing

With inte tsyde was fount to be the netabolite. on

ee ea ta by paper chromatography and thin Layer ehrooa.

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eee Saynecprodusea netabolives 0 prove identity,

tography in a number of different solvents.

laboratory were compare

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Cocaine 66 .6T -TI 67 89 ?73

\*orcocaine +200 20 3 +35 +72 3

\*Bonsollecgonine 0 m 9 OK

= ne 1 56

\*Eegonine

¥ Prepared in the laboratory.

\*\* Extracted from the incubated media and chromatography.

b, Distribution of N-demethylase of cocaine in different tissues of different animals, Brain, kidney, liver, heart, and intestinal mucosa were tested in the same fashion to see if N-demethylation of cocaine to produce formaldehyde and norcocaine occurred only in the liver. The enzymatic system was a mixture of microsomes + soluble fraction and TPWiip regenerating system.

Different rates were observed in different animals but in all then the liver was the only one that had the enzymatic system for N-demethylation of cocaine, The intestinal mucosa system produces benzoilecgonine, but not nor-cocaine,

c. Enzymatic induction of cocaine N-demethylase by the substrate. Two groups of animals, one with a normal defined diet (23% protein), and another in which the diet was 54% corn protein, were subdivided: one in which the diet contained 15 ng of cocaine/10g of food and the other served as controls. After four weeks, all groups were sacrificed and the rate of demethylation of cocaine was tested in vitro. In the group that received a normal diet and GMB A gleniscant? There was an increase in the enzymatic rates in the Liver was observed (05), but no increase was observed when a low corn protein diet was used.

4. Effect of cocaine on the incorporation of  $^{14}C$  to choline in rats with different methionine levels. See also Cee wae

to choline in rate with difference between Sates and SE as

#5 PR test the hypothesis that? cocaine could serve as a reticulon donor in

animal: cocaine. Because cocaine labeled in the tertiary N-demethyl was not

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in enteric and we consume "in the stomach" reserve

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wieh SOE Se tonal Giots ?toverers shan efpeestis, activity of choline ia?

fits corn diet (5% protein) (See Table 2) Was not found in animals? that

Titom: Fagen oe sciivstion of acetis ant \$7 cocaine ia

ss geognles (ltny steantion)iSyag of eonte Sete ee te

is etd haan gk opin ye en

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iiinen cocaine was islized tn vivo and the Liver hapogenate of the sere?  
tested 4n vitro the rate of acetic acid uttlization (Hos) was dinierrees ate  
ERS PBS TE ISLS Afactad nthe sagen Ge op ceeecnimaies

?TABLE 1.

?eoREORATION OF METHYL GROUPS FROM METHZONINE INTO CHOLINE PHOSPHATIDYL,  
cHOLIIE)  
IN LIVER OF RATS FED IN DIFFERENT NUTRITIONAL STATES\*

specific activity in c.p.m./mg. of choline\*

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2 19et

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\* Wethiontne labeled with cl in methyl group used as precursor

?+The values are averages of duplicate determinations after the intreperitonesl

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SCHISTOSOMIASIS PROJECT

MAINTENANCE AND USE OF THE LIFE CYCLE OF 8, MANSONT

liew aquaria for snail-culture with continuous flow of water have been developed. The amounts of copper in the water have been checked repeatedly by flame photometry. That a hazard exists is apparent, but this has been controlled by crude charcoal filtration; commercial filters are now being installed. We have demonstrated some advantages of applying the food formula for the snail onto paper toweling, drying 4%, and then placing pieces of the paver of appropriate size in the aquaria.

A system for collecting cercariae for preparing antigens has been developed that allows concentration of great numbers with relative ease and with minimal hazard for the operator.

In March (1968), our infection of mice with *S. mansoni* was almost reduced to zero in most groups. This situation persisted for about 6 months for all exposures. The cercariae were penetrating, and exposed mice kept in other buildings acquired good infections. It was noted that high concentrations of cercariae were present in the air of the infected animal rooms due to decomposition of mouse urine; air conditioning had recently been installed. The windows were then kept open to improve air circulation, when the infections showed improvement, we experimentally exposed newly infected mice to *S. mansoni* fumes. The resulting infections were normally leaving us without an explanation for the infection failure. Our worm recovery rates are now

ceatorly 40 to 508 of the cercariae used in exposures, Uniformity of individual worm burdens seen to have improved.

Infected mice and rats are being used in increasing numbers for immunological studies, particularly to explore the mechanism of acquired resistance against *S. mansoni*. Worms are being collected and lyophilized for use in preparing antigens

## INVESTIGATIONS ON FASCIOLA HEPATICA, LIVER FLUKE OF CATTLE AND SHEEP

*Fasciola hepatica* causes a loss of revenue in the cattle and sheep industries in many parts of the world. Reports from Peri, reveal that the feed at tone ce ST ieee cea Tere Sat

is aaa oe ?The occurrence of infection is reported to be 80-90%

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tsk ore Fan fo be fgdals MY A 29H OF sock chien tn 10 of

ster conelagee eeeras SHELing the mass of inforsation on schistosoalasts is

4 hepatica has been established in our laboratory, ? Sm the fe cycle of

The anal vec

Aquaria with connect «mae Solunella) has been successfully cultured. Tray

ecinens about 25 wen, CHNPENE vateF provide mature snails in one nonth act

\* Zong in 3 months. The phenomenon of crowing may have

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Tage, Gea oF a

Ho. fish :

& Condition | tested wars | 24 Hre(Z)

2h

Background activity, subtracted from data,

In trial No. 3b, the fish were fed normal cercariae repeatedly prior to test (i.e, they were familiarized); the guppies in trial 3a, had not encountered cercariae prior to test.

x only 12 fish were observed after 1 hour of feeding.

TABLE 2

<The effect of prior feeding of normal cercariae (familiarizing) before determining cercariophagic activity of guppies with labeled cercariae-

?Trial No.

& Condition

1. Familiarize

Wot Familiarized

e¥(a) Familiarized

Hot Familiarized

(b) Familiarizea

Hot Familiarized

\* Trial 2.(a) & 2.(b) were run simultaneously;

2.(a) in light and 2.(b) in total darkness.

+ Background radioactivity was subtracted from the data presented.

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their number 12 excessive

siete maar avis) 122 f004 formule used for Biomphalaria glabrata

ymanses.

?To expose snails, eggs of *F. hepatica* and

eggs were obtained from livers of infected

snails. | Most snails were infected after 55 days of exposure, set

Peete netascercariae the MALLE after 50-60 days and encysted in the

Infections in mice provide evidence for completion of the

laboratory. ?ompleting the Life cycle in the

The duration of infectivity of the netascercariae 4s being determined

by exposing mice periodically. The latter cannot tolerate the

infection. The Course of the infection in this respect are

in agreement with published reports, Studies on biological

progress. Sero-diagnosis and vaccination Studies are

in progress. Sero-diagnosis and vaccination Studies are

The combined importance of schistosomiasis and fascioliasis, and the possible

danger from paragonimiasis in part of South America, appear to warrant

the establishment of a Pan American Control and Research Center for snail

borne diseases.

THE CERCARIOPHAGIC ACTIVITY OF GUPPY FISH (*LEBISTES RETICULATA*)

DETERMINED WITH RADIOACTIVE CERCARIAE

This study was designed to quantify cercariophagous activity of guppies using cercariae labeled with radiosele-<sup>75</sup>Se, and it was able to show whether the cercariae were consumed through a predatory act or if ingestion coincided with respiration.

Most guppies, regardless of sex or maturity, became radioactive after being fed cercariae. There were marked individual differences and heavily gravid females usually did not become active. The number of cercariae per unit of volume was varied by feeding the same number in different volumes, and different numbers in the same volume. In both cases a gradient of radioactivity in the fish occurred for counts taken after 24 hours, at which time the guppies had acquired 20-50% of the total activity of the cercariae. The counts for the fish were relatively low after one hour, but increased considerably after 2 and 4 hours,

Guppies took up radioactivity more slowly in darkness than in the light (table 2). After one hour, fish in total darkness were essentially normal, and after 4 hours the fish in the light were 5 to 6 times as active as those in the dark. This difference was greatly reduced after 24 hours, suggesting the guppies developed means of detecting the cercariae in the dark.

Guppies that were familiarized by repeated feedings of normal cercariae

Prior to giving them labeled cercariae, became radioactive much more quickly than fish that had not encountered cercariae previously (Table 2). After one hour the difference was 7 to 13 however, it was only 2 to 1 after 24 hours,

Selected fish with highest radioactivity were decapitated and the intestines removed from the body. The difference between head and body was size-  
dependent while the relatively small intestine had about half the combined activity. Head and body, Thus it appears that cercariae passed through the digestive system and that products thereof were absorbed.

The evidence clearly indicates that guppies are predaceous.

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The in vitro effect of the hemolymph of *B. Glabrata* on the metabolism of *S. Manson* worms

Fig. 1

Fig. 2 Effect of whole body radiation on host-parasite relationship involving mice infected with

ey

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1w ress UF WHOLA-BODE RADIATION (609) ON THE HOST-PARASITE RELATIONSHIP INVOLVING MICE INFECTED WITH SCHATSTOSCHA wusISOH

Acquired resistance against *S. mansoni* has been conclusively demonstrated, but the mechanism involved remains uncertain. The involvement of antibodies is doubtful, while resistance mediated by cells is a possibility. Moreover, the combined effect of both these factors must be kept under consideration. In order to dissociate these 2 possible mechanisms, whole body radiation of the host was used to depress humoral antibody formation, whereas cellular components such as macrophages and reticular cells are relatively more radio-resistant.

When mice were irradiated with 400 rads and then exposed to cercariae in varying numbers, there was a trend for animals exposed to intermediate doses (60 and 120 cercariae) to show higher mortalities than animals so infected but without irradiation (Fig. 1). This finding may merely relate to combined sublethal effects of irradiation and the pathology of the infection, which jointly overwhelmed the host, or irradiation may have reduced the development of resistance, allowing for more worms or greater egg production. This aspect of the problem was studied.

Mice were irradiated and infected the same day and sacrificed after 26 and 49 days. There were no differences in the worm recovery rates for irradiated and non irradiated animals. Male and female worms were both a little longer in irradiated animals at 28 days, while the reverse was true at 49 days; however, the differences were small. Egg numbers in both the liver and intestine were

higher in the irradiated animals.

?The granuloma in irradiated mice were twice the diameter of those in the non irradiated controls. The larger size was due to the fibrous component, while the cellular infiltration around the granuloma was reduced in the irradiated animals.

### [IMMUNOLOGICAL STUDIES WITH SCHISTOSOMIASIS]

General experience in immunology suggests that cellular immunity or delayed hypersensitivity, rather than humoral antibodies, is the effective system in host parasite interactions. However, there is little experimental work investigating the cellular aspects of immunity in Schistosomiasis.

Experiments have been initiated in an attempt to demonstrate passive transfer of immunity to schistosomiasis in mice using cell suspensions from immune animals. For many reasons the experiments are difficult and lengthy. For a concerted attack on the problem it is essential that one have an in vitro system for studying the problem. Attempts are being made to develop such a system. Preliminary experiments suggest that a practical system can be obtained incubating together adult worms and lymphocytes purified by sedimentation from spleen cell suspensions. When these are incubated overnight in tissue culture medium, the adherence of the lymphocytes to the worms appears to be correlated with the immunological status of the animals which supplied the lymphocytes

With the immune lymphocytes, there appears to be a reduction of about 50% in the glucose metabolism of the worm. Attempts will be made to quantify the lymphocyte adherence and improve other features of the test.

## ?THE EFFECT OF SNAIL HEMOLYMPH UPON THE METABOLISM OF SCHISTOSOMA MANSONI

The observation of Oliver-González that mice could be cured of Schistosoma mansoni infections by snail hemolymph led us to investigate the effect of this material upon the metabolism of  $^{14}C$  pyruvate by the worms using the techniques outlined above (Fig.2). It was established that the hemolymph inhibited the

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metabolism of  $^{14}C$  pyruvate by the worms and that inhibitory activity was stable upon storage at  $4^{\circ}C$ . Separation of the hemolymph into low and high molecular weight fractions by ultrafiltration and dialysis, respectively, established that the inhibitory activity against the metabolism of pyruvate resided in the low molecular weight material, and not in the high molecular weight fraction. Molecular sieve chromatography using P-2 acrylamide gel established that the molecular weight of the active principle was between 500-1000. However, tests

Mith infected mice denonstrated that both the dialyzed heaolymph and whole henolyuph reduced the worn burden of the snail by over 90%, whereas the ultr filtrate cave a 22% reduction. It appears that one must invoke soxe nechanism Sther thas that of an anti-netabolite to explain the effect of snail henolymph upon mice infected with *Schistosona mansoni*,

#### DESTRUCTION OF SCHISTOSMA MANSONI IN MICE BY THE HEMOLYMPH OP I2S SUAIL VECTOR, BIOMPHALARIA GLABRATA

After Oliver-conzdlez observed that mature yorns of *S. mansoni* in mice were killed by the henolymph of ts snail vector (1968, Proc. Soc. Exper. Biol. Litied. 125, 1029), we demonstrated that the rate of metabolic degradation of pyruvate by the wores was less when they vere incubated with the hemolymph and the ultrafiltrate thereof, but not by the dialyzed henolymph. With these three materials, we carried out in vivo tests in mice, following the experimental, plan of Oliver-conzélez.

whole henolymph (16.66 mg. protein per nl) and dialized residue were

Anjeoted into mice with 50-day infections by the i.p. route daily for 5 days in amounts of 0.1 and 0.05 ml. (diluted 1:5 or 1:10  $\phi$  saline); and 0.2 ml. of the ultrafiltrate was injected on 3 consecutt 7

orm counts were made 1 to 20 days Jections in comparison with nice injected with saline. With the wiole herolyaph, worn burdens were reduced bout 50% after 5 days ani 9Of acter 20 days, contiraing the results of Olivers Goneiiez, ?Tee dialyzed herolymph reduced the worna GO ani S9f, respectively, after, 10 and 20 days from the Last injection, In case of the ultrafiltrate fae worm pen wat Teguoera cray'e 2ittie (Ef) 15 days after the last injection ble 3). Theos results  $\phi$  dialysed henolymph and the ultratiltrate are Ste reverse of thone obtatned in blochesioal teat Saais en

TABLE 3

[BRFEOTS OF HEMOLYMPH OF BIOMPHALARTA GLABRATA SAILS

(ON INFECTIONS OF SCHISTOSOMA MANSONI IN MICE

Wear Wiebe Works Recovered "W" Days AS THSCeISaT

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eo

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Control mice | { y

Reduction (8) | 8 Lo \$ H 2 @

?= Dian CEO SO LAD 5 Fe

Control mice i os Te

Reduction (4) i 25 8

Reduction (4)

Figures in parenthesis indicate the number of mice involved,

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Fig. 3 Metabolic release of CO<sub>2</sub> from  
pyruvate 2-0 by varying numbers  
of worms

Fig. & Degradation of Pyruvate =  
and female worms of;

Fig. 5 amounts of lactic acid produced  
when varying numbers of male  
and female *S. Mansoni* were incu-  
cubated with  $^{\circ}\text{C}$  glucose for  
3 hours at room temperature

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evolution by varying numbers

pyruvate 2- $^{\circ}\text{C}$

Incorporation of Metabolites of  
pyruvate-2-  $^{\circ}\text{C}$ , acetate-1-  $^{\circ}\text{C}$   
and glucose-  $^{\circ}\text{C}$  by cercariae  
of *S.*

Fig. 8 Kinetics of

pyruvate 2-4

cercariae of

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METABOLIC UTILIZATION OF PYRUVATE AND GLUCOSE BY MATURE

WORMS OF *Schistosoma mansoni*

Metabolic utilization of pyruvate and glucose by mature worms of

*Schistosoma mansoni* was determined by the method of Chiziuoga & Roy,

Hess (1962), modified. Amounts of lactic acid resulting from glycolysis

were also quantified. Varying numbers of worms were incubated with each sub-

strate, and relative amounts used by single female worms were determined.

When the same numbers of worms were incubated with pyruvate and glucose,

each with a radioactivity of about 0.5  $\mu$ Ci, CO<sub>2</sub> evolutions of 80,000 and 26,000

cpm were obtained, respectively. Dead worm controls with glucose gave counts

of only 207.

Five (5), 10 and 20 pairs of *S. mansoni* worms metabolized pyruvate in

proportionately larger amounts, the  $\text{CO}_2$  releases giving 27,700, 60,700, and

60,300 cpa, respectively (Fig.3). When the pyruvate activity was varied, using about 0.125, 0.25, and 0.5  $\mu$ M, the corresponding counts were 15,300, 19,200 and 60,700 (open); for dead-worm controls, the count was

In four trials, each with 3 or 6 replicates (flasks), the Cp recovery from male worms incubated with pyruvate was about double that for females (Fig.4). In contrast, the degradation of glucose to lactic acid was found to be about equal for the sexes, and with varying numbers of worms of each sex, 80% of lactic acid production was obtained (Fig.5)-

Utilization of pyruvate 2- $^{14}$ C, acetate 3- $^{14}$ C, and glucose 6- $^{14}$ C  
BY CERCAE OF SCHISTOSOMA MANSONI

Bruce (personal communication) found that cercariae of *Schistosoma mansoni*, while free-living, incorporated and metabolized radiolabeled pyruvate and glucose. Certain aspects of this problem have been studied in our laboratory, using pyruvate 2- $^{14}$ C, acetate 3- $^{14}$ C. To date, the investigation has involved only the evolution of  $^{14}$ CO<sub>2</sub>, but it is intended to determine whether the cercariae degrade glucose to lactic acid.

It was shown experimentally that 1.0 and 0.5  $\mu$ M of glucose or pyruvate

were optimal for testing, A direct relationship between the amount of CO<sub>2</sub> released from pyruvate was demonstrated (Fig.6). Larger amounts of CO<sub>2</sub> were released from pyruvate and acetate than from glucose, On the other hand, more glucose accumulated in the cercariae (Fig, 7 ), suggesting that gut metabolic degradation of glucose by cercariae may be "incomplete" (Ginereste).

With temperatures of 10, 20 and 30°C, cercariae gave a progressive increase in CO<sub>2</sub> evolution, while at 40°C a sharp decrease occurred.

When cercariae were incubated in pyruvate and glucose for periods of 1 to 5 hours, proportional increases in labeled CO<sub>2</sub> were obtained (Fig. 8). This observation was checked by allowing cercariae to age for corresponding periods before they were incubated (1 hour) with the substrate,

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TRYPANOSOMA PROJECT

1. Effect of whole body irradiation on *Trypanosoma rangeli* infection in mice, how is the host's response affected? (500 BASS) Administered to mice infected with *T. cruzi* produced greater parasitemia, there extended organ invasion and death of the animals at an earlier period than non-irradiated. It was of interest to see whether similar effects were observed in mice inoculated with *Trypanosoma rangeli*, parasite often found together with *T. cruzi* in human beings;

New-born mice were divided in two groups, one receiving 400 rads, the second one without irradiation, Half of the irradiated mice were inoculated by the intracerebral (i.c.) route with a culture of *T. rangeli*. The remainder were inoculated by the intraperitoneal (i.p.) route. The non-irradiated mice were inoculated in a similar manner.

one month after inoculation, the mice were sacrificed and parasites were sought in the spleen, liver, and heart, which were found negative. These results suggest that the host (mice) cells do not become more susceptible to infection with this parasite.

2, Induction by radiation of attenuated mutants of *Trypanosoma cruzi*, To determine whether radiation would induce genetic alteration resulting in an attenuated strain that could be used as vaccine, a culture of *T. cruzi* (strain Bertoldo) was exposed to the CoS source. The cultures were then the appropriate

Bluse of growth and the doves adzinered were 100, 1,000, 10,000 ana? 50,000

Fade, After radiation, the trypanotones were inoculated icp. in groups of 21  
day cla mice; the nediim was replaced by e new one and furher incubated at 26°  
during 2i days, uhen the irradiation was repeated. In all, the different doses  
were administered 4 times at daily intervals. The mice were searched for  
trypmosones in blood and ven found a henoculture was made in Liquid weatum.  
Subeultures were nade twice in Yaeger? s medium ani then titrated for virulence  
sud infectivity in mice and tieaue culture. Four weeks tater, the mice wore  
challenged by the i.p. route with 1,000 blood forms of T, cruzi (Tulahuen strain).  
(Gee table) sae

the mimese data seem to indicate that better protection can be obtained when  
fe microorganisms have been subjected to frequent exposures.

---Page Break---

Iventy four days after inoculation 4

ice?vare chatiensea'ste? SG0mlstion tp. of Out mt of these cultures, thy  
with the rantonnees,f:Be with 109 blood forms of the virulone eet traty

CuuauRe ?Raptarzon Prorzcrive,

mer mosis inocu contieme

Joset \_Tines concentration infectivity Lethality tat. yop

2 2,000 2 2.26 e107 af oh nap

2 1,000R 2 1.82 x 107. 1/6 ofa 6/6 3/6

3 10,000R 3. 0.81 x 107 6

4 50,000R 2.12 x 106 2/6 o/5 bh om

5 of 55s

4 Of6 6/6 bfe

5 1,000R 2.06 x 107 2/6

6 Of6 36 26

6 of6 6/6 5/6

6 20,000R 2.85 x 107 Ys o/s 5/5 2/5

6 oe 6/6 3/6

5 i

st

7 10,000R 3.41 x 107 3/5 o/s 3/5 5/5

26 oe be 2

3. Sensitivity of T. cruzi-infected cells to sin. The metabolism of

3. crust-Infected colle Te very differant Hom Soe ete Te ee eat

celts, which saree

?Tnterest to compare metabolic pathways of normal and infected

it necessary to obtain almoet pure populations of both tysess ?k'esgug of Doe

celts were infected with a fluid neditm containing 10° Teparonene ores,

Starting the 4th day after inoculation, a set of 4 tubes was ?Separated and

treated for 2 minutes at room temperature vith trypsin and with Hank's seine

solution. This treatment was repeated at different Line intervals vith the

following result:

Rate of Infection by 7. cruzi in Celis Treated with Trypsin

TREAMENT

Day. Kone 0.25 trypsin (0.12% trypsin 0.025% trypsin

ae 2.38 3.7% 4.66

2 3 3 38 56

1 12. 3.2 So 67

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Further studies are under way in order to separate and transfer the infected cell population, since it has been observed that infected cells can attach to the glass and even divide.

4, Tmantes of 1. crust infection in different cel Lines, Tenpersture  
ts one ?of the Fiovare Wecounting Tar tntraceiioier Grower, ceorly da  
experixent vas designed to see whether other factore (tyre of celly cirain of  
frerusi) could play an inportant role. Dp celle (reported in FRC fnmsn  
eport 1965) and monkey kitney cells wore intected with T. eruri coltures The  
tubes were divided in two groups, one inoculated at 26°C and the fecond one at  
Sire. ?Every 2h hours one ?ube cf each group was rexoved from the Sncubacor and  
exmsined microscopically for the presence of Leishmania forms sneise she celle,  
With the following results:

## Intracellular Infection in 2 Line Cells Incubated

THE OF CHS

Yonkey Kidney Cells Pep Cele

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These results show that there exist differences of susceptibility among the different cell lines. They also suggest that the principal factor affected by the temperature is the period of adsorption penetration.

5. High temperature effect on *T. cruzi* infection at cellular level, Cp cells, Clone I, were inoculated with *T. cruzi*. After inoculation, and every 2h hours thereafter, 4 tubes without inoculum and 4 of the inoculated group were transferred to a 40°C incubator. After 7, 5, 3, 2, and 1 days of incubation at 40°C a subculture of these tubes was made; one was incubated at 26°C and the other at 37°C. either showed growth. No intracellular parasites were observed even when the tubes were brought back to 37°C for further incubation.

4p complement this experiment, 18 roller tubes were inoculated with *T. cruzi* and incubated at 37°C and those showing intracellular infection were transferred to 40°C. After 7 days of incubation at this temperature, 2 tubes were removed daily and brought back at 37°C. The tubes removed from 40°C after 7 days incubation had large amounts of trypanosomes, but those incubated longer were negative, to see whether those tubes had intracellular parasites, the cells were removed at 7, 8, 9, 10, and 22 days were trypsinized, gently broken in a theme grinder and titrated in Hp cells.

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Dey After Inoculation showing Trypanosomes

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## DILUTIONS OF THE INFECTED MONTAYER

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ground end prepared in various dilutions. Two tubes were inoculated with 0.1

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Dey After Inoculation Showing Trypanosomes in the Medium

Day After Inoculation Showing Trypanosomes

or

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ot tor? tor aoa a0 ao

Brain 4? & 7 8 9 13 Weg

Ger ot oo of 9 ko

Spleen 4 4 7 8 9 1T Weg

ee a rr a rr

Heart 4 4 4 8 9 Neg Neg

This method of quantitating trypanosomes in a tissue system is very accurate and it is being tested in the effects of radiation, drugs, etc., affecting the host-parasite relationship.

1, Effect of Poly 10 on Trypanosoma crust infection in mice, Poly 1.t.y

olymictBctide, Inducer TnterTenes a anata ae Bee Poly Ty

farses ter to eienine wetner the ester othe vet tae Intel in

by rypmnotona cruzi, five groups of mice (29 days old) received soe Gree ee

1c; th 0.5 ml of Wn tip. route. Five groups of ten mice each were

control, the day before both groups were inoculated with the He

1, crust strain, in dilutions 10<sup>2</sup> to 10<sup>10</sup>, Poly I.C. was administered 3 times a

Sel For 2 weeks, then 1001 aon

Effect of Poly I,

An Mouse Lethality by 7. cruzi

DILUTIONS OF 7. cRUZT

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20-2103 a0-4 0-5 0-6

Hee wer Py Le, 5/5 te 375 375

Mice without Poly I.c. 5/5 5/5 5/5 3/5 0/5,

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A small degree of protection seems to exist in th

seems to exist! 1¢ group given Poly I.C. and

further experiments are under way to ascertain if this is eign floant.

8, Effect of Poly 1.0. on A int

20. on, osoma cruzi infection in celle, A einilar

expert was eet op Oy Getta, ge aeee See ecto a esTge: A ete

amounts of 100; after 2h hours a titration off. eruzi was male, ?The medium

es changed 3 tines? a week and at these interval iGoy" of fely Te, were aideede

Observations were made daily by inverted microscopy. ee

## DILUTIONS OF ©, CRUZI

30? a0"? \_a0°3\_\_ ro? \_\_ao5\_\_ ao

celle + Poly nc. + + 8 + + +

Cells No Poly Tc. + re : + +

he effects of Foly 1.C. on the growth of 7. cruzi in vitro was studied, To

it mediun, 10, 100, and 500y of Poly 1.c, with T. cruzi was added and then

Snooulated. ~

Effect of Poly I.C, on the Growth of 2. cruri in 100)

Wetfun end te Infectivity

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2 30100 500 tone

Growth + + + ars

?Titer in cells/ml 205 205 105 1S 105

9. Adsorption and penetration of *T. cruzi* into cells, To determine the

time necessary for *T. cruzi* to penetrate cells, cells were grown on coverslips in Petri dishes in CO<sub>2</sub>. Once confluent, they were inoculated with 10<sup>7</sup> (culture forms) *T. cruzi* and incubated again at 37°C. At specified times thereafter 2 coverslips were removed, one was put into a Leighton tube and EBM with

5% calf serum added; the other one was washed 3 times with Hank's saline solution containing 1% of an anti-*T. cruzi* serum, and then placed into a Leighton

tube with Hank's and antiserum for 10 minutes, washed for the last time and incubated at 37°C with EBM. The medium was changed 3 times a week and the 7th day the coverslips were removed, fixed with methylalcohol and stained with Giemsa.

Number of Infected Cells in Yonoleyer

Inoculated with T. cruzi and Washed at Intervals Thereafter

Washed with W.D. eT \_170 at a7

Washed with W.D. 3

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Adsorption occurs almost immediately after inoculation, but penetration of the parasites seems to have an optimum between 12 and 16 hours. Experiments being conducted indicate that the period of adsorption and penetration depends on the form of the parasite (in vitro culture or tissue culture) and strain used,

20, Ce12 receptors for 7. cruri, To test whether DC2 cet receptors were destroyed by T- Haapells elle Tere Lnoestated with 107 forms from fosee? een medium and incubated at 37°C during different periods of time. The renclayers were washed 3 times with Hank's saline solution and then inoculated with 10 and 109 of T. cruzi with 2 tubes left as controls. The cells were incubated at 37°C during one week with medium changed every 2 days.

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Intracellular Infection by 7.

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?These results show that cell receptors are not affected ty 7. rengeli.

11. Trypsin action on cell receptors, The mediun of DC2 cell growth in roller tubes was changed and replaced by a new one to which trypsin was incor= porated at a final concentration of 0,0025%. The cells were further incubated at 37°C and at different intervals inoculated with 10<sup>7</sup>, cruzi from tissue culture. Two tubes were left without inoculum as control of the trypsin on the cells, two additional tubes were used as control of the parasites. After 2 hours of trypsin action, the cell sheets were washed with Hank's new medium added, and incubated further at 37°C.

## Action of Trypsin on Cell Receptors for *T. cruzi*

?HOURS OF ACTION

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Talis treated ad inoculated

Gelis treated

Celis inoculated

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to trymein ction vas observ on the cel receptors by the dferen  
periods, at least with this concentration. ? " Otters

12. Resietance of *T. cruzi* to tempersture. to determne the resistance

of & nisi to different temperatures, blood of an infected mouse with a concentration of  $32 \times 10^7$  parasites per ml. was diluted 1/1 in Tueger's media with

50 units of heparin. This mixture was divided in 3 tubes, one left in refrigerator at 4°C, the 2nd, at room temperature ( $21^\circ\text{C} \pm 2^\circ\text{C}$ ), and the third one at  $37^\circ\text{C}$ .

At different intervals, 0.1 ml of the blood was taken and titration made on 0.2 cells. The results: ?

Effects of Temperature on the Inactivation of *T. crust*

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?The great resistance of *T. cruzi* to temperatures prevalent in tropical regions would allow the sending of blood samples to a central Laboratory to process specimens for diagnosis of the disease as reported in this report.

13. Separation of DNA components of *T. cruzi* infected cells by centrifugation and SRE. Several components of the parasite have been started to separate the several components of trypanosomal DNA by density centrifugation in CsCl<sub>2</sub>. There is reason to believe that it may be possible to separate the trypanosomal DNA from that of the tissue culture host cell. If this proves to be true, the use of thymidine incorporation and irradiation for a study of host parasite interaction at the cellular level will be very valuable.

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Non irradiated inoculated controls were included.

Animals were also included in the experiments. ?The:

Animals were bled daily during experiments. These

Animals were bled daily and the virus content of the blood was determined in |

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the irradiated animels. vanes S sisiowying &

Results obtained with wild rats are very similar to those obtained previously with adult white mice. Rats irradiated with 400 Rads and inoculated with virus showed a significantly high concentration of virus in the blood from the first to the 7th day. Rats irradiated with 600 Rads and inoculated with virus showed viremia on the 1st day which lasted for more than 7 days. Although not as high titer, virus persists longer in animals irradiated with

B, Activation of coxsackie virus by radiation,

1. In Adult Mice, A selected number of mice of similar age (26-30 weeks) and weight average of 22 grams were divided into 7 groups of 26 mice each. They were irradiated as follows: Group I was kept as unirradiated control, Group II with 100 Rads, Group III with 200 Rads, Group IV with 300 Rads, Group V with 400 Rads, Group VI with 500 Rads, and Group VII with 600 Rads. Each group was then divided into 2 sub-groups, each one containing 13 mice. One sub-group was kept as irradiated control and the other was immediately inoculated with 796 1D50 suckling mice coxsackie ALO virus. As previously reported, as seen in this experiment, animals that were irradiated and inoculated with the virus showed a viremia that lasted for several days, depending on the irradiation dose. No viral activity was found in the irradiated uninoculated group. After 16 days, animals were bled again and no viral activity was found in the blood. 22 days after irradiation and inoculation, no viral activity was found in the blood or in selected organs of animals that were sacrificed. A second dose of irradiation (400 Rads) was given to the surviving mice. After

18 hours the animals were bled, sacrificed, and the following organs were selected and harvested individually: brain, lung, heart, Liver, pancreas, and Spleen. Pools of similar organs from animals of the same group were made and tested for the presence of virus in suckling mice. Viral activity was found in spleen, brain, heart, liver, and pancreas from the groups receiving 400, 500, and 1000) Rate? in order to determine if the virus isolated from these organs was the same virus, neutralization tests were done. Only the original virus, Coxsackie A10, was found. The important point here is that after the second Seer to Coxsackie, virus was isolated from groups of mice that just previously had had no virus in the blood nor apparently in any of the organs tested. Either the active virus has been present in very low concentration, and was not detectable by our methods) or the virus, in a latent state, was activated by radiation.

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It is a virus (fattus rattus) from EL verde forest wip

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rola apgrage of HA7 eras Ord oro bled innwitatly 10 test for constckle  
EIBGE orfnqctranising ancioodies against fe, Orly one animal shoved virus  
Sn see Oe ety diarrhea and died 2 aye later. he virus

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(irradiated and inoculated with virus). This again indicates activation of

Tatent infection by radiation.

in the tissues of adult mice and adult wild rats: (1) a significantly greater

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fate of mitrition, hormonal balance and sthor factors? feng STmatss backer ound,

affects sone of these puraneters, making the aninal susceptible to the infections

## ©. Isolation of Virus from Inmune Animals after Gamma Irradiation

1, Hemme Adult Mice, Adurt mice (CF 1) wore immunized with coxsackie ALO

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sucking nice on three occasions at T day intervala;? Inecatenes 2p eet

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Virus vas isolated frou these nice at any of the tines tected?! ?3° de SSy8

Aatvar the last virus inoculations Uw anleaia vere tivises tiie Stett 22m HAF

(2) Immunized not irradiated; (2) immunized irradiated with 409 rads  
Immunized irradiated with 600 Rads, Non-immune animals of the same age (3)  
also divided into 3 groups to serve as controls; (1) non-immune not irradiated,  
{2 non-immune irradiated with 100 Rads and (3) non-immune irradiated  
+ the animals were bled immediately after irradiation at 15

00

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24 hours, whereupon the animals were sacrificed and several of the organs harvested  
and tested for the presence of virus. Coxsackie virus type A1 was isolated  
from mice that were immunized and irradiated with 400 Rads, no viral activity  
was found in the immunized not irradiated, or in the not immunized irradiated,  
?The animals from which the virus was isolated had demonstrated neutralizing  
antibodies, Here we have the case in which a virus persists in an  
immune host

2, Iasune Wowborn Rate, Nevborn rats inoculated i.e, with coxsackie virus type A developed a very Intensive vizenia for 72 hours. After the virenia, the rats remained alive and after 18 days antibodies were recovered from the ser, No active virus was found the 6th day. ?The nother of these newborn fate had no neutralizing antibodies, The rats were divided into tvo groups: (1) rradiated with 800 Reds and (2) inmne not irradiated control. After rrradiation, coxsackie virus was isolated from the innune-irradiated rats while none was isclated froa the inmne-not irradiated.

ff viral and rickethsial diseases, Just as in some bacterial ?and fungal diseases, one attack almost invariably Causes 1ifelong irmunity; examples of thie azç enallpox, measles, munpe, pollo, yellow fever, and epidenic ius. Most pergon vho recover from these raldies continue to have denonstrac ble specific circulating antibodies for many years afterward. One might account for persistent inmunity on the basis of repeated contacts with the viral agents. om the other hand, this explanation does not account for persistent antibodies in persons who recover from yellow fever or typhus and then ive for eany years in areas where the disease is not endenic. It is often assumed in such instancee that the agent persists in the recovered individual. In the experi- ents that have been descrived we have shown that the virus does persist in the Yrnune animals and that it can be activated by gamma radiation.

The mechanism by which these pathogens survive in the immune host is not understood. They may exist intracellularly, where they are protected from the usual humoral or phagocytic defense mechanisms of the animal or they may exist in a form that is not affected by these defenses.

D. Enhancement of Interferon Production by Gamma Irradiation in Chick Embryos (Citation of Mrs. Carmen Rivera).

The effect of gamma radiation on the production of interferon (IF) by 20-day-old chicken embryos induced by Newcastle disease virus (NDV) was studied. Embryos were treated as follows: Group I received no irradiation and no virus; Group II 100 Rads; Group III 200 Rads; Group IV no irradiation and 0.5 pfu NDV. The virus was inoculated immediately after irradiation. Separate pools of allantoic fluid and embryos were made at 14, 24, and 48 hours after irradiation and infection. The IF was assayed by the plaque inhibition test of sinibis virus in chick embryo fibroblast. Only small amounts of IF were produced at 14, 24, and 48 hours in Group IV. The allantoic fluid and the embryos of groups I, II, and III did not show TP at any of the times tested. The allantoic fluid and the embryo of groups IV, V, and VI at 24 hours had 60, 2500, and 1280 units of IF per ml, respectively. The amount of IF at 48 hours in Groups V and VI was 120 and 120 units of IF, respectively. All embryos in Group IV died between 24 and 28 hours. Embryos of groups V and VI began to die at 48 hours. This partial

protection could be related to the high concentration of IF present. in exbryos.

Sore complexed polynucleotides induced the production of IF ant, since irradiation liberates nucleic acid from cells, nucleic acid could be involved in enhancement. Irradiations also break the permeability of the cell membrane; this damage could make more cells capable of producing IP access to the

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## REACTOR

The Reactor Division provides support and services to other divisions of PRIC which require neutron and/or gamma irradiation. It operates and maintains:

(1) @ one megawatt, pool type research reactor; (2) a ten watt, aqueous-heterogeneous In77 reactors (3) a cobalt-60 gamma irradiation post, and (4) high

?The Reactor Division also operates and maintains all the auxiliary equipment associated with the reactor such as beam tubes, rabbit system, fuel element irradiator and gamma room, transfer port, etc., and all pool water cooling and

purification equipment.

During the year, the one megawatt reactor operated routinely two shifts per day, five days a week, accumulating a total of 2970.116 megawatt-hours. A total of 773 side-of-core irradiations were performed. In the ganna pool, 419 irradiations were carried out.

The L-77 reactor was used for training and student experimentation throughout the year. The pile oscillator experiment was successfully completed and served as basis for the thesis of a graduate student.

Work on the one Kilovatt reactor slowed down, pending revision of the Safety Analysis Report. This work will be continued next year, at which time all necessary documentation will be prepared and submitted for consideration.

The operating limits for the one megawatt pool type reactor were revised and brought up to date. Test procedures were prepared and implemented to comply with most of the limits set forth in the document. Procedures will be prepared for the remainder of the limits during the coming year.

Plans and negotiations are underway to convert the one megawatt reactor to a more powerful, versatile unit. The present reactor will be converted to a two megawatt thermal constant power reactor with a pulsing capability of two thousand megawatts. The reactor to be installed will utilize modified (FLIP) Triga type fuel of zirconium hydride with erbium as a burnable poison, and be stainless steel clad. Conversion and full power operation is expected to take

Place in the spring of 1970.

## EDUCATIONAL ACTIVITIES

Mr, Fernando Lopez Carrasco, from Mexico, who served with the Reactor Division after completing his H.S. Degree, left the division in May, at which time he received a certificate indicating that he had served and was qualified as a Reactor Supervisor.

The Reactor Operator Refresher Course, initiated in 1967, continued during the year at a slower pace and will continue through next year.

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HEALTH PHYSICS,

The Health Physics Division, which deals with health and safety;

° » which deals with safety problems,

Operates at both Rio Piedras and Mayaguez with two main functions: it provides the services needed for safe operation of the Puerto Rico Nuclear Center and implements the regulations; it contributes to PRIC's educational and research programs.

The services (see Table I) include consultation and supervision, in all matters concerning safety and especially in radiation safety.

To implement and enforce safety regulations, the Division instituted regular safety inspections in addition to existing monitoring practices and established safety committees with members within each Division. Instruction on safety, especially on radiation protection, is offered to PRIC personnel either through special courses or through the safety coordinating committee.

The education and research program includes:

2) Courses offered at UPR, Mayaguez, and UPR, San Juan, and the Medical Center, Rio Piedras in basic Radiation Protection at the graduate level for students not specializing in the field.

2) An M.S. degree program in Health Physics at UPR, Mayaguez. This program has been offered since 1959. Two students were enrolled during 1968.

3) A new one-year program leading towards the N.S, degree in Radiological Health at UPR, San Juan campus. hia progran is offered by the Department of Preventive Medicine and Public Health in conjunction with the Puerto Rico Nuclear Center. Fifteen new courses were designed to meet the needs of the students especially from Latin America, Six of then were offered during the Fall Semester 1968. Four students were enrolled, two of then from Latin Anerica,

4) Advice and supervision of student research theses.

5) Special training in Applied Health Physics, and

6) Basie research

Special emphasis was given this year in improving the FRIC sefety standards

and in developing the new program in Radiological Health. The progress so far in both areas is quite satisfactory.

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TABLE I

oving services are offered by the Division to any other project at

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General laboratory safety

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ec. Calibration of radiation Li Fire safety

monitoring equigment Br Goneuttation on matters conser

Radioactive materials all safety, especially on ratiatin

& and radioactive naterial:

handling

e. Enviromental surveillanc n, Indoctrination of staff nenbers in

f. Dosinetry\* Health Physics, Industrial ygtene,

g. Nuclear accident dosinetry+ Industrial Safety and Fire Pre-  
vention.

1. Decontamination

i. Waste disposal

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## SERVICES

ALL service functions have been improved with emphasis on prompt service, Procedures have been revised and updated. The PRIC personnel exposure report, for example, is now distributed within two weeks after the collection of the film badges. Further improvements are expected when the computer program, now in development, becomes effective. Personnel monitoring films are now being supplied to the I. Gonzalez Martinez Oncologic Hospital, University Hospital, the UFR School of Medicine, and the BOWUS power plant, as well as to PRIC personnel (see Table II).

The full program of environmental surveillance of soil, water, and vegetation in the vicinity of Mayaguez was discontinued. Only one sample of each is collected in addition to a water sample from the well of the India brewery, and these samples are processed monthly. The laboratory, however is completely capable of performing a surveillance in case of an emergency.

The construction of the calibration facility was discontinued, Yew constructions in Mayaguez permitted the Division to hold the old calibration facility for lower range calibrations. The 20 Ci Cesium 137 source was placed in one of the hot cells which was modified into a calibration room for higher range calibrations,

The film badge service laboratory was moved to the installation at Cornelia Hill. A dark room was constructed for this purpose, he presrem operates satisfactorily in the new location. Plans are underway to incorporate a digital voltmeter in the circuit of the densitometer. This adaptation will speed up the film density reading. Space is also provided for the Nuclear Accident Dosimetry program. ?The relocation will be done as soon as the eneréel cy power lines are completed. A complete revision and updating of the TAD Program is planned for next year,

?The radiation safety program at the Oncologic Hospital has greatly improve! The program, except for the film badge service, includes regular railevion surveys at the wards and rooms used for patients with implanted radiation sowcee> advice and recomendations on radiation protection, training in radiation pro? tection of the nurses in charge of the patients carrying radioactive sources, ?and indoctrination in Health Physics for new hospital personnel,

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Table 11

Health Physics Services 1968

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Film Service to PRIC and BONUS for the year 1968:

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?Total se o 1392

Radiation Survey neters calibrated:

2) cama 306

) neutron %

Total = 332 332

?Area Vonitring Somples Analyzed

a) scears

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8) air

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Environmental Surveillance samples

analyze:

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&) vegetation 2B

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Review of requests for use of irradiar

Hon fectiities other than reactor: ? a

Review of requests for radiotsotope

procurement: \* 2

Medica Dispensary - To. of cases seen:

8) minor accidents 28

f) pavetceb ename RT ws

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?he new procedures for the procurement, production and use of m1

materials are being followed satisfactorily. sienctiny

?Anew 4500 c4 60ç0 source, was ordered from ORNL to replace the ola

60cq toure in Rio Piedsan, A permit to transport the source was obtained fog"!

the Department of Transportation. he eld source vas transferred in Mayaguer

fani was Placed in the seactor pool next to the gama 7003. The gREmA Poon xin  
be used ac a now radiation facility for moderate dose rates.

A special three-room storage building is being built behind the eninal,  
houses Radioactive materials, flarmables and other hazardous materials vili pe  
stored there, The bulding will be ready in Warch 1969.

Plans to construct @ special irradiation room for the Texas Nuclear Keutros  
Generator were pale. The safety features for this room are being examined,

?an emergency plan in case of any catastrophic event in Mayaguez vas pre-  
pared,? the Plan, & general one, relates PRIC problexs and competencies to the  
surrounding community.

two coomittees vere organized to deal with all safety problems. The  
comnitvees have branches in Mayaguez and Rfo Piedras. ?The first consists of alt  
Getston heads and one wenber fron the Director's office. Through this comittee,  
General eafety policy and rules will be approved. The second consists of one  
Bother fron each division who has supervisory or technical background, Through  
The comittee, followup of recomendations are implemented. Indoctrinstion of  
Hereonnel is offered in two ways: first, through safety institutes in Mayaguez  
Per pio Piedras in conjunction with the Labor Department of the Cocnonwealth of

Puerto Rico; and second, through lectures, personal contact and information pamphlets and posters supplied by the National Safety Council.

The Industrial Safety and Fire Protection program has greatly improved in Mayaguez and Rio Piedras during the year. Personal safety and Fire fighting equipment are provided by the division as needed.

### EDUCATION AND TRAINING

The education program has two main objectives. The first is to provide graduate programs leading to the M.S. degree and advanced training in Applied Health Physics for students who are planning a career in Health Physics. The second is to provide indoctrination in radiation safety and general safety for PRC personnel, and courses for students who will be working with radiation sources, but who do not intend to specialize in Physics.

A new Radiological Health program was developed by the Division through a joint effort of Medicine, Department of Preventive Medicine and Public Health (PAH) in addition to the existing Health Physics program offered by the Department of Biology, UPR Mayaguez campus.

Two students were enrolled in the Health Physics program UPR, Mayaguez. Five were accepted in the Radiological Health program PMPH-San Juan, two of whom are from Latin America (see Table III), One student from Mexico has

completed his training in Applied Health Physics. The program was arranged to meet the specific needs of the student (to be applied in his country).

Three courses, one at: UPR Mayaguez, and the others at the School of Nelson A. Rockefeller, are regularly scheduled for students not specializing in the

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Table m1

List of Students

Wane County, Program of Course

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1. Efigento Rivera Puerto Rico
2. Amalia Vélez Paradis Puerto Rico Deptor niniae rites

Dep. of Biology, UPR-ayaguez

1. tats Rodríguez Eoundor WS. in Radiological Health;

Dip, of Maven e Hetcimn at

wise Healthy Uri-San dan

2, mnie Aqutles Santana Colombia, We8. in Radiological Health

Dep, of Preventive Vdicine ana

Pibise woelth, UrResen Juan

Daniel Torres Ortiz Puerto Rico Meds in Raldological Hosaths

ops of Preventive ledisine and

Fibiie teeithy UPi-Sen Juan

|. Heriberto Torres Castro Puerto Rico a8. in Radological Healths

Deps\_of Preventive Medicine and

Pubise Health, UPR-San Juan

Agnes Weise Taraat Hoss in Radlodgeicea Helens

Dops\_of Preventive Hedicine ant

Pibise Health, UPR-Sen Juan

Ignacio Valéonado Rico Mexico Applied Health Physics

1, Alice Ortiz de Caraballo Puerto Rico «M.S. in Radiobiology

2. Michael Gileadi Iereel M.S. in Public Health

1, Luis David Bernier Puerto Rico PIPE 961

2. F. J. Fernández Puerto Rico Principles of Radiological Health

3. F: Folch Puerto Rico o 0 ?

Alo A. Iores Puerto Rico io G 5

5. J. A. Hegrén Puerto Rico 5 i

6. Ri. Orta Allende Puerto Rico : f

T. RL Roarfsuez Puerto Rico 5 :

8. AL J, Santiago Puerto Rico 5 : 5

9. R. Sinchez Valentin Puerto Rico a : a

10. Jesus Léper Garcla Puerto Rico

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sacy coe comes sae topice ats bas nsits psi; rdicett  
snteraction of radiation vith satser Te) and the principles of handling of  
Instrumentation a eres [aboratory on Radiation Detection vas included in  
radiation in all its 70% ç Public Health aspects of radiation were enpha-  
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ary engioners, | Ta audition spn Mmaddolsotope Bechniques? course offered four  
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it Research Status

Genma-Rey Spectra Around the PRIC Reactor. Heriberto Cusbas. This work is

sncoupletee Hie Purete of thie Tey Te ee dateraine the spectral: eaten

of gama radiation around the reactor. The regults so far indicate that the

predosinant gansas have an average energy of about 0.1 Mev. ?The student 1s not

working at the present tine.

Study of Exposure Received by Patients During Chest X-Ray Exantnations,

Anaiia Véies. The purpose of this stuly 1s to determine the dose delivers?

to the patients during routine chest X-ray exposure in Puerto Rico. ?The age

and size of the patienta, and the particular X-ray unit used, ¥Vp, nA setesags

and the filtration used are considered, The entrance and the exit dose were determined, utilizing theoluminescent dosimetry techniques. The data were

Published as a PRIC report.

?The New Program In Radiological Health

?The new program in Radiological Health is offered through the School of Public Health, which is considered by many leading universities in USA to be the natural environment for a program in Radiological Health~ All Courses

Some of the Public Health courses are new ones offered by PRNC, and are specifically designed for the students of Radiological Health

The academic prerequisites for enrollment in the program are a B.S., and 6 credit hours each of university level physics, chemistry, and statistics

?The duration of the program is one full year, including thesis. See page 2 of

and field practice was introduced since it appears to be more beneficial. However, if there is a future need for more sophisticated courses (including thesis) a course can be offered to students who mean a serious career. | During the summer the facilities of the Bloodier Sita consist

How Piedras are made available for Hospital Piytean-tinged student rates the

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clear reactor and other facilities at PiCcMayagues are erat

a 2 are available for studente

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of the stations and ?theds country.? NE 4# strange according t2 the need

?There is also a possibiity for futy

for future expansion of the program o that t

Bay erve 8 a core for an ¥.8. program in Radiation Biclogy and in Hospital

Most of the instruction 4s given tn Spanish, (approximately 754) with texte

books in English. This makes the program especially attractive for students

from Latin Americ roe a a a

The Curriculum

The curriculum is designed to provide integration of related disciplines

as the most effective way to create radiological Health Specialists, A minimum of 40 credit hours of course content is required. Table IV is a list of the courses offered, Full description of the courses is given elsewhere.

## BASIC RESEARCH

The calorimeter project. Substantial progress was made last year in the improvement of the sensitivity of the calorimeters. The purpose of the work is to measure the weak monochromatic X-ray beams produced by crystal diffraction. The work so far has demonstrated that this is feasible. Powers lower than 0.05  $\mu\text{W}$  can be measured. A new design of a multiple bridge is completed and it is expected to reduce the noise level sufficiently to measure powers of the order of 0.01  $\mu\text{W}$ . The power content of diffracted X-ray beams is considered to be within this range. Further progress was made this year. There are plans to continue this work next year.

The neutron dosimetry project. This work has been discontinued; it will be completed only if requested by another project, pending decision on the new reactor. The data collected so far at the beam tube suggested the redesign of the plug system with a new shutter and a new collimator four inches in diameter.

The filter will be of pure bismuth and is expected to reduce the gamma field considerably. A new development in this project is the purchase of a solid state neutron spectrometer. This system is the best available today for measuring neutron spectra, Thus it will be possible to develop fairly accurate neutron dosimetry for chemical and biological studies using the neutron beam and the pool as well.

The enzyme inactivation project. This work will be reactivated next year.

The purpose is to study the heat inactivation pattern of Horseradish Peroxidase (HRP) in solution before and after irradiation, and to determine the radiation damage induced. It was found that a dose of 200 rads delivered in the solution was capable of inducing considerable damage which could be made manifest by heat inactivation but which has not been detected by other means. The new development includes reconfirmation of HRP results and use of other enzymes to check the same effect.

The transpiration of the tritiated water project. This work was completed and a report on the service of aureaureasnte vere perfored at the rate forest. The transpiration of tritiated water from the rain forest soils was studied in cooperation with the Terrestrial Ecology Project. The Terrestrial Ecology Project is studying the movement of tritiated water in soils, and the Health Physics Division is studying the movement of tritiated water in the atmosphere. A cold trap technique using liquid nitrogen was utilized to collect tritium samples from the atmosphere at different heights and around the 1-square meter area sprinkled with 50 mCi of tritiated water diluted to 1 gallon of water.

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?Table IV

List of courses offered for the M.S. Program in Radiological Health

?The Following are Required Courses! treats ??

PRIC 501 Radiation Physics 2 cr

PRIC 505 Radiation Chemistry 2 cr

FRIC 510 Radiation Biology 2 cr

PRIC 525 Radiation Effects on Mammals and Humans 2 cr

FRIC 520 Radiation Detection 2 cr

FRIC 525 Radiation Dosimetry 2 cr

FRIC 530 Radiation Hazards and Protection 2 cr

PREC 535 X-Ray Protection 2 cr

FRIC 540 Decontamination & Waste Management 1 cr

FRUC 545 Laws and Regulations on Radiological Health 1 cr

FRIC 565 Basic Nuclear Electronics 2 cr

FAPH 47 Environmental Health 3 cr

HMGH 5563 Indust. Hygiene and Indust. Accident Prevention 2 cr

Pik 50 Biostatistics 2 cr

FRNO 599 Field Practice 4 cr

The following are Elective subjects:

PRIC 550 Radioactivity of the Environment 2 1

FRIC 555 Safety in Reactor Operations 1 n

FRIC 560 Reactor Technology 2 n

BPH 476 Seminar 1 ir

FMPH 189 Basic Epidemiology 2

ROH 420 Fundamentals of Public Health Administration 2

PH 430 Social and Cultural Aspects of Public Health 2

Phys. 325 Atomic Physics Laboratory 3

Phys. 326 Nuclear Physics Laboratory 5

Biol. 231 Genetics i

Biol, 351 Cellular Physiology 4

Biol, 372 Nuclear Techniques in Biological Research 4

Chen. 221 Chemical Analysis 4

Chen. K65 Radiochemistry 4

Math. 152 Statistical Analysis 3

Math. 203 Mathematical Analysis 3

Math. 20 Mathenatical Analysis 3

Math. 307 Ordinary Differential Equations 3

Net. 101 Introduction to Meteorology 3

Met. 103 Introduction to Clinate 3

\* One credit is equivalent to 18 hours of lectures or at least  
36 hours of laboratory work.

\*\* I= first semester, II = second semester, 8 = Sumter

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The results thus far indicate that the transpiration of water in the rain forest  
is a very slow process. Following an initial rise of a few hours, the activity  
persisted for several weeks at low rates, The relative hunidity was 60 percent.

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Population exposure project. A study was undertaken on population exposure

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corts were directed in measuring the gonadal dose to patients

undertaking medical X-ray exposures. It was felt that thie kind of exposure

ay be nore hazardous to the public in Puerto Rico than any other exposure.

?The work was divided in two areas. Measurements of the exposure dose deliv  
ered to the patients during routine chest X-ray exposures were performed. The  
gonadal dose vas then calculated. Secondly, direct neasurements of the exposure  
Goce and the gonadal dose delivered to the patients during routine abdominal  
X-ray exposures were performed.

?Thermoluminescent (TLD) dosimetry techniques were used. The age and the  
size of the patients and the particular X-ray unit used, Kvp, BA settings and  
the filtration used vere considered. The first part of the work consisted of

Gate compiled throughout the western part of the island and included statistical variations, The results will be published as a PRNC publication.

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## MARINE BIOLOGY

The work in the Marine Biology Program at FRNC 4né

includes both field and

laboratory studies. Special emphasis is placed upon field sampling and measurements to determine biological and environmental mechanisms which influence the transport and distribution of trace elements and radionuclides in the

ecosystem and their radionuclides in shallow

waters. The objectives of the program have not been changed in the last

decade. Methods

of approach do change, however, to take advantage of new analytical techniques and to resolve questions raised by recent investigations in this and other

laboratories in radiocology field studies.

The program was started in January, 1962 to provide background information

for use in the application of the specific activity approach in predicting envi-

ronmental hazards from radionuclides. The purpose of the program was, and continues to be, the development and use of field and laboratory techniques for measuring the amounts of selected trace elements including Be, Ca, Sr, Se, Yn, Fe, Co, Ni, Cu, Ag, Zn, Cd, He, Al, C, Si, Po, N, P, Br, I, rare earths and U in rocks, soils, river and marine water, marine organisms and river and marine sediments. The methods developed in this work are directly applicable to the use of the specific activity approach for marine contamination problems. These methods have been used during the past two years in a feasibility study for a sea-level isthmian canal.

The program is composed of six projects which are coordinated and integrated into a team approach to environmental and ecological measurements including:

Analysis for selected trace elements by flame spectrophotometry, atomic absorption spectrophotometry, x-ray emission spectrography, neutron activation, colorimetry, fluorescence emission, polarography and electron spectroscopy.

Measurements of concentration factors and turnover rates in selected organisms for given radionuclides in different forms.

3. Baele marine ecology investigations.

14, measurement of Biological productivity and energy transfer between trophic levels.

Background measurements in physical, chemical and geological

oceanography.

Determination of distribution patterns of "Light" and "heavy" rare

Determination of ions including river and marine water wide cations, and the hard and soft parts of marine invertebrates.

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The main geographical area of study is on the west coast of Puerto Rico,

In this area the outflows of three rivers empty into a 20 mile stretch of coast,

The Culebrinas river to the north drains an area containing large amounts of

Limestone. The central river, the Añasco, drains an area of volcanic origin in

Which are located hydrothermal deposits of copper sulfide. The Guanadito to the

south drains a mountainous region containing large amounts of serpentinite which

4s especially rich in cobalt and nickel. Although all rivers contain the group of trace and major elements, their ratios of abundance vary greatly, with each watershed supplying its characteristic assemblage to the marine organisms in the near-shore waters.

[A second area of study 2 on the south coast at Phosphorescent Bay in Vanich Investigations upon the seasonal changes in trace element content in the phytoplankton, zooplankton, water and sediments have been started.

The production of radioactive materials continues to accelerate. The number of reactors constructed for electrical power and desalination of sea water for irrigation or drinking increases yearly and the use of nuclear explosives for excavation and other peacetime applications is in the planning stage. Both reactors and nuclear explosions are capable of producing large amounts of radionuclides and one of these, accidentally or intentionally, will be introduced into the marine environment. In addition, the use of reactors for the propulsion of ships, rockets and other vehicles will continue to provide occasional injections of localized, but relatively large, amounts of radioactive material into marine areas as a result of accidental damage or destruction of the reactors, smaller amounts of fission products and neutron-induced radionuclides are released periodically into or near harbors by nuclear propelled ships. With continued advancement in engineering design this source of contamination may be reduced or eliminated but at the present time it must be considered. With the increasing number of countries developing nuclear weapons the possibility of the use of nuclear weapons for attack or retaliation does not diminish and the wide scale use of nuclear explosives in an ensuing all-out

struggle can not be discounted. In an action of this kind a large fraction of the terrestrial areas now used for the production of human food could receive additions of radionuclides including Sr<sup>90</sup> and Cs<sup>137</sup> in sufficient quantities that man could be forced, to turn, in part at least, to marine sources of protein. Strontium-90 and Cs<sup>137</sup> are subjected to sufficient isotope dilution in sea water

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M95 72! 485, am, 'mIS, "wee Pe, "COM, co88, 'coP?, ful03, ana RuOSRHIO could be introduced into estuarine and other 'shore' areas by direct releases from rivers or by advection of contaminated ocean waters. All of these radionuclides are subject to rapid sedimentation in shallow waters and, thus would be tied up in sediments and be continuously incorporated into human food organisms of marine origin. Radionuclides deposited by means of upwelling along the west coast of South Africa or Africa would also be trapped in coastal sedimentation. It is not clear that radionuclides in the fish populations of the sea would occur with time, "Some radionuclides would migrate to the Gulf of Guinea sequence and then to the coast, because of their characteristic mobility. They would not be incorporated into food chains leading to man. At least one of the radionuclides listed above, however, have relatively long half-lives of 25000

and are accumulated by marine organisms to levels that may contribute

Significant radiation dose to populations living there?

The more populated areas of the world, in general, border the major seas and oceans; man's principal point of contact with the marine environment is in the shallow near-shore areas. In these marine regions are located most of the world's harbors, the nursing grounds for many larval and immature forms of

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commercially important marine food animals, as well as the habitat of otters

Including algae, molluscs, crustaceans and other sea life

Some of the organisms of interest are the

single-celled organisms

found in the

sea

Some of the organisms of interest are the

single-celled organisms

found in the

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Some of the organisms of interest are the

single-celled organisms

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?The dominant mechanisms which control the distribution patterns of non-conservative trace elements and their radionuclides in the open ocean differ

from those which operate in the near-shore regions. In most estuarine, and

other shallow parts of the sea, the biomass and biological productivity are usually large as a result of nutrient additives from the land or from upwelling of deep waters. In addition, the waters are mixed throughout their depths to

the bottom and are in contact with bottom sediments which are often resuspended by tidal currents and waves resulting from winds. ?Thus, the near-shore areas

constitute regions of intense biological, physical and chemical activity in comparison with the open seas where the distribution patterns of added radionuclides are controlled mainly by water currents and density gradients except

for those radionuclides added as particles large enough to be subject to gravity.

In these regions biological effects upon the distribution of most elements are small except for limited transport downward of phosphorus, nitrogen, silica, lead, barium and rare earths. Biological transport of these elements is effected mainly through their incorporation into faecal pellets by zooplankton with subsequent transport to the bottom. Significantly all of these elements would exist as relatively insoluble salts in faecal pellets.

In the near-shore areas the sediments appear to exert the major influence upon the distribution patterns of several biologically important trace elements and their radionuclides. These sediments also influence the distributions of some radionuclides whose stable counterparts have no known biological function although they are accumulated significantly by some marine organisms. (These elements include (1) Biologically important P, Cu, Zn, Mn, Fe, Co, (2) non-Biological Ru, Zr, Nb, Mo, A, W, Sc, Re, Ca, Al.) Many of these elements, added to estuarine regions by terrestrial runoff, are precipitated or coprecipitated in areas of mixing of fresh and saline waters. Plant detritus in the bottom sediments of these areas often contain several hundred times as much iron, manganese and scandium as is found in the source plants on land.

Investigations designed to determine the distribution patterns of stable trace elements in the soil, land plants, river waters and sediments, marine waters and sediments and the marine organisms may be used to measure and define the relative influences of physical, chemical and biological mechanisms which control the distribution of radionuclides introduced into the marine system. In the Marine Biology Program these distribution patterns are being made. For all biological samples the amounts of trace elements are reported on the bases of wet, dry and ash weights and per gram of carbon and nitrogen and phosphorus and per 10,000 calories. In this way the transport of trace elements through food webs may be related to transport of organic material and energy through the marine system.

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## DEVELOPMENT OF ANALYSTS yETUODS

During the past year additional methods to

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Copper, ?Seperation proceaures for geotogich) eanples using carbonate fursen

feilowca ty elution, edjstgt of apd exttfootion wth emesi rvtisice

focarbonate (APS) allows the anaiysis of copper, nickel, Piast, en

cadmium with simple chemistry. a SpE

A method for analyzing uranium content of biological samples of marine organisms has been developed utilizing neutron activation followed by chemical separation. One hundred milligrams of irradiated (Neutron flux  $2 \times 10^{21} \text{ n/cm}^2/\text{sec}$ ) sample is quickly dissolved and the uranium is coprecipitated with 3 successive ferric hydroxide precipitations. The precipitate is washed, dissolved in 5% HCl; and extracted into ethyl acetate. The extract is dried under a stream of air and the  $0.0767 \text{ MeV}$  photopeak of  $^{239}\text{Pu}$  (11/2 23.5 min.) compared with that of  $2.10 \mu\text{g}$  uranium standard. The yield is about 90%.

A method has been developed for measuring small amounts of tellurium in biological samples. Tellurium has been reported to be relatively volatile at ashing temperatures. In tests made on exoskeleton, muscle, gills, hepatopancreas and gut tract of opiny lobsters raised in sea water spiked with  $^{125}\text{Te}$ , however, the loss of this radionuclide from ashing at  $50^\circ\text{C}$  for 2 hours was less than 1%.

In the analysis for stable silver one gram of biological sample is sealed, under vacuum, in glass capsules with alternate capsules containing  $5 \mu\text{g}$  of Ag on Whatman filter paper. The samples and standards are irradiated for 10 days (60 hours). After a few days silver carrier and a minimum amount of  $^{109}\text{Cd}$  is added to each sample which is dissolved by heat and diluted with water. Silver is precipitated as the chloride and the precipitate is dissolved in HCl and reprecipitated as the sulfide which is washed with water and dissolved in boiling HNO<sub>3</sub>. The solution is scavenged with ferric hydroxide, the precipitate rinsed

tin added to the supernate and the pH adjusted to about 3 with HCl. The silver was extracted with dithionite in carbon tetrachloride. The sample was dried and counted for the 0.6576 and 0.0815 MeV peaks. Yield is determined by neutron activation of carrier silver.

total particulate and "soluble" zinc, manganese and scandium in sea water may be measured with a relatively simple procedure. Twenty Liters of filtered seawater (G05) are acidified with 200 ml of 10% HCl and carrier-free Zn, SEI CAT 6B" added for the determination of chemical yields. The seawater is precipitated with purified ferric hydroxide (100 ng Fe) at pH 9 during an 8 hour settling period. A half of the precipitate is irradiated for 4 to 16 hours and allowed to decay for 3 weeks. The 0.6896 and the 1.1206 MeV peaks of  $^{46}\text{Sc}$  are counted by coincidence spectrophotometry and compared with a Se standard,

the other half of the ferric hydroxide precipitate is dissolved in 8 HCL  
and the iron extracted with isopropyl ether. The acid layers are retained and  
diluted to 10 ml with deionized water. One ml of the solution is irradiated 4  
minutes along with a 20y 6 Y comparator standard, The solution is scavenged  
with stannous hydroxide, The 0.6468 MeV photopeak is compared with that  
of the standard, Chemical yield is later determined from the tr

Determine determined by extracting the element twice with Bowex-50 from 5 ml  
of the same solution used for the manganese analysis after it had been adjusted  
to pH 1. The stable iron is analyzed by atomic absorption spectrophotometry and  
the yield is determined from the 2% spike.

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Particulate iron, iron, manganese, calcium and strontium retained on  
micropore filters (pore size 0.45µ) may be determined by atomic absorption  
spectrophotometry after ashing and dissolution of the samples. Feandium is,  
measured by neutron-activation analysis as described above.

A new method has been developed for the measurement of particulate phosphorus retained on micropore filters. The filter paper is compacted and placed in a stainless steel oxygen bomb at about 100 FET of oxygen. The bomb is fired electrically and the ash removed with distilled water. The normal losses of phosphorus volatilized during ashing are avoided with this method. The sample is diluted to appropriate volume and analyzed by colorimetry in an Auto-Technicon analyzer.

Tests of the accuracy of quantitative gamma spectroscopy have been compared with analysis by neutron activation on sediment samples. The standard deviation of gamma spectroscopy for aluminum and manganese is about twice that for neutron activation analysis. The two methods appear to be equally accurate for iron. Comparisons of accuracy between gamma spectroscopy and neutron activation have been started on biological samples. Development of methods for concentrating metals from biological material for use in gamma spectrographic analysis have been started using precipitation, liquid extraction and ion exchange.

## MEASURES OF CONCENTRATION FACTORS AND TURNOVER RATES IN MARINE ORGANISMS

The systematic study of the uptake of radionuclides by *Artemia salina* has

been continued. Carrier-free radionuclides for all of the elements tested are not available and the effects of isotope dilution upon uptake introduce significant errors into some of the tests,

Preliminary investigations have been completed on the uptake of  $^{62}Ni$  by the alga *Gaetonoerion costatum*. No difference in uptake was observed in dividing cells under light and dark conditions? but dead cells accumulated as much  $^{62}Ni$  per cell as did living cells. This may be caused by increased surface adsorption in the dead cells, probably as a result of increased number of associated epiphytes.

Studies upon the effects of marine microbes in increasing the apparent uptake of  $Hg^{2+}$  and other radionuclides in diatoms, marine benthic algae and the genus *Donax* are being continued,

## MARINE ECOLOGY

Studies on the assemblages of foraminiferans off the west coast of Puerto Rico

have been continued. Four species of reef foraminifera are present in the

high stegina Ar assemblage off the west coast of the island and include

?Hophistegina givbosa, Archaiss angulatus, Acterigerina carinata and Rotorbinells

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Submerged Pleistocene reefs off western Puerto Rico with relatively high percent

ages of the organim at two different levels representing submerged reefe and/or

wave-cut terraces at 55 meters and sutmerged reefs at 85 meters depth. The

dominance of this species in the relict reef fauna is an indication of texpera-

tures colder than the present ones during the building of these reefe. ?The

Amphistegina- benthonie foraminifera ratio is mich higher if only glmiconttized

Tests are considered, showing that the Anphistegina asseublage of the submerged

reefs is older than the living assenblage.

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Samples of foraminifera are being separated and prepared for trace element analysis. Comparisons will be made between recent and relict fauna,

Comparisons of the foraminiferan reef assemblages of Puerto Rico with those of Caribbean and Pacific Coasts of Panama and Colombia have been made. One of the principal factors causing differences of assemblages in the Caribbean appears to be that of local upwelling.

During the studies under on foraminiferan assemblages a new species and a new genus have been observed in the sediments off the island platform off the west coast of Puerto Rico. The new species, *Reophax caribensis*, is provided with a friable test composed of no well-centered grains, generally laminar. It lives in shallow waters. The new genus, *Glaucamina*, has been included in the family Lituolidae. The type species is *Reophax trilateralis*. The foraminifer is highly variable in shape and occurs on the outer submarine shelves of the Caribbean sea. Its friable test is composed of poorly centered grains, mainly of glauconite or calcite or combinations of these with other dark minerals,

total carbon, hydrogen and nitrogen content. in the Leptodermis (Hoober) and is the copepod *Poneelia sinocerea* (Gonsalee) Bee been determined. Results show that the copepod contain 45% C, 6% H and 11% Nitrogen on dry weight basis, and 30% O, 14% N and 6% N for the teopod.

The absolute amount of the three elements C, H and N, in mg/g dry weight increases linearly with an increase in size (weight) of *Fontella minor*; however, the ratio of the amount of C, H, and N to the organism's dry weight

remain constant. The animal thus seems to be able to maintain a fixed per cent of the three basic elements carbon, hydrogen and nitrogen. Samples which had been ashed at 520°C showed amounts of ash ranging from 9% to 26% of the organic dry weight. The ash did not contain any inorganic carbon.

Investigations continued on the distribution patterns of trace and major elements within components of biogeochemical systems. The frequency distributions of trace elements within sediment samples, rock types and homogeneous populations of marine organisms in all instances have always approximated a log-normal rather than a normal curve. Major elements appear to be normally distributed. When a pair of elements, whose biological uptake is similar, constitute trace elements in a tissue or organ (eg. calcium and strontium in muscle) their atom ratio frequencies are normal. When one of the elements is a major element in a tissue or organ (eg. calcium in bone or shell) and the other constitutes a trace element, the atom ratio frequencies are log-normal.

#### BIOLOGICAL PRODUCTIVITY AND TRANSFER BETWEEN TROPIC LEVELS.

The statement is often made that trace elements or radionuclides may be concentrated with passage through food webs in the marine environment. Marine food chains have been investigated during the past year for several elements including Fe, Ni, Cu, Fe, Zn, Cd, Pb, Mn, Co, Ni, Cr, Sr, Ba, Th, U, Pu, Am, Cm, Pu, and Cf. The nine-carand starfish

*Senegalensis* eats the snail clams *Tellina punicea* and *Mulinia forticorica*.

Is. Preliminary investigations suggest a slight increase in r, -Ye ant Cate

predator over that in the prey. However, all other elements listed above were present in the starfish in lower amounts than in their food. The intake of sediments, accidentally ingested by the starfish, upon the levels of copper in these animals is being investigated.

In pelagic food chains including mixed plankton, herbivorous fish and carnivorous fish all elements examined thus far, with the possible exception of zinc, are discriminated against with increase in trophic level,

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Studies have been made on biological productivity in Fluorescent Bay on the South Coast of Puerto Rico. One of the principal organisms in the Bay is the luminescent flagellate *Vibrio fischeri*. Plankton samples are also being collected in the Bay. Slightly elevated and elevated Fe and other elements, High concentrations of iron, manganese and aluminum have been found. These High values may indicate contamination of the phytoplankton with terrigenous detritus stirred up from the bottom although there is also the possibility that they indicate precipitation and coprecipitation of the elements from colloidal phases in runoff waters. Phytoplankton are known to concentrate aluminum by factors of 100 over the amounts in the water mostly by surface adsorption.

In order to establish the mechanisms responsible for the high values of iron, manganese and aluminum in *Fryodinium*, a culturing room with light source and temperature control has been constructed for raising this dinoflagellate in culture. Carrier free radionuclides will be used to measure concentration factors and turnover rates under controlled conditions. It is anticipated that turnover of most nutrient structural and catalytic elements will not occur during the exponential growth phases.

#### BACKGROUND MEASUREMENTS IN PHYSICAL, CHEMICAL, AND GEOLOGICAL COFANOGRAHY"

Large samples (40 Liters) of sea water have been collected to depths of 1500 m in the Caribbean and Atlantic regions near Puerto Rico. Samples of Plankton have been collected to 1000 m. Both the water and plankton samples are being analyzed for several trace elements to determine their distributions with depth. Vertical changes in amounts of elements in the water are expected. Vertical biological transport is an important mechanism in carrying trace elements from the surface to deeper waters.

The transport mechanisms for scandium are of interest because Sc is produced in cooling waters of reactors using river water and is also produced

in the use of nuclear explosives for excavation projects. Equilibrium calculations indicate that  $\text{Sc(OH)}_2^+$  and  $\text{ScPO}_4$  are probably the most abundant species in solution under sea water conditions. Similar calculations indicate that the concentration of total scandium in the ocean is much too low to be controlled by equilibrium with solid scandium hydroxide, studies reported thus far indicate that either adsorption onto hydrated iron oxide or onto phosphate minerals; or precipitation as scandium phosphate may be the controlling mechanisms for the concentration of scandium in sea water.

Two types of studies have been started for the purpose of tracing the sedimentary geochemistry of scandium. First, its vertical distribution in the ocean is being measured. The second phase involves the measurement of dissolved and particulate scandium around the outflow of the Afiaseo River to determine what happens to scandium during the interaction of fresh water with sea water. Results thus far show a disparity of concentrations between river and sea water which cannot be accounted for by dilution alone. Studies now underway include comparisons of changes in concentrations of scandium in soluble and particulate fractions with variations in salinity, pH, and in concentrations of iron and

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stations are located on Tani Beach near the outflow of the Aiasce River have been

sergeant collected on tan sech pur te ctu fe, scFv be een

heavily used by sire masts, fraeclwmt omen ae ums cert

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collection of sediments for physical and chemical analysis were done and studies

of pollen content in the water and sediments were in H

of pollen content in the water and sediments were determined as guide to

A cooperative project in mathematical modeling has been started with

Dr. Aviva Gileadi, Department of Nuclear Engineering UFR together in a

effort to develop methods for better planning of field experiments, measurements=

measurements and collections for use in defining the factors which control the use of

the specific activity approach to predict hazards of marine contamination with

radioisotopes. A model has been developed for physical dilution of a plane

source of radionuclides introduced into a marine area with an upper mixed layer

overlying a well defined pycnocline with a shear zone in between. A computer

program has been written in which several variables may be altered, including

amount of radioactivity, depth of mixed layer, degree of shear and site of

fallout patterns. The model is applicable only to radionuclides in solution.

Another model for vertical biological transport has been completed and a

computer program written. Variables which may be altered include: depth of

mixed layer, size of plankton population, biological half-life for the element,

characteristics of the vertical migration, chemico-physical characteristics of

the radionuclide.

Studies on the amounts of "Light" and "heavy" rare earths have been continued. Analyses of contaminants in YO used for yield determination, have been made. Preliminary tests on the use of Sc as a tracer for yield determinations have been started.

#### VISITING WEstrGaTORS

Several visiting scientists worked with the Marine Biology Program during 1968, financial and/or logistical support were provided for: Dr. Edward R. Tepley (Unit 8, Naval Radiological Defense Laboratory, San Francisco, California), who developed a method for measuring the amounts of palladium in sea water;

Dr. A. Gorkon Pirie (Dept. of Geology, University of Wisconsin at Milwaukee) continued his studies of the sediments and clay minerals off western Puerto Rico; Dr. Denier Habib, William Willer and Martine Dreyfus (Dept. of Geology, Queens College City University of New York) began sediment and pollen studies off western Puerto Rico; Dr. Walter A. Glooschenko, an Oak Ridge Research Participant (Florida State University) began phytoplankton cultures and investigated the uptake of mercury by phytoplankton; Hugo José Jiménez, a technician from

the Instituto Venezolano de Investigaciones Científicas worked on the development

Of analytical techniques for neutron activation and atomic absorption; Michael

Si Canoy, a student at the University of North Carolina (Chapel Hill, N.C.)

participated in his thesis research on the distribution patterns of DNA in marine

several animals. Best and F. A. Cross worked on neutron activation analysis

of marine organisms.

consultants visiting the Marine Biology Program during 1968 included

Dr. Neerstin (State University of New York at Stony Brook), Dr. Bernard

C. Patten (University of Georgia, Athens, Ga.) and Dr. Theodore J. Fry

(University of Rhode Island, Kingston).

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TERRESTRIAL ECOLOGY PROGRAM 1

THE RAIN FOREST PROJECT

The Rain Forest Project is an ecological research program focused upon an area of tropical montane rain forest on the island of Puerto Rico.

The original objectives of the program were: (1) to study

the effects of gamma radiation on the tropical ecosystems (2) to study cycling

of stable and radioactive isotopes through the ecosystem (popularly known as

"biogeochemical" or "ecogeochemical" cycling studies); (3) and to study the basic bio-

logical functions of this ecosystem, such as respiration, transpiration, and Photosynthesis in order to better understand phenomena related to the First two

The project is now in its sixth year, The first objective has been accomplished; results will appear in @ volume scheduled to be printed this year.

The radiation experiment has been followed up via recovery studies, and basic biological studies, including diversity studies, have been continued, but the major effort during the past year has been the study of radioactive and stable Isotope cycling.

## EXCLING STUDIES

Over the past several years, there have been numerous tracer experiments to determine rate of Isotope movement between ecosystem compartments, such as the movement between epiphyll and leaf, between soil and plant, and between Litter and soil. Tracer studies this year included movement through canopy trees of several gamma-emitting radiotopes, as well as tritiated water.

Quantity of stable elements in all major compartments were determined, as well as the rate of movement of these elements between compartments. Nitrogen-fixing capability of epiphylls on the leaves of trees was studied, and fallout work was continued.

Now that the isotope studies are well established and we have quantified balance and movement in certain parts of the ecosystem, the time has come to

start to put all these studies together into an ecosystem model that will have Predictive value for a large range of conditions which will occur, but for which it is impractical to conduct an experiment. Because of the complexity of the ecosystem, the model should then be transformed into a computer program. A computer could tell us, for example, the concentration of a given radioisotope in a given portion of the food chain at a given time following a given input of fallout into the system.

The first step in making the model is the framework (Fig.1) which ties together all the isotope studies completed, or currently under way. The arrows represent isotope movement into, through, and out of the tropical rain forest ecosystem. The boxes represent compartments where the isotope is held for varying lengths of time before being passed on to the next compartment.

Studies completed during the past several years relevant to this role

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Fig. 1, Schematic diagram of the tropical rain forest, showing storage compartments for isotopes (upper case letter: routes (lower case letters)

important

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Fig, 2. Rate of calcium movement through four transfer routes, on a monthly basis

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Fig. 3. Rate of leaf fall on a monthly basis

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include: isotope movement from litter to soil; from epiphyll to leaf; and from mosses into snails; isotope uptake by understory plants; fallout input into the system; and fallout retention in the canopy. Current studies relevant to this model are discussed in the following paragraph.

Fallout Distribution Within the Forest:

To program the input of fallout into the system, we must know exactly how it enters the system once it is brought to the system by rain. Generally

speaking, the rain carries it to the leaves and litter, but it is important to understand the factors that cause variations in the amount of fallout intercepted by leaves.

Table 1 shows that: site (Location within a general area) has no influence on quantity of fallout present; species has no influence (except for the understory species *Palicourea riparia* not included in the table); location of leaves in the canopy or understory had no statistically significant difference in 1968 (although Kline found a definite difference in 1966, and the difference was still distinguishable in 1968); but presence or absence of epiphylls on the leaves had a marked effect on the quantity of fallout present. Judgment as to whether a factor is influential is based on how many tests showed differences, and what the error level was of these differences. For example, in the tests for differences caused by species, only 1 out of 12 tests showed a difference and that was at the 10% level, whereas 4 out of 6 tests for clean vs. epiphyll-covered leaves were significant, and these showed differences at the 1% error level, or less.

Movement of Stable Elements Through the Ecosystem

Rates of movement of a representative element, calcium, are graphed in Fig. 2. There is no apparent relation between amount of calcium input into the system via rainfall, and quantity of rainfall (compare Fig. 2 and Table 2). Most likely, input is more closely related to wind direction before and during rainstorms. Movement out of the litter and through the soil closely follows changes in leaf fall rate (compare Figs. 2 and 3). A graph of the difference between rainfall input and runoff loss (Fig. 4) shows that there is a net loss of calcium from the system during most of the year. Presumably this loss is made up by weathering of parent material.

A knowledge of the water budget is essential for calculating the rates of isotope movement between compartments. A budget based on direct measurements is shown in Table 3.

A series of experiments using tritiated water has been initiated for two reasons: (1) Tagging the transpiration stream with a pulse of tritium is virtually the only method of studying the rate that water is pulled through the tree by transpiration (Fig. 5); (2) Movement of tritium through the ecosystem is of interest, because tritium will be one of the principal products if thermonuclear devices are used to dig a new canal through Central America. Participating in the tritium studies are Dr. Jerry R. Kline, Argonne National Laboratory, Dr. John Koranda, and Mr. John Martin, Lawrence Radiation Laboratory,

Fig. 4,

Fig. 5.

Fig. 6.

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Fig. 7+

Fig. 8.

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Total amount of calcium input via rainfall per month minus total calcium loss via runoff

Specific activity of tritium in leaves of *Dacryodes excel*:  
function of days from date of injection of tritium into tree

General trends of ecosystem functions during secondary succession

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?pom 5 43 0 60

?Total population of tree species originating from seed after 15 in  
the radiation area

Total information content in binary bits

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Movement of Isotopes Through Canopy Trees

see text, Supporting portion of Fig 2 shows the upward movement of isotopes through

the canopy

by understory trees,? To determine rate of isotope movement through

canopy trees, and to determine if this rate is affected by transpiration rate,

the canopy tree was injected with a pulse of  $^{137}\text{Cs}$ ,  $^{32}\text{P}$ , and  $^{45}\text{Ca}$ , simultaneously

with the pulse of  $^{14}\text{C}$  and  $^{3}\text{H}$ , and to determine the upward

movement of  $^{14}\text{C}$ ,  $^{3}\text{H}$ , and  $^{13}\text{C}$  is very slow;  $^{137}\text{Cs}$  actually shows a marked

downward movement through the phloem from the injection point.



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equilibrium of the table isotopes in the ecosyster

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SECONDARY SUCCESSION

auceorttn (1967 Rain Forest Project Annual Report) has stated that succession following gamma radiation damage does not differ from succession following mechanical cutting, or following herbicide treatment, with the exception of the sprouting pattern, sprouting following gamma radiation from source occurs principally from the base of stems that were shielded from radiation by rocks or soil.

This does not mean, however, that if large doses of radioactive debris are dumped on an area, this area will recover normally. The crucial difference is that after three months of irradiation by the external source, the radiation was stopped as there was no further absorptive energy input to the system but if large doses of radioactive debris are dumped in an area, the disruptive energy persists in the ecosystem for hundreds of years, depending, of course, on the half-life of the isotopes involved. Therefore, the key to understanding the long-term disruptive effect on the ecosystem is having a basic knowledge of how the ecosystem works.

While there is some basic knowledge of change in species composition during succession, there is very little information on change in ecosystem functions during succession, especially in the tropics. Because of the availability of facilities, and the impetus of the radiation recovery studies, a detailed study of secondary succession is now underway.

It is generally recognized that certain properties and functions of an ecosystem, such as biomass and gross photosynthesis, gradually increase during

Succession, and reach a maximum at the so called "climax" stage. Also generally recognized is that total respiration gradually approaches gross photosynthesis, and the two rates are equal at the climax stage. These trends have been found to hold for the tropical rain forest (Fig. 6) by comparative studies in the irradiated area 1, 2, and 3 years after radiation ceased, and in the recently undisturbed surrounding forest, which is in a much later stage of succession, equivalent to roughly 60 years.

However, the current successional studies indicate that some functions of the ecosystem approach the maximum just a few years after start of succession, others decrease during succession, and others remain steady throughout.

Net photosynthesis, leaf area index, total chlorophyll content, and possibly total nucleic acid content of the system increase very rapidly during the first few years, and reach nearly their maximum value within five to ten years after the start of succession (Fig. 6). Maximum rates, however, are probably not attained until climax.

Surprisingly, total diversity including trees and herbs in the irradiated area one year after radiation was equal to total diversity in the older undisturbed forest. This is probably due to a somewhat unique situation. In the successional area, much of the diversity is due to herbs, while in the forest, there are virtually none. In the successional area, there are also many tree seedlings, due probably to the proximity of the older forest. In most successional studies, such seed sources are not so near.

Total growth efficiency actually decreases during succession. During early stages, a larger proportion of the energy captured by the plants goes into manufacture of tissue than in later successional stages. What happens to this energy in the more mature forest has not been answered to everyone's

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Fig. 9. Diversity (average information) in bits per individual

Fig. 10. Relationship between relative abundance curve (A) diversity index

curve (B) and reciprocal concentration curve (C), ?The points are

actual data from 1967 seedlings less than 1.5 feet high?

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Sovcws LEAF AREA INDEX.

Fig. 11. Diversity structure in tree species of new vegetation after radiation,

Slope is indicated in species per decade

Fig. 12, Relationship between ratio of Light at 800 and 675 millinterons on the forest floor, end leaf area index of the canopy

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The successional study 4s also a productivity study, and thus will o  
tribute directly to the overall nission of the internat onal Bialogteal °°  
Program, which 1s anong other things, to deteraine the potential productivity  
of ail the biones of the world. Dr. Carl Jordan who ie involved in the pro  
ductivity portion of the successional stuly, is a nesber of the Tropheal  
International Biological Progran steering counittce.

## ?DEVELOPGNE OF TREE COMMUNITIES

Last year, detailed analyses of forest comunity structures were being  
made, both in the radiation recovery area and in the surrounding forest. A new  
technique for portraying comunity diversity has been developed, utilizing the  
Large quantities of data collected yearly in the radiation recovery area, and  
@raxn also from insect diversity studies which span several years. Recent  
techniques of diversity study, employing inforation theory equations, have  
also been applied to this data,

Results indicate three basic types of mature or steady-state forest at this

elevation, related to drainage patterns in the soil, in addition to a continua of successional states leading up to the nature condition. The changes in community structure associated with radiation damage and subsequent recovery have been complex, mostly due to overlapping effects on the quantity of light reaching the ground as radiation damaged trees slowly lost their foliage and the fast growing secondary trees began to produce shade.

The first effect of increased light reaching the ground was germination of large numbers of seedlings of sun-adapted successional trees, herbs and vines. Trees are defined as plants having woody stems, capable of standing alone and reaching heights of two meters or more. Seedlings measure less than 1.5 feet high, while saplings are young trees over this height. Figure 7 illustrates population changes in these categories for the first three years of regrowth following the irradiation in 1965 for 676 square meters that are censused annually. The number of tree species was 31 in 1966, increasing to 62 in 1967 and decreasing slightly to 59 in 1967.

Diversity is the relationship of numbers of species to numbers of individuals of each population. A simple ratio is a poor expression of diversity because the ratio of individual numbers for many species to that of the commonest species always spans many orders of magnitude and may approach infinity if a large enough sample is taken. Diversity of a sample is adequately expressed by using the equation developed to measure the symbolic information content of a message composed of different symbols. Each species is treated as a differ-

Each symbol and the individuals of the sample comprise the "message." Total information content is  $-\sum p_i \log p_i$  where  $W$  is the total individuals and  $n_i$  is the number of individuals of each species taken in turn. Diversity is then the average information content of each individual. Figure 8 is the binary information content of the samples of new tree species, and figure 9 the sample diversity of each.

Because new species are added as a sample is enlarged and there are no clear theoretical limits to this in biological systems, sample diversity can be generalized to population diversity, which could be more or less diverse than the sample, depending on the rate at which new species are encountered as the sample is enlarged. A method of examining this rate of increase was developed: the plotting of  $\log W/n$  against cumulative species. Figure 10 illustrates this method and shows that the curve of  $\log W/n$  closely duplicates the classical diversity index curve with respect to rate. It utilizes more

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information, however, and gives better resolution of detail. In all vegetation studies the rate has been found to be a more or less linear function of  $10g$  with a single change of rate in passing from abundant to less abundant. Deliberate or accidental inclusion of more than one category of plants such as trees and herbs will exhibit two break points, one for each type. More than one habitat type usually causes the break to appear much farther out on the curve. Figure 21 shows the log Waver versus cumulative species curves for the restoration recovery area samples, the 1966 overlying curve suggests that two habitats, one sunny and one shady were sampled.

The community development pattern that has emerged from these studies has an initial phase of low diversity caused by more rapid increase in individuals than in species, a second phase of increasing diversity as the number of species increases, and a prolonged third phase during which diversity continues to increase slowly without increase in number of species as the more abundant species are thinned more rapidly by competition and shading than are the less abundant ones.

ANIMAL ECOLOGY

During the summer of 1968, Dr. Elisabeth McMahan of the University of North Carolina returned to continue her long term studies of termites in the irradiated and control areas. She found an increase in abandoned nests in the irradiated area since 1967, while there was no increase in the control area. This may be due to sterilization, but not to killing of the termites in the irradiated area during radiation. She also found new nests being established in the successional area.

The staff continued to study isotope tracers, insect diversity, and amphibian ecology. Isotope studies were enlarged to include uptake and bio-elimination of tritium in the form of tritiated water,  $\text{H}_2\text{O}$ , applied as a spray to the forest floor. Tritium was absorbed by direct contact and respiration by insects, snails, frogs and lizards.  $\text{H}_2\text{O}$  uptake was exhibited by insects, frogs or lizards captured in the area subsequent to 36 hours after treatment, while snails continued to show uptake as long as 72 hours after treatment when collected from the contaminated litter surface. No animals showed evidence of secondary uptake from trees that had taken up tritium. A method for live testing snails consisted of teasing them back into their shells, at which time they released from 1 to 4 ml. of urine. Urine samples were found to exhibit approximately the same count rates as tissue fluids obtained by dissection. Biological half life of tritium in snails was very short, less than 24 hours,

Tracer and bicelination studies of zinc 65 in a natural population of  
?the enail *Carasolus caracolla* moved into the second year, with resolution of  
sone of thie mysteries of the first your. Area of hone range in this snail was  
found to be @ finction of sge, increasing until the second year after sexual  
maturity and decreasing after that. Adult size, previously denonstrated to be  
Andepentent of hone range area, is likewise independent of age, shell disneter  
ceasing to grow at maturity. Present estimate of life span in this species is  
up to 18 years, with sexual maturity not developing until 8 yeare of age.  
Growth in the past two years places confidence limits of plus or minus two  
years on those estinates.

Incect diversity stulles involved research on the methods of obtaining ant  
expressing diversity messurenents as well as the clox, contiming job of sep-  
arating and identifying species of sone of the poorly know groups. In sone  
groups the known fauna of the island has been more than quadrupled in this

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study alone. Comparisons are being made between diversity  
measures obtained  
with various trapping methods such as sticky traps, pitfall traps, Light  
traps and Malaise (flight) traps. Attractant traps avoid the distorting effects  
of irregular natural concentrations or foci of distribution by imposing their  
focus on all species and by comparison to the natural concentration, to  
produce a curvature of near relationship between number of species  
and log number of individuals, independent of species

Interest in amphibian ecology this year has been focused on the possible  
function of the vocal call as a population spacing device. Marked antagonistic  
behavior by males has been observed in response to artificially reproduced  
calls. Experiments are now in progress to determine if the speaker of a tape  
recorder playing a loop of normal call at the natural repetition rate will  
maintain an area free of infringement by males.

## WEATHER STATION

A fully automated weather station is now operating. Temperature is being  
measured at four levels in the forest. Also being measured is solar radiation,  
rainfall, wind direction, and wind speed. The information from the sensors is  
carried to the instrument shack by cable. Once an hour, a scanner scans the

output from all the sensors and transmits this information to a data logger tape. A computer program is now being written to get periodic averages directly from the tape, as well as other information such as what proportion of the time a temperature inversion exists in the forest, and what time during the day the wind usually comes up.

## LEAF AREA INDEX

After several years of effort, a good correlation has been found between leaf area index and the ratio between infra-red light on the forest floor (Fig. 7). Leaf area index is important because it is a measure of biomass of leaves, a measure which is prerequisite to modeling biogeochemical cycles since leaves are an important ecosystem compartment (Fig. 1). The theory behind the correlation is, the forest canopy is relatively transparent to infra-red radiation while it absorbs red radiation proportionately to the amount of chlorophyll, and thus biomass, in the canopy. Thus with a meter that reads light at wave bands centered at 675 and 800 millimicrons, a man on the forest floor can measure leaf area index without having to read above the canopy as in the optical density method of measuring leaf area index. A paper entitled "Derivation of leaf area index from quality of light on forest floor" is currently being prepared for publication.

## BL VERDE FIELD STATION

Maintenance and upkeep of the El Verde field station and associated roads and trails continue to constitute an important effort of the field crew.

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?Table 1

Results of analysis of variance to determine significance of differences in fallout. Blanks indicate a difference at greater than 10% error level (no significant difference).

Te eesFeFeFSFSeSSsSe

Significant differences  
at indicated error level

Test for

Difference in Concentration 137Cs Mice Bae

Species Understory, clean - - :

Species Understory plus epiphylls : : -

Species Canopy, clean x 3 :

Species Canopy plus epiphylls - :

site Understory, clean o : aH

Site Understory? plus epiphyllis : a

Bite Canopy, clean : :

Site Canopy? plus epiphyllis : S

Clean-epiphyllis Canopy ~ -

Clean-epiphyll Understory 05 05h

Canopy-understory Clean - wh

Canopy-understory ?Plus epiphylls 6 = 5

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Table 2

Rate of water input into ecosystem via rainfall

Average rate of water input,

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october, 1967 Bo

Kovenber, 1967 B

December, 1967 So

January,? 1968 3B

Fevruary, 1968 aot

March,? 1968, 525

april, 1968, 20

May,? 1968, 13

June, 968 33

guy, 19 oh

?august, 1968, 83

Beptenber, 1968 as

able 3

ferde.

Water buiget for the rain forest at EL

Figures are based on yearly totals.

EL Percent of total rainfall

69.5

Throughfall. %

Sten flow HY

Evaporation from leaves 3

?Transpiration . 9

Run off and deep drainage

a

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PRNC PARTICIPATION IN THE US AEC 'ATOMS IN ACTION'

EXHIBIT IN LATIN AMERICA

Since 1965 the Puerto Rico Nuclear Center has been 0  
conducted in conjunction with the Atoms in Action Activities to increase cooperation  
{in Latin America, The Oak Ridge Associated Universities is responsible for the  
Enrichment Training Program and the USAEC operates « Technical Priority as part of  
the Exhibit, "We Exhibits provide information on peaceful application of  
nuclear energy to persons of varying backgrounds,? The general public is given  
guided tours of special displays which demonstrate the safety applications and  
developments of atomic energy. Students, scientists and physicians are offered  
demonstrations, lecture courses and supervised participation in research 1  
volving applications of radiation to problems of regional origin and interest,  
?with emphasis on the use of gamma and neutron sources available at the Exhibit.

In April and May, the exhibit visited Caracas, Venezuela; in October it visited Córdoba, Argentina,

## RESEARCH ACTIVITIES IN CARACAS, VENEZUELA

A preliminary visit to Caracas indicated that the basic interest of the Venezuelan Institute for Scientific Investigation (IVIC) was the use of radiation in agricultural applications, A food preservation by irradiation Laboratory was to be established and, in coordination with IVIC, projects were designed to be initiated during the Exhibit.

The Science Faculty of the National University of Caracas made use for the first time of a gamma radiation source for its research work.

In general the gamma energy source was used in genetic, food preservation, microbiology, entomology, and chemistry projects.

The Exhibit received special cooperation from the Central University of Venezuela, IVIC and from the Center of Agronomical Investigations at the Ministry Of Agriculture.

Seven scientists and two technicians from the Puerto Rico Nuclear Center collaborated in this program.

## [LECTURES IN CARACAS

In conjunction with the research program, PRIC personnel gave the following lectures during the Atoms in Action Exhibit which were attended by 755 persons.

Dr. Quen Hs Wheeler - Associate Director, FRIC, Mayaguez Campus.

(a) Hydrolysis of Amino Acids and Peptides - Faculty of Pharmacy, University of Los Andes, Mérida, Venezuela; (b) Excited Atoms Reactives - Institute of Science, University of Los Andes, Mérida, Venezuela; (c) Practical Uses of

Nuclear Explosives - Use of Radioisotopes and Radiation in Agriculture =

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Nuclear Plants in the United States - Congress of Chemical Engineers

Dr. David W. Walker - Associate Scientist, PRIC. (a) Nuclear Buon Bom

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ive, Hert Yoernie(o) zine: Series ena SuELaY Aupticarions oP iuclear Enstay -  
Faculty of Agronory, Uv; (e) Baject for Meatienting the Dasreua Per

Central University of Venezuela

Dr. Alec Grintzon - Associate Scientist » PUD.

a Setentist , FRID. (a) Ratiation Bf.

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Faculty, Central University of Venecuel o

Dr. Robert A. Luse - Associate Scientia (2) apps

ser aigBRORÉ As Late = Aaa ty PRIC. (a) Application of Nuclear

an npDispamite wartines Siva - Associate Scientist, PRC. (a) Eadiation Bffe  
an-sripesosons Crust = Troleel Hedioine Institute, Central University of

Mr. Hector Barcelé - Chief Scientist, PRIC. (a) Non-Destructive Testing

ana ouajarative SUaifer in tuciens ann fosela fuse =Wtelbergie Dear aart  
?and Chemistry Department, UCV. ms

\_ Me, Juan Stiva - Associate Scientist, FRIC. (a) Nuclear Reactor Instrumenta-  
tion'= ERAIDIt; (b) Uses of Radiation Sources - Exhibits (c) Radioisotopes in  
Research - Exhibit.

FRNC personnel gave 17 conferences as well as various seminars and round  
table discussions at the University of Los Andes, Mérida, Venezuela.

## RESEARCH ACTIVITIES IN CARACAS

### Food Preservation

IVIC carried out the following projects in food preservation, initiated  
by Dr. Luis M. Revetti from the Chemistry Department at IVIC.

Studies in Potato Preservation: (*Solanum tuberosum*). Samples from a recent  
crop were irradiated in doses varying from 5000 to 15000 rads (steps of 1000

Measurements in ascorbic acid were performed in the laboratory. Successive analysis of free sugar starch and ascorbic acid will be continued by you to make comparative studies in relation to non-irradiated samples.

Samples from a two week crop

studies in Yucca Preservation (*Allium cepa*).

Laboratory determinations

were irradiated in doses ranging from 3 to 12 rads.

Will be made later on by IVIC.

Studies in Yuca' Preservation (*Manihot aipi*). Twenty four hour crop samples were treated. Since this is the first time work on this product is being done, samples from 10 to 100 rads were used. In this first phase it was observed that better preservation was obtained by irradiating the products with doses of 60 rads.

The experience was repeated with doses ranging from 60 rads and 100 rads. Satisfactory results were obtained and will be published as soon as the necessary analyses are completed, qualitative tests were made to determine the presence of iron, copper, tin and ascorbic acid.

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oe BPR one Se TS et,

laboratory atuiies will be mde eubsequently by TVIC.

## Genetics

siies An back beans (Caraota), Genetics studies of radiation effects in

this Spite Gatsuctan preace were initiated by the Center of Aeronsonicer

Investigation in Maracey? Dr. Pedro Obregén was in charge,

studies in Corn (Zon mays). Genetics studses of 3 varieties vere initiates

ty the Canes St Reronoctal Research with Bre Ohregba tr eneeees

Studies in Topido (Solan Topido). This progr was initiated in collabe

oration with GEV Exyerinental Biology School} Drs Lule Torres de Mastl woke

charge.

Microbiology

Dr. Eddy Varsausky from the Departeent

Irradiation of fungus cultivation.

or mloroulology of the Schoat of Bloioey began stulise in ths Gaitmectoe ee 3

3 aspergillius in order to observe the differences

varieties of penicSilum ant

4m response to the same doses with different doses per unit of tine,

Previous studies had been nade eplying a dose of 5 xrads/hr. Wo satis-

factory results were obtained, so the Atons in Action game facility was teed

to drvadiate then vith doses of 170 krade/ur-

Entonology

Studies in the Ceratitis Cepitate (Mediterranean Fruit Fly). The Center

ted studies irradiating

Studies in *Anastrepha serpentina*,  
by the Center of Agronomical Research with  
works on the Island of Margarita, 200 kms,

Pilot scale by liberating sterilized in  
Venezuela's coast. The Center for Agronomical Research for went Project,  
will visit FRIC installations.

Radiochemistry

Preparation of Molybdenum -<sup>99</sup>, The Department of Nuclear Chemistry at  
# Molybdenum-99 in collaboration

The IVIC reactor was used, as well as the  
facility, since part of the samples were first subject to the effects of the  
gamma radiation and then introduced in the reactor. This series of  
underway,

Chemistry

Reaction Effects in Petroleum Derivatives. Dr. Sergio Flores in charge

of the project, Walsh consists of studying the effects of gamma radiation

effect of oxygen was also studied. Analyses of

crude petroleum fractions. The

Series of analyses being made by the Department of Natural Products

UoV's Faculty of Sciences.

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## RESEARCH ACTIVITIES IN ARGENTINA

The same procedure used to establish the FRUC program in Venezuela was followed in Argentina. How was it?

The program was given in the National University of Córdoba, and at the Catholic University of Córdoba, and

The Chemistry Institute of the National University initiated works in Biology and Biochemistry using radioactive isotopes, and works in Physics and Chemistry in the Faculty of Engineering of the Catholic University.

Five scientists from the FRNC participated in the Exhibit.

Conferences in Córdoba

In conjunction with the research program the PRIC personnel offered 22

Lectures, with 621 attending:

Me, Juan Silva Parra ~ Director, Research Programs in Action Exhibits.

[Reactor did Test Fow Delay and Yts Influence in Reactor Control, at the  
Reactor Instrumentation,

Power

Faculty of Engineering, Catholic University of Córdoba  
at the Exhibit.

Dr. José A. Custrián - Associate Scientist I, Radioisotope Applications  
Division. Liquid Scintillation Counting, Use of Radioisotopes in Organic  
Chemistry T and IT and Counting Techniques, at the Chemistry Institute of the  
National University of Córdoba.

Dr. Aldo E. Lanaro - Associate Scientist II. Clinical Radioisotope:  
Applications Division. Current Research in Nuclear Medicine, Introduction to  
Nuclear Medicine, Uses of Radioisotopes for Studying Kidney Function, Organs  
and Tumors, at the Faculty of Medicine, Catholic University of Córdoba; Liver  
Scanning and Spleen, in the Exhibit Conference Room.

Dr. Julio Gonzalo - Associate Scientist II. Nuclear Science and Technology Division, Ferroelectricity, Neutron Diffraction, at the Faculty of Engineering, Catholic University; Ferroelectricity and Neutron Diffraction, at the Institute of Mathematics, Astronomy and Physics, National University of Cordoba.

Dr. Jorge Chiriboga - Assistant Director for Scientific Programs. Studies of the Relationship of « Parasite to its Host Using Radioisotopes, Use of Radioisotopes in Metabolism Studies, at the Chemistry Institute, National University of Córdoba.

RESEARCH ACTIVITIES

The following research projects were carried out during the Atoms in Action

Exhibit in Córdoba:

Chomtatry

reparation of tritiun-labeled Eepingosine and Acyl Esphingostne

Eaphingosine and Acyl-Esphingosine stimulate the Tnecrperetion Sf-OiF elucove

and cerebroide, It 4s not certein whether these compounds act as catiysts or

Precursors in this stimulation. The tritiun label vill enabis the tnvestlautre,

Drs Curtino of the Departvant of Biological Chenistry of the Institace or

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tavestiention was started

(Crentced Scences, to anguer this gestion. This 8

Co ?the help of Dr. José P. A. Castrillén of the PRIC Physical Science

Division and 48 now contining.

Biochontetry

ny of the action mechantsn of Fuytobenaglutinine (PHA) using radio

sacecSt \$f eee eT co iforlie.tnformtion on the action bechae

Fete a inva variety of Phaseolus vulgaris cultivated in Argentina. The

sereatlantton conried ext by Profs Beatris Fushecg de, Rupilyili fulfii2 part

af the Sequirenente for doctoral degree. Iron-°9 > and!c~ rebeled

Glyniline and uridine are used. Work nov continues at the Institute of

Chemical Seiences.

of the helogenation mechanian of pherylnacetaldehyde with n-halontaes,

We anjection of Winolele acid Into eninals deffeLent Zn vopopierot increases

P incorporation into the messenger Rlla of the Liver. This increase may be

the result of @ change in phosphate pools, a change in phosphate permeability,

or it may reflect.a stimulation of RUA synthesis. It 18 possible to study this

probeim by using FP and tritiue labeled orotic acid or odine.

Dr, Sefieriz of the Department of Biological Chenistry of the Institute of

Chenical Seiences is carrying out this study. Dr. Jorge Chiriboga of the PRIC

Directors! Office assisted Dr. Seferiz during the Exhibit.

## Pharmacology

Study of learning mechanism using radioisotopes. This project in the field of tapectasntal Fopehology was started by Dr Oeinger of the Department of Experinental Peychology of the Institute of Chenical Sciences to provide experinental information for a doctoral dissertetion for one of his graduate students. Briefly, the project consists of studying learning mechanisne in laboratory animals and making observations by using labeled compounds.

## Paysites

Radiation effects of ferroelectric materials. The Department of Electrical Engineering of the Catholic University in Cordoba started a research project utilizing triglycine sulphate (TGS) as the ferroelectric material. Variations in critical temperature were studied by irradiating 16S crystals with different doses above and below the critical temperature. The experimental part of this project was completed during the Exhibit by two students who will use the data to prepare a thesis. Dr. Julio Gonzelo of the PRNC, Iluclear Sciences Division assisted with this project.

During the Exhibit @ Technical Program was also carried out and is described below.

Dosigatris Staly of the ganna facility, two students from the Engineering

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fhe gums fs0ility, Plotting itotees carves for G2ffteeet re nea  
tourée end ealeulseing actus activity, untae: tenes tee eae one  
cperinental data vas accumulata anda refore eat oe eek  
Sieiante aa part of their dogiee eqetresert?

Use of Saotepes in hydraulice, two stutents from the Cathotte Universit  
carried out series Of experinents vith hydraulle eystons ettiteine settee  
SSotopes, Reeldence tine teasurenente flow chartay eet ethos tie wore cved  
by the studente Will be used to prepare a easels oy tee ouime

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## OFFICE OF THE DIRECTOR

The Director's Office, in addition to its tasks of daily administration,  
4s concerned with planning and coordination of prograns: it is responsible for

?support to ongoing operations and for initiating, or assisting in the creation of, new training and research.

The office also serves as the center for internal and external communication, including public information, management of meetings and conferences, and serving the needs of students and trainees from abroad. Individual members of the staff also participate in teaching and research activities of several PRNC divisions.

Significant progress was made during 1968 in serving the objectives of the Director's Office within FRIC. Particularly important was the establishment of new scholarship assistance programs for students and trainees from Latin America. The University of Puerto Rico has granted \$10,000 for PRIC-administered scholarships and the OAS--under the Centers of Excellence program--has granted 10 fellowships for study at PRIC in the last three months of FY 1969. Aid to Latin American students is essential if PRIC is to continue to play a meaningful role as a training center for Latin American scientists. Travel costs from most Latin American republics to Puerto Rico are quite high. The cost of living in Puerto Rico is higher than any other part of Latin America. This often makes it a hardship for Latin American students to study here unless some supplementary funds are available to cushion these costs.

Latin American interest in PRNC is growing only because of the quality of the center's training and research programs. Maintenance and improvement of

quality requires adequate facilities in which to carry out programs, and here, too, significant progress is being made. In Rio Piedras construction began on a new wing of the Bio-Medical Building, to be completed by early 1970. At a cost of about \$1 million, the new building provides 24,700 square feet of additional laboratory and office space. Facilities in temporary structures will be rehoused, adequate service areas will reduce the crowds of waiting patients in our hallways, and files and other gear now kept in passageways will return to office and laboratory areas. The Present building will be renovated as functions in particular areas change, and space has been set aside for a staff reading room. There is also a small meeting and staff service area.

our construction activity is part of a very extensive program in progress:

at the Medical Center, which will bring the UFR Medical School to Rio Piedras.

The Director's Office, with assistance from a PRIC-UPR Medical School committee headed by Associate Dean Dr. Conrado Asenjo, is studying the changing nature and needs of the interaction between PRNC, the Medical School and the community.

Out of these considerations are emerging actions to increase Medical School, and Medical Center responsibility for training and service, using the established techniques in radiation therapy and nuclear medicine; this frees PRNC to do more work of an experimental and research nature. Plans include greater interaction with the basic medical science activities, particularly as these groups move to the Medical Center, and a substantial increase in radiation biophysics activity.

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TRavEL

Officials from the Director's Office participated in several meetings, conferences and trips within Puerto Rico and in the United States and Latin

Perhaps the most significant were two visits to the lowlands of Colombia to explore possible areas of agriculture-oriented research, undertaken in April and July. Dr. Gonberg traveled together with Mr. Héctor Barceló, Assistant Director for Operations, and Dr. Robert A. Luse, head of the Agricultural Bio-Sciences Division. The purpose was to conduct an on-site survey of the very humid, low-land area lying directly east of the Andes, called the Llanos Orientales. The area, almost uninhabited, has good climate conditions and river transport facilities, which make it attractive as a potential agriculture-dairy Production center of vast proportions. However poor soil conditions have discouraged any large-scale ventures and it appears that only some technological breakthrough in soil fertilization can permit the area to realize its potential,

Colombian government agencies have displayed interest in the area, through its Institute of Nuclear Affairs, and Institute of Agriculture and Animal Husbandry, We have discussed with USAID? officials in Bogota, the Colombian capital, the possibility of PRIC's participation in research programs aimed at seeking ways to make Los Llanos a productive agricultural area. The subject was also discussed with officials of the Rockefeller Foundation. During the two survey trips, the PRIC officials, accompanied by members of the Colombian government, traveled by plane, boat, Jeep and truck through the extensive--and quite primitive--areas,

Of particular interest was a visit to Hacienda El Pifial, far into the Interior, where Colombian agronomists are experimenting with corn, soya, peanuts and sorghum.

In October, Dr. Gouberg made a multi-nation program planning tour of Latin America. He met with atomic energy commission and university officials in Argentina, Bolivia, Brazil, Chile, Paraguay, Peru and Uruguay.

#### [INTERNATIONAL COOPERATIVE RESEARCH

PRN participated in two formal international cooperation projects during 1968.

Through its Agricultural Bio-Sciences Division, PRNC will exchange with IAEA information on research dealing with the effect of neutron irradiation on foods. Anticipated future research on genetic and physiological effects of

fast neutrons will be coordinated with the international IAEA program in gene-  
?tle and mutation breeding.

In a program receiving financial assistance from US AID, ICAITI(The! Central  
American Institute of Research and Industrial Technology) in?Guatemala City will  
send staff to PRIC for training in food irradiation preservation. PRIC will  
make follow-up visits to Guatemala to assist in setting up food irradiation  
research programs. Dr. Koo of PRIC visited Guatemala to coordinate final  
planning for this program.

wwwErINGS,

Early in May, FRNC participated in a meeting in San Juan sponsored by the  
US ABC Division of Technical Information to discuss the future direction and  
program of Atomic in Action Exhibits in Latin America. Participants were from  
the U.S., Puerto Rico, Guatemala, Argentina, Brazil, Ecuador and Colombia.

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In August, PRNC scientists took part in a Special Seminar on Food Production

and Human Development organized by UPR in Mayaguez, and attended by food

science and nutrition specialists from Latin America, Haiti, Trinidad, Jamaica,

England and U.S.

In February and September, the PRIC Advisory Committee met for its twoday

annual review of the Center's activities.

visitors

seni:

Numerous visitors from different parts of the world came to inspect PRNC's

installations in Rio Piedras and Mayaguez during the year.

PRNC's increasing role as an international center was characterized during

the year by several visits from European scientists. Dr. Milan Osreduar of Yugoslavia, a consultant for IAEA in Jamaica, consulted in our Mayaguez installation in February on the use of nuclear techniques in agriculture and the development of nuclear power in Puerto Rico. In March, Dr. J. Joseph, director of the IAEA laboratory of Marine Radioactivity, Oceanographic Museum, Fontvieille in Monaco, observed our Marine Biology and Terrestrial Biology programs. In April, Dr. Walter Seelentag, Chief Medical Officer, Radiation Health, World Health Organization, Geneva, and Dr. H. Eiseniohr, Dosimetry Section, Division of Life Sciences, IAEA, Vienna, discussed a possible training course in medical radiation physics for South American participants. And in June, Dr. H. Altmann of TABA Vienna visited our Mayaguez laboratory.

We were particularly gratified to learn of a letter written by William C. Johnson, M.D. of St. Naxy's Long Beach Hospital, Long Beach, California, who spent a month here during the summer of 1968. His visit resulted in the following article being included in the September 5, 1968 Congressional Record:

HOW, CRAIG HOSMER  
of California

in the House of Representatives

Thursday, September 5, 1968

MR, HOSMER. Mr. Speaker, I was pleased to receive from an expert qualified to render expert judgment in matters pertaining to nuclear medicine the following communication:

St. Mary's Long Beach Hospital

Long Beach, California

August 26, 1958

Hon. Craig Hosmer

Member of Congress, House office Building

Washington, D.C.

Dear Mr. Hosner:

Thank you for your letter of June 26th, 1968, prior to my visit to Washington.

I am sorry that the shortness of our stay there precluded my visiting you in

your office and I hope that I shall have the opportunity to do this on another

Following my visit to Washington, I spent two

visiting at the Puerto Rico Nuclear Center there," I? San Juan, Puerto Rico,

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As you probably are aware, this is a medical unit operated by the  
Puerto Rico for the United States Atomic Energy Commission. My interest  
primarily in the clinical radiotherapy, nuclear medicine and radiobiology sec-  
tion. The group of very excellent clinicians headed by Dr. Victor Marcial have  
over the past ten years proven that first class clinical cancer treatment can  
be very beneficial in a developing country, particularly one with a high cancer  
risk population. Not only do they do a superb job of diagnosis and treatment  
of cancer, but they have also been active in training physician-radiotherapist  
medical students and x-ray therapy technicians in their several programs.  
Their level of patient care and medical training would be considered  
excellent by any standards in the continental United States.

?The Atomic Energy Commission and the varying Congressional committees interested in atomic-related progress (of which I believe you are a member) should be rightly commended for their farsightedness in this vital part of medical care in the Commonwealth of Puerto Rico, I was impressed at the effectiveness of this use of United States aid money spent in an underdeveloped country.

Sincerely yours,

Witlias C. Johnson, M.D.

Reverend Dr, Zgnacto Cantarell, Assoc!

Division, was named Citizen of the year for the city of Yagajay for 1967 by Junko Chitober of Comoree. The award was given for Dr. Cantarell's intellectual and scientific contribution to the community through the creation of the Institute of Modern Science in Yagajay. The Institute offers a graduate

Propran in nuclear acience, leading to an WS. dogres, i which 29 states

tiet in the Muclear Ses

Mr. Kal Wagenheia, part-tine correspondent for the N.Y. Times in Puerto

Rico, joined PRIC on Jtly 2 with the title of Bitor. His duties inciue the  
ng, design and production of the annual report and other PRI publications,

tas assisting Latin American PRIC staff menbers in Spanieh-to-Ensiish

in of their scientific saterial,

## APPENDIX

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PUERTO RICO NUCLEAR CENTER

DIRECTORY

Advisory Committee

Chairman: Dr. Paul B. Pearson

President, The Nutrition Foundation

New York, New York

Dr. W. O. Baker, Vice President,

Research

Bell Telephone Laboratories

Murray Hill, New Jersey

Dr. John C. Bugher

USAEC General Advisory Committee

Washington, D.C.

Dr. Juan A. del Regato

the Penrose Cancer Hospital

Colorado Springs, Colorado

Office of the Director

Dr. John A. D. Cooper

Dean of Sciences

Northwestern University

Dr. Michael Ference, Jr.,

Vice President

Scientific Research Staff?

Ford Motor Company

Dr. James G. Horsfall, President

?The Connecticut Agricultural

Experimental Station

Dr. Frederick Seitz, President

National Academy of Sciences

Washington, D.C.

Stat

Henry J. Gonberg, Director, Ph.D., U. of Michigan (Physics)

Anador Cobas, Deputy Director, Ph.D., Columbia U. (Physics)

Oven H. Wheeler, Associate Director, Mayaguez, D.Se., U. of London (Chemistry)

Victor A. Marcial, Associate Director for Medical Programs, M.D., Harvard, U.

(Radiotherapy)

Jorge Chiriboga, Assistant Director for Scientific Programs, M.D.,

University of San Marcos, Peru (Biochemistry)

Héctor M. Barcelé, Assistant Director for Operations, M.S.,

University of Puerto Rico (Nuclear Technology)

Marie Barton, Executive Assistant to the Director

Frederick Rushford, Technical Assistant to the Director

Kal Wagenhein, Editor

xJohn D. Weaver, Chief Scientist I.

?terminated before Dec. 31, 1960.

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Nuclear Science Division

Julio A. Gonzalo Gonzales, Head, Chief Scientist I.) FB.D->

U. of Madrid, (Physica)

Florencio Vazquez Martinez, Chief Scientist I, Ph.D.

U. of Madrid, (Electrical Engineering)

Rev. Ignacio Cantarell, Associate Scientist 1, Ph.D.

University of Santiago de Compostela, Spain (Nuclear Physics)

Rupert A. Lee, Associate Scientist II, Ph.D. U. of London (Chemistry)

Baltasar Cruz Vidal, Associate Scientist I, Ph.D., Harvard U. (Physica)

Josefa Elica Traval, Research Associate 1, Ph.D. U. of Puerto Rico (Chemistry)

Miguel Milo Villanar, Research Associate I, Ph.D.,

U. of Puerto Rico (Chemistry)

José M. Rivera, Research Associate I, Ph.D., U. of Puerto Rico (Physics)

Mouton Diffraction Program

Mortimer I. Kay, Head, Chief Scientist II, Ph.D. U. of Connecticut (Chemistry)

Robert Kleinberg, Chief Scientist I, Ph.D., Michigan State U. (Physics)

Seymour F. Kaplan, Associate Scientist I, Ph.D., U. of New Mexico (Geology)

Braulio F. Mercado, Research Associate II, Ph.D.

U. of Puerto Rico, Nagai (Electrical Engineering)

HotAtom Chemistry Project

Oven H. Wheeler, Head (See also office of the Director)

Josefa Elica Trabal, Research Associate I, (See also Nuclear Sciences Division)

Marfa Luisa McClintock, Research Associate I, M.S., U. of Puerto Rico (Chemistry)

Nuclear Engineering Division

Donald S. Sasser, Head, Chief Scientist I, Ph.D.

Toronto State U. (Nuclear Engineering)

Aviva B. Glenday, Chief Scientist I, Ph.D., U. of Budapest (Reactor Analysis)

\*Paul Lipson, Osborne, Chief Scientist I, Ph.D., U. of California (Nuclear)

Eddie Ortley Minis, Chief Scientist I, Ph.D., Texas A & M College (Physics)

Joss L. Garcia de Quevedo, Chief Scientist I, Ph.D., Duke U. (Physics)

Knud E. Federsen, Associate Scientist II, Ph.D.,

Iowa State U. (Nuclear Engineering)

\*Kenneth Solerstrom, Research Associate III, M.S.,

U. of Florida (Mechanical Engineering)

Fausto Nufloz Ribadencira, Associate Scientist I, M.S.,

U. of Puerto Rico (Nuclear Engineering)

Heriberto Plaza Rosado, Associate Scientist I, Ph.D.,

\*Texas A&M (Nuclear Engineering)

Antonio Rivera Cordero, Research Associate II, M.S.,

U. of Puerto Rico, Mayaguez (Nuclear Engineering)

Brick Méndez Veray, Research Associate I, M.S.»

U, of Puerto Rico (uclear Engineerings Netallurey)

?\*Terninated before Dec, 31, 100

\*\* On leave as of Nov. 30, 1968

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Physical Sciences Division

fealor Cobes, Head (S00 aiso Office of the Director)

?ti. Haory Sonat, Head, Chiet Scientist 21, Pa.b.y Puriue Ue (Oryante Chesistry)

ise Grinteony chief Scientist Z, MheD, U. of London (Chesietry)

José Ps A. CasteElién, Associate? Seientiet 11, Dey

1.? of Buooge Aloe (Radiolsotopes? in Organte Chectctry)

coorge A. Siapeon, Associate Seientiet fy Ph.D.y lotre Dene U- (Chesietty)

Siarien N. tals, Asgoctate Solentise Ty Ph.Ds, Wbingen U- (Organic Chesitry)

Gerardo Moline? Veeny Research Astoclave Tiy WeSy,

Netina Veet Of Fennaylvaria? (Choalety)

vanfred Boorhardt, Associate Scientist 1, Ph.D. U. of Labingen (Cheststey)

Foca Santana de Tiraloy Research Associate 22, M8,

?Tbr Puerto Rico (Chosiaty)

Eadiation Chen stry

Mec Grinizon, Head (See also Physical Sciences Division)

George A. Simpson, Associate Sciontist I, (See also Physical Sciences Division)

Solid State Physics Progran

?Anndor Cobas, Head (See also Office of the Director)

Shovel Zvi Weisz, Chief Scientist I, Ph.D., Hebrew U. of Israel (Physics)

Jacob Yehuda Levinson, Associate Scientist?, Ph.D., The Hebrew U. (Physics)

Clinical Radioisotope Applications Division

Sergio Irizarry, Head, Chief Scientist IZ, N.D.,

V. of Buffalo (Internal Medicine)

youd Oscar Morales, Chief Scientist II, M.D., Us of Maryland (Endocrinology)

Ato Ernesto Lanaro Chief Scientist 1, M.D.,

. of Buenos Aires (Nuclear Medicine and Endocrinology)

seiro Jyan Santiago, Associate Scientist I, W.D., U. of Puerto Rico (Pediatrics)

¿Niorsa Géndara Cruz, Res. Tech. in Clinical Applications of Radioisotopes

Yella Crespo de García, Res. Tech. in Clinical Applications of Radioisotopes

Adriana Rodríguez de Calderón, Res. Tech. in Clinical Applications of Radio-

¿Isotopes

Hada L. Rodríguez de Coin, Res. Tech. in Clinical Applications of Radioisotopes

Radiotherapy and Cancer Division

Victor A. Marcial, Head (See also Office of the Director)

José M. Toné, Chief Scientist 1, M.D., U. of Zaragoza, Spain (Radiotherapy)

Jeanne ¿Ubliad Villeneuve, Chief? Scientist 1, M.D.»

Universidad Nacional Autónoma de México (Radiotherapy)

Antonio Bosch, Chief Scientist I, M.D.,

| \_\_ Universidad Nacional Autónoma de México (Radiotherapy)

¿Guillermo Gémez Cardenas, Associate Scientist II, M.D.

Universidad Javeriana, Bogotá, Colombia (Radiotherapy)

Marfa M. Palacios de Lozano, Research Associate 111, N.S.-y

U. of Rochester (Radiation Biology)

Zenaida Prias Monserrate, Research Associate 11, M.P He,

U. of Michigan (Bio-Statistic)

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Agricultural Bio-Sciences Division

wrRobert A. Luse, Head, Chief Scientist 1, Ph.D.» U. of California (Biochemistry)

Francis K. 8. Koo, Acting Head, Chief Scientist I, Pa.D.5

. U. of Minneota (Radiation Genetics)

José A. Ferrer Monge, Chief Scientist T, Ph.D., Louisiana State U. (Biology)

David Walker, Chief Scientist I, Ph.D.» Washington State U. (Entomology)

\*Shrinivas H. Kanath, Associate Sctontlet 11, Fh.D.»

U. of Bombay, India (Biochemistry)

Horace D. Graham, Chief Scientist 1, U. of Illinois (Food Science)

Shreekant N. Deshpande, Associate Scientist I, Ph.D.,

Purdue U. (Food Technology, Biochemistry)

Joos Cuovas Ruiz, Research Associate II, M.S.) U. of Puerto Rico (Biology)

Angélica Muliiz Oliver, Research Associate I, M.S., U. of Puerto Rico (Biology)

Edith Robles de Irizarry, Research Associate 1) M.S.)

U. of Puerto Rico (Genetics)

Susarcane Borer Project

David W. Walker, Head (See also Agricultural Bio-Sciences Division)

Victoriano Quintana, Research Assistant I

Radicecology Division

Frank G. Lowman, Director, Chief Scientist IZ, Ph.Ds,

U. of Washington (Marine Biology)

Stephen Walsh, Deputy Director

Marine Biology

Frank G. Lowen, Head, (See also Radicecology Division)

Donald K. Phelps, Chief Scientist I, Ph.D., U. of Rhode Island (Marine Biology)

Robert Y. Ming, Associate Scientist 1, Ph.D.

U. of Washington (Fisheries Biology)

Steven B. Barnes, Associate Scientist I, Ph.D., U. of California (Chemistry)

Sohn H. Wartin, Associate Scientist I, Ph.D.,

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Pedro Velez Mendoza, Adainistrative officer 7

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Vélez de Santiago, M. - See Facets, J. Fe

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Zuazaga de Ortiz, C. - See Adan, W.

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WEEKLY SEMINARS, RIO PIEDRAS

Drs. José A. del Castillo and Dr. Félix Cordova, UPR School of Medicine, The  
Relaxing Action of Fermanide in Muscle, January 19.

Professor A. G. Maddock, Cambridge University, Radiation Damage Due to Nuclear  
Transformation in Solids, February 9.

Dr. G. J. Dienes, Brookhaven National Laboratory, Theoretical Studies on the  
Kinetics of Cell Proliferation, February 23.

Dr. George Benski, Instituto Venezolano de Investigaciones Científicas (IVIC),  
Paramagnetism in Hemoglobin, February 27.

Dr. Francis K. 8. Koo, Human Chromosomes and Syndromes, March 1.

Dr. Victor A. Marcial, Fractionation in Radiation Therapy of Carcinoma of the Uterine Cervix: Results of Prospective Study of 3 Vs. 5 Fractions per Week, March 8.

Dr. Efraim Toro-Goyco, UPR School of Medicine, Labeling of Protein with  $^{131}\text{I}$  for Immunological Purposes, March 15.

Dr. Robert Kleinberg, Magnetic Structure Determination of  $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ , March 29.

Dr. Allan MacColl, University College, London, Mass Spectroscopy, April 10.

Dr. Julio I. Colén, UPR School of Medicine, Effect of Radiation on Virus Growth in Mice, Wild Rats, and Tissue Culture, April 19.

Dr. Rodan A. Sharp of Beckman Instruments, Inc., Recent Advances in Liquid Scintillation Counting, April 26.

Dr. Owen H. Wheeler, Radiolysis of Amino Acids and Peptides, May 3.

Dr. Anthony Keney, University of Puerto Rico, Molecular Analysis of the Bobbed Mutant of *Drosophila melanogaster*, May 10,

Dr. Theodore Villefafia, Johns Hopkins University, Radiologic Image Evaluation, July 2.

Dr. Gabriel Chuchani, Instituto Venezolano de Investigaciones Científicas (IVIC)»

The Effects of Amine Groups in Aromatic Electrophilic Substitution, July 11.

Dr. Michael Barfield, University of Arizona, Theory of Nuclear Spin - Spin

Coupling, July 18.

Dr. Baltazar Cruz, F Center Formation at 76°K in KBr and in RbBr During Exposure to Monochromatic X-Ray Energies Around the Bromine K Edge, August 2.

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Dr. B. A. Arastrow, University of California, Davis

Sulfur Compounds, August 8, 1968

of Aqueous Solutions of

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Dr. Roger Pedersen, Yale University, Specific Gene Multiplicity: The Ribos

Cistrons, August 30. Y Sees mee

Dr, Raymond Brown, A System for Studying Inaunologieal Phenonena, Septexber 6.

Dr, Julio A. Gonzelo, Critical Behavior of Ferroelectrics, Septenber 13,

Dr, Rodrigo Fierro, Mationsl Polytechnical School, Quite, Ecuador, Biolosy of  
the Andean Man, September 20,

Dr, Walter Stahl, UPR School of Medicine, Letetmant  
Chicleros, September 27.

Dr. José P. A. Castrillén, Relación Entre Estructura Quinica y Extinción en el  
Gentelleo en Fase Liquida (Relation Between Chemical Structure and Extinction  
in Liquid Phase Scintillation), October 1.

Dr. Carl F. Jordan, Tritium Movenent in the Tropical Ecosystem, October 11.

Dr, Waftale Katz, Wational Institute of Endenic Rural Diseases, Belo Horizonte,  
Minas Gerais, Brazil, General Aspects of Schistosomiasis in Brazil, October 18.

Dr, Alfredo Bennun, University of Puerto Rico, The Relationship of ATPase to  
Structure and the Function of the Photophosphorylative Mechanism, October 25.

Dr. José Kine Curt, UPR School of Medicine, Health Conditions in Puerto Rico,

November 1.

Dr. Ruheri Pérez Tanayo, Ellis Fishell State Cancer Hospital, Columbia, Missouri, The Use of Digital Computers in Radiation Therapy, November 15.

Dr. Victor A. Marcial, Smoking and Health, November 22,

Dr. Fermin Sagard{a, UPR School of Medicine, Comparative Studies on Glycogen Phosphorylase from Crab Muscles and Yeasts, December 13.

#### WEEKLY SEMINARS, MAYAGUEZ

Professor A. G. Maddock, Cambridge University, and Visiting Professor of Chemistry, State University of New York at Buffalo, Nuclear Techniques in the Study of Solids, February 6.

Dr. Jack Chernick, Brookhaven National Laboratory, Reactor Physics at the Brookhaven National Laboratory, Reactor Physics at the Brookhaven National Laboratory, February 16.

Dr. George Bonski, Instituto Venezolano de Investigaciones Científicas (IVIC), Caracas, Faranegnetion in Hemoglobin, February 2.

Dr. Robert Kleinberg, Magnetic Structure Determination of  $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ , March 2),

Dr. Allan Maccoll, University College, London, Ion Molecule Reactions, April 8.

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Dr. Milton Yatvin, University of Wisconsin, Madison, Regeneration Activity in Irradiated Cells With Particular Reference to Protein Nucleic Acids, April 11,

Dr. Robert Kleinberg, On the Use of Moderators to Reduce Fast Flux in Beam Tubes and General Problems to be Considered for Installation of a D<sub>2</sub>O Tank at FRI, April 29.

Dr. J. A. Swallow, Christie Cancer Institute, Manchester, England, Radiation Chemistry of Organic Compounds, April 20.

Dr. Janos A. Muir, University of Puerto Rico, GeSeo, 757 pp, a5--A few Semiconductor, May 13.

Mr. Mario Saca, W Value Determination of Fluorofors, May 27.

Dr. Gabriel Chuchant, Instituto Venezolano de Investigaciones Científicas (IVC), Caracas, The Effects of Amino Groups in Aromatic Electrophilic Substitution, May 10.

Professor D. R. Wiles, Carleton University, Ottawa, Canada, Recoil Reactions in  $\eta^6$ -arene Metal Carbonyls, July 15.

Dr. H. As Gersch, Oak Ridge Research Participant, Georgia Institute of Technolo-  
@) Space Time Spin Correlations, July 29.

Dr. D. A. Armstrong, University of Calgary, Alberta, Canada, Radiolysis of  
?Aqueous Cysteine Solutions, August 6.

Dr. Walter A. Glooschenko, Oak Ridge Research Participant, Thermal Pollution--  
?A Problem to Aquatic Life, September 11.

Dr. Werner Fiatla, University of Puerto Rico, Ion Reflection, September 16. .

Dr. Jack Chernick, Brookhaven National Laboratory, Reminiscences of @ Brookhaven  
Scientist, October 21.

Dr. Flavio Padovani, Louisiana State University, Isolation Characterization and

Partial Purification of the Sex Ratio Factor in *Estigrene acraea* (Drury),  
November 6.

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Biol 355 = Cytogenetics

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