PRNC - 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 ---Page Break--- PRNC-131 (GENERAL, MISCELLANEOUS, AND PROGRESS REPORTS. (TID-1800) 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 ---Page Break--- ---Page Break--- TABLE OF CONTENTS Introduction.++++ Nuclear Science Division...++++ Soe eeatesemuneesameansesemmnI Neutron Diffraction Program....s.+0+ pomenenen 9 Hot-Atom Chemistry Program....sssssssssseccceeee 0 Wa Nuclear Engineering Division.....+.+ aeeene 3 wy Physical Sciences Division..... paseeerestan 29 Radiation Chemistry Project....++ peeeenennnes 31 Solid State Physics... Eetteeee eer 3 Clinical Radioisotope Applications Division....seesssseesseeees rr Radiotherapy and Cancer Division. posnennteeeenenesnnree SS) Agricultural Bio-Sciences Division...ssssecsesssseeessseesesssseteess 63 Sugarcane Borer Control Program...sssscsssssscseeeseeee nn Radiation Preservation of Tropical Foodstuffs. co 5) Medical Sciences and Radiobiology Division. peceeen TD) Schistosomiasis Project, sesame & ‘Trypanosoma Project. eee 92 Virus Project. .seeeessseeeeseee 39 Reactor Division...ssseesee+ 203 Health Physics Division.....+. 107 Radioecology Division Marine Biology Program... Terrestrial Ecology Program se 1 ‘The Rain Forest Project... International Exhibits Program... Office of the Director. Appendix. .... PRNC Directory. Papers Presented: Publications.....0.sscseccesseee Weekly Seminars, Rio Piedras..... Weekly Seminar, Mayaguez eeeeceenenennnnnn PRNC Students by Country; Student Enrollment at PRC during Fiscal 1967 and 1968. Auk ---Page Break--- ---Page Break--- 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 30, including 80 scientists. PRIC's student enrollment last year was 235, four times the amount during its first year. About one-sixth of its 1,7 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 1 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 at 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 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 republics. The exhibit provides 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 snail 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 on the South American and African continents. Studies are being made of Schistosomiasis (also known as Bilharzia), of Trypanosomiasis (also called Chagas' Disease), and of coxsackie virus. These parasites and viruses are being observed in mice, 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 oxen or 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. “ ---Page Break--- ---Page Break---

---Page Break--- 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 "Jeol" 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: Course Professor Enrollment, Nuclear Chemistry Dr. Oven H. Wheeler 20 Intro to Solid State Physics Dr. Julio A. Gonzalo 4 Radiation Chemistry Dr. Rupert A. Lee 3 Intro 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 Julién Dr. O. H. Wheeler Neutron activation of aromatic iodine compounds. Carmen Lecunberry Dr. O. H. Wheeler 1 ---Page Break--- ---Page Break--- Dielectric properties

of alkaline tritydrogen selenites. HCL Radiolysis in a Nuclear Reactor. W and G(H2) values for CHAP and CHF. F center formation at 78°K in RbBr during exposure to monochromatic X-ray energies around the bromine and rubidium K edges. Electroreflectance in silicon and germanium crystals. Lule C. Tilo Lats Rivera Oyola José Mario Sace Fernando Díaz Julio Marrero Dr. J. A. 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 pyridines labeled with radioiodine. Incorporation of radioisotopes in pharmacological compounds. Copolymerization of vinyl compounds with crotonic acid induced by gamma radiation. Mechanism radioprotection of peptides. Synthesis of Radiopharmaceuticals labeled with short half-life isotopes. Radiolysis of aqueous organic sulfur 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 Rodríguez Hilda López Ivin Mazerio Teana Casanova, Cénida R. de Jess Raquel Rodríguez Gabriel Infante Carmen Cecilia Motta Manuel Lagunas Laureano Iiiio Francisco Kerninde: 3 Advisor Dr. O. H. Wheeler Dr. O. H. Wheeler Dr. J. A. Gonzalo Dr. O. H. Wheeler Dr. L. Felic Dr. R.A. Lee Dr. O. H. Wheeler Dr. O. H. Wheeler Dr. R.A. Lee Dr. B. Cruz Dr. F. Vazquez ---Page Break--- Specific heat anomaly in ferroelectric transitions (763 and isomorphous compounds). A.L. Mock Dr. J. A. Gonzalo RESEARCH COMPLETED Radiolysis of Gaseous Hydrogen Trifluoride: The Effects of Pressure, Ionization, and Attenuated Bisecting Particle Beams. The ionization yield for the decomposition of gaseous hydrogen trifluoride by soft gamma rays has been obtained.

using the ion chamber method. A G(li) value of 9°T can be calculated from the K reies for nitrogen bromide. Studies with added bromine and sulfur indicate that about 30 percent of the hydrogen yield can be inhibited at scavenger concentrations of about 10 mole percent. The remainder of the hydrogen yield is not easily suppressed, indicating the presence of two hydrogen-forming species. An electric field applied during radiolysis causes no change in the hydrogen yield in the

recombination region, implying that ion neutralization processes are unimportant in the formation of hydrogen. "Radiolysis in a Nuclear Reactor" - R. A. Lee and Luis Rivera (W.S. Nuclear Engineering, September 1975) - Gas from nitrogen 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 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 + 0. has been determined in the PRC reactor, at a point where the neutron flux is 5x10^9 neutrons per cm^2. The gammas are the dominant source of energy deposition. W and G(Hg) values for CH3Cl and CH3Br - R.A. Lee and Mario Saca (M8. Physics, October 1966). The gases methyl fluoride (CH3F) and fluoroform (CHF3) have both been irradiated with 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-Gray theory of

eavity 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 from Petty's fluorite and chloroform respectively. O(Rp) values of 1.0 and 1.05 were determined from the measured W values and ion pair yields for the gases and CH3, respectively. Hydrogen formation may be due to the fact that the C-H bonds in these compounds are slightly weaker than the C-P bond. Thermal Hysteresis in Both Phase Transitions of NaI(Se Jo = J. A. Gonzalo and L. C. Tito (N.S. Chemist, April 1966) Dielectric constant and hysteresis loop measurements in NaI(SeO3)2 show the existence of thermal hysteresis accompanying both phase transitions which appear at 79° and 80°C. The most reliable values obtained from the T curves give estimates of 4063.2°C and -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. Estimated 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 Triglycine Sulfate - J. 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, (aP/2E)pres and (P/aT)z_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 MgO-Si, MgO-Ge, and MgO-Sn - Y.

Vésquez, Richard A., Forman, and Vanuel Cardona (ERIG and Brown University). ‘The room-temperature electroreflectance spectra of the II-VI compounds XeS, MgGe, and MgSn are reported in the energy region 1.5-4.5 eV. All measurements were performed using the electrolyte technique with a nonaqueous electrolyte. "These materials crystallize with the antifluorite 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 “T2” 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 "bicuadratic exchange correction" used in the theory of magnetic transitions. The Antiferroelectric Phase Transition in CaF3(SeO3) - 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 Celis(SeO3)2. The transition takes place at 123°C. The temperature interval between measurements was 0.25°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 °0o gannas. 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 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. Manuel Togunas, Organic sulfur compounds have been shown to be extremely good protecting agents against radiation. Thioureas 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 two compounds will be irradiated both in the presence and absence of air. (Hp) will be determined and the effect of pH will be studied. By using 14C labelled compounds a product analysis will be attempted to help elucidate the reaction mechanism. Radiolysis of CHP, and C8H10 in the presence of scavengers - R. A. Lee. Preliminary work on the live case has already been carried out. W and O2 values were obtained. It is believed that the formation is due to the reaction of the

Haton 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 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 K 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 keV). 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 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, ---Page Break--- ---Page Break--- ---Page Break--- NEUTRON DIFFRACTION ‘The neutron diffraction group at the Puerto Rico Nuclear Center is working on two types of problems: (1) the chemical binding 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 sometimes be analyzed that show the arrangement of atoms in the crystal. Since the amplitude of x-ray diffracted 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 from 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 1950s 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. 9 ---Page Break--- It may be seen from Figure 3 that the top ring is bent down and the bottom ring 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 set to planar. We note that the carbon atoms determined from x-ray data are an average of 0.006" 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 an 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. Bak 63 program. The carbon atoms fit a rigid body far better than did 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 A after rigid body correction 1.082 A. The C(12) - C(13) distance is 1.46 A as opposed to 1.43 A derived from molecular orbital calculations, Coulson and Haigh (1963), Tetrahedron 19, 527 calculate that there should

be an increase of about 0.02 A 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 Heit potential is harder than assured. The clear-cut effects of overcrowding show up in the H(4) or H(5) thermal parameters. Figure 2 shows that the angles formed by atoms C(4), H(4), H(5), C(5), C(13), C(12) are somewhat larger than normal, probably due to the low precision. IL, Thermal Vibrations of the Sulfate Group in Sodium Alun, NaAl(SO4)2·12H2O. Some alun structures were reported in PRODI. On page 9 of that report, 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 O3(SO4) group is on a three-fold rotation axis which passes through Grand 8. The three O atoms are at the apices of an equilateral triangle. The spiral or translation-rotation motion described above consists of a rotation about the O3 combined with a translation parallel to the axis. 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 motion; 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. ---Page Break--- Fig. 1. Phenanthrene: Numbering system used to name atom 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 Angstrom units Fig. 4. A representation of the crystal structure of NiCl2*6H2O viewed 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. ---Page Break--- 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° from the three-fold axis. The torsional oscillation is 0.278 radians. One artifact 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 g-O and S-O distance increased from 1.461 Å and 1.459 Å to 1.479 Å and 1.495 Å, respectively, in the present work. III. A Relationship between Incoherent Neutron Scattering and Nuclear Magnetic Resonance. The nuclear and nuclear spin scattering experiment involves an external perturbation

applied to nuclear spin systems, 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, SCG) = ah 2¢aP ay ty Gud, x' Bw) = InfTexKw)} S66) oF fier 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. Ty, Zhe Crustal Structure of MiCle‘6ip0 et Hoon Temperature and at U.K by Neutron Diffraction. In recent nuclear magnetic resonance experiments in ‘the magnetic fields at the proton sites in antiferronagnetic NiCl,*6H;0 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 antiferronagnetic state, as well as the crystal structure in the paramagnetic and antiferronagnetic 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, ice group C2/n, and contains ‘two formula units per unit cell. Cell dimensions determined by x-rays are = 10.23, b= 7.05, c = 6.57 A, with g = 122° 10'. The nickel ions are situated on 2/m inversion centers of the ab faces. They are all octahedrally coordinated to four oxygen and two chlorine atoms. The oxygens form a slightly distorted square, with the nickel at the center, while the chlorines are ovate on the two normals to the oxygen plane. The remaining two water molecules of ‘he 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 = 7.0h, c = 6.58 Å, and β = 122° at room temperature, and a = 10.20, c = 6.50 Å, and β = 12° at 4.2 K. Isotropic least-squares refinement of the intensity data gave the positional and isotropic thermal parameters given in Table I. The positions of the atoms measured at 4.2 K are in good agreement with the room temperature results, indicating that the crystallographic structure of the antiferromagnetic state at 4.2 K 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-Meeogy (the O) and OpeB + H2O, which link the NiCl2·6H2O octahedra into a face-centered two-dimensional network parallel to the ab plane, and bridges of the type B3-O-H2O which bond together the neighboring two-dimensional networks. Hydrogen atoms from each OY water molecule enter into two hydrogen bridges which are essentially "parallel", while those from each OR 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 directions, and this results in the perfect cleavage parallel to the ab plane. In the

hydrogen bonding system, H3 has a bifurcated type bond with O2 and its mirror image O7(2), but it is interesting to note that H3 appears to be hydrogen bonded to the point B, the midpoint between OY and O7(2). The distances for H3 + B, and OY - H3 + 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

Oy-#---0r1"+ Curiously enough, if the hydrogen bond is essentially electrostatic, having effective point charge q on each oxygen atom, the O2 and Or(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[I-H] bond is due to overlap in projection between Cl and H atoms in adjacent mirror planes. Other bonds and angles are in agreement with previously reported results. Proton-proton vectors for CoCl2·6H2O in the paramagnetic state have been measured by El Saffar, using the IMR method. Since this salt is isomorphous to NiCl2·6H2O, 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 calculations are probably also isomorphous with respect to the hydrogen atoms. 3B ---Page Break--- TABLE I Interatomic distances and bond angles in KCl2·6H2O at room temperature, and at 4.2K 7% 2.375 O2-O2(2) 2.86 (1) B 19x(2.936 to 2.05 (1) 2.098 clay 320 Q) 3.16 2.091 2333 HiL0; 3.90 (1) 3.932 heavy" 3.7 * 3.853 as Grey) 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-O;;-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'=O2-C2" 89.5. (4) 90.7 12k (2) a © Gpper number in each number set refers to room temperature, lower number to 4.2° bond or angle > gona lengths and angles in these columns were

calculated from x-ray data ---Page Break --- 2 R.D. Spence, P. Middents, Z.M. Gaffer, and R. Kleisbere, J. Appl. Phys. Suppl. 35, 65h (1964) 2-R. Kleinberg, J. Appl. Phys. 38, 1453 (1967) 3.5, Mizuno, J. Phys. Soc. Japan 16, 2574 (1962) 42, M. El Sattar, J. Phys. Soc. Japan 17, 1334 (1962) TABLE 1 ‘Comparison of parameters in HiCl2-6Hg0 determined from: anisotropic least-squares refinement of room temperature x-ray data; isotropic refinement of room temperature neutron data; and isotropic refinement of 4.2K neutron data = 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 temperature, neutrons at room temperature; and neutrons at 4.2K, respectively © In each hydrogen atom set of numbers, the positions determined by neutrons at 4.2K, the atomic parameters for the water molecule in the set position were selected to give reasonable molecular and hydrogen bonds. The upper and lower subsets correspond to room temperature and 4.2K, respectively ---Page Break --- HOT ATOM CHEMISTRY ‘The studies being carried out in the field of hot-atom chemistry involve the investigation of the products formed when an atom covalently bound to carbon undergoes nuclear recoil. The recoiling nuclei have included the transition metals and heavy metals, as well as non-metallic atoms. The carbon compounds employed have been phenyl derivatives, metallocenes and metal carbonyls. The purpose of these studies is to determine the mechanism of high energy

reactions in organic compounds through a study of the products formed under different activation conditions. The

possibility of directly preparing 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 NiII fraction. There was no increase, however, in the organic MiII activity, indicating that recombination results in the formation of organic MiII products. Metal carbonyls - The retention of 2.56 hour 651k in nickel carbonyl is being studied by rapid vacuum distillation of the products, as a means of obtaining 67Ni in high specific activity. Carbonyl - 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 "retention." The inorganic activity consisted of Re*3, Re*4 and Re*7. Molybdenum-99 - 99% has been prepared as a source of Pm, by activating K2Mo(GH)6.24g0. The unchanged salt was precipitated with ethanol. From an Helium diffusion, the 99% activity is maintained. Silanes - The Si activities formed in the activation of tetraphenylsilane, triphenylsilene and diphenylsilane were separated by chromatography on alumina from benzene, after washing out the silicic acid activity with sodium. 16 ---Page Break--- Paraguayan woods ---Page Break--- ---Page Break--- NUCLEAR ENGINEERING The Nuclear Engineering Division teaches graduate courses at UFR, Yayacw 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 research sensors 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 Master's degree in Nuclear Engineering requires 30 hours of graduate work and the satisfactory completion of a 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 curriculum 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 characteristic studies at one nucleus and radioactive decay, interaction of radiation with matter, and basic neutronics. ---Page Break--- Grace selection of seven topics. Reactor theory, three lectures per week. Consists of neutron balance parameters, kinetics theory and slowing down theory, bare homogeneous reactor theory and transport theory, time dependent reactor theory. Advanced Reactor Theory. Three lectures per week. Advanced reactor theory, reactor kinetics, transport and heterogeneous reactor theory. Reactor Laboratory. One lecture and one three-hour laboratory per week, involving the nuclear reactor design problems. Nuclear Engineering Application of Wave Mechanics I. Two lectures per week. Physical behavior and properties of moderator materials. Properties of fuel materials. Collision theory. Quantum mechanics and the Doppler Effect. Nuclear Engineering Application of Wave Mechanics II. Two lecture discussions 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 anisotropic 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 on Peaceful Use of Nuclear Explosives. For graduate or advanced undergraduate engineers and technical students, three lectures per week 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. 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. Non-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 Master's 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 (printed 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 López 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, "Analysis of Hydrogen Chloride in a Nuclear Mr. Lee and Mr. López 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. ---Page Break--- ‘The progress of students active in the Nuclear Engineering degree programs is shown in Table 3. Mr. Lee,

Since returning to China, he 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 "Comisión 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
Ente Rivera Oyola	Puerto Rico	EC
Rafael L. Ufret Acevedo	Puerto Rico	EC
Gilberto Vélez Delgado	Puerto Rico	FRARA
Francisco Rodríguez Perazza	Puerto Rico	UPR
Rafael Alcalá Quesada	Puerto Rico	ABC
Braulio Mejía Avité	Puerto Rico	ABC
José Castro Montalvo	Puerto Rico	ABC
Antonio Castro Rosario	Puerto Rico	Self

TABLE 3
Progress of Nuclear Engineering Students in 1968

Students who received the M.S. degree in Nuclear Engineering during 1966	
Students who have completed all course work for degree (presently working on theses)	
Students engaged in course work for M.S. degree in Nuclear Engineering	5

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Master of Science Degrees in Nuclear Engineering 1968 - Research Graduation

Director		Date
Lee, Cho-fu	"A Study of Computational Methods Used to Determine Fuel Depletion in Nuclear Reactors"	Dr. Gileadi, May, 1968
López Carrasco, Fernando	"Determination of the Transfer Function and Certain Kinetics of the L-77 Reactor"	Dr. Gileadi, May, 1968 Aviva E. Fernández
Pérez Bracetti, Fernando	"Use of a Gamma Ray Threshold Detector in Reactor Control"	Dr. Ortiz, Edie, May, 1968
Rivera Cordero, Antonio	"Investigation of Gas Produced by the Nuclear Irradiation of Concrete Containing a Boron Additive"	Dr. Sásacer, Dec. 1968 Donald B. Barytes
Rivera Oyola,	"Radiolysis of Hydrogen Chloride in a Nuclear Reactor"	Dr. Lee, Rupert, Sept. 1968
Vélez Delgado, Gilberto	"Measurements of Temperature Distribution in the Water Pool of Puerto Rico Nuclear Center Reactor"	Mr. Berceld, May, 1968

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RESEARCH

PROJECTS The research projects of the division, in process or completed during the 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 β/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, K. Pedersen). Two population models for the suppression of the sugarcane borer Diatraea saccharalis Fab. (Crambidae, Lepidoptera) were investigated to determine if the release of irradiated adults would manifest sterility in the F1 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 IBM 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 U-235/U-238. 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. S. 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 neutron fluence. 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 Burst in an Infinite Medium (A. 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 PRICMTRIGA Reactor (A. E. Gileadt). 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 Ramirec). Gamma rays — From 8 source TANT on Puatator, eliciting via the characteristic gamma ray 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 is being developed to aid the work of the Marine Biology Division of PRIC. In process. 25 ---Page Break--- Applied Nuclear Power Engineering for Practicing Engineers (K. Pedersen), studies are being conducted with BF the Glow and Di D. 3. Sasscer for Entertain to be used in a book to be published by the firm of Barnes and We'aia the engineering understanding of nuclear power plants. In process 12, Escape Peaks From a Proportional Chamber (B. Ortiz). When the energy of the incident radiation is zero in the excitation energy, 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 ($CuFeS_2$) was heated to different temperatures for various times. The heated samples showed an increased leachability of copper from samples heated up to 350°C as well as a 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. Muñoz-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. Muñoz). 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 (J. 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 Two-Dimensional Block Shaped Instantaneous Source Diffusing within an Infinite Medium (open sea) by A. B. Gileadi, 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, Head of the Theoretical Program, met with the team in November. Dr. Chernick is advising the Division on its research projects, giving lectures to nuclear engineering students and seminars, and is giving lectures. Using his stay with PRI to complete a book on reactor traditions, he must be at FRG until May 1959. Dr. Aviva S. Gileadi was a Guest Research Collaborator with the Nuclear Engineering Division of the Brookhaven.

Tationel Laboratory from June 10 to sometime July 20, 1968. 26 ---Page Break--- Dr. Knud B. Pedersen attended a short course (May 7-10, 1968) to familiarize 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 Ridge, Tennessee, held to acquaint participants with educational uses of a small accelerator (less than 0.5 MeV). 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 (March 25-26). Dr. Pedersen 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. (Nov. 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 been becoming engaged in a new, major area of teaching and research, called "plowshare," 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. Three publications (See appendix) have resulted from this research. The research projects pertain to: (a) in situ mining by nuclear devices, specifically, the leachability of chalcopyrite ($CuFeS_2$) in sulfuric acid solutions and, (b) applications of distorted model theory to predicting cratering dimensions. ---Page Break--- (1) Dr. Amador Cobas, deputy chair also heads the Physical Science (2) Dr. Manfred Eberhardt works at an IBM card preparation for molecular orbital.

calculation: ---Page Break--- 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 (Chen, 599 or Phys, 501, one to six credits). Graduate students supervised by PRNC personnel and their geographical origins are shown in Table II. 29 ---Page Break--- 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 B. Z. Weisz; Janice Petrovich with Dr. J.P.A. Castrillón. PARTICIPATION IN THE "ATOMS IN ACTION" HABITS Dr. Alec Grinzon participated in the "Atoms 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 small 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 Castrillón participated in the "Atoms in Action" exhibit in Cordoba, 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 labeling of sphingosine and dihydrosphingosine, using the catalytic technique, and on the use of tracers in the study of the oxidation of aldehydes with n-bromosuccinimide. MEETING LECTURERS During 1968 the following visiting lecturers presented conferences of particular interest to the division staff: February 23, Dr. G. J. Dienes, Head Solid State Physics Group, Brookhaven National Laboratory. "The Properties of Small Substitutional Impurities in the Alkali Halides." April 10, Dr. Allan Maccoll; Reader in Physical Chemistry, University College London, London, England.

"Mass Spectroscopy." May 28, 29: Dr. Martin Pope, Solid State Physics and Radiation Laboratory, Dept. of Physics, New York University, "Photoconductivity as a Spectroscopic Adjunct." June 12, 13, Dr. Marvin Silver, Organic Crystals Solid State Physics Project, Dept. of Physics, University of North Carolina. "Study of quasi Free Electrons in Liquid Helium by Electron Injection," and "Determination of Electronic States in Anthracene from a Study of the Temperature Dependence of the Recombination Coefficient." July 11, Dr. Gabriel Chuchant, Head Chemistry Dept., Instituto Venezolano de Investigaciones Científicas (IVIC), Caracas. "The Effects of Amine Groups in Aromatic Electrophilic Substitution." July 18, Dr. Wichael Barfield, Chemistry Dept., University of Arizona. "Theory of Nuclear Spin-Spin Coupling." August 8, Dr. D. A. Armstrong, Chemistry Dept., University of Calgary, Canada, "Modolyst of Aqueous Solutions of Salite Coe." ---Page Break--- 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. Szmant has accepted a position as Chairman of the Chemistry Department, University of Detroit. Two of the graduate students working with Dr. Szmant, 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. Castrillén. 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. Miss Julian will soon present this thesis for the M.S. degree. SCIENTIFIC

MEETINGS AND COURSES QUE PUERTO RICO March 17-20, 1968: American Physical Society Meeting, University of California, Berkeley. Attended by A. Cobas and B. 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 Hoerhardt 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." May 4, 1968: Central University, Caracas. Dr. Alec Grimison delivered a lecture entitled "Uses of Radioisotopes in Scientific Research." June 28, 1968: Hebrew University, Jerusalem, Israel. Dr. B. Z. Weisz delivered a lecture entitled "Radiation Damage in Organic Crystals." July 1, 1968: Mth Molecular Crystal Symposium, Enschede, Netherlands. The following paper was presented: "Radiation Induced Paramagnetic Centers in Anthracene and Deuterated Anthracene" by B. Z. Weisz, J. Castellanos, A. Cobas, and G. A. Simpson. August 20-23, 1968: Loyola University, Chicago, Illinois. Dr. George A. Simpson attended an International Conference on Molecular Luminescence. September 26, 1968: University of Montreal, Montreal. Dr. Alec Grimison delivered a lecture entitled "Electron Attachment to Pyridine and the Diazines." ---Page Break--- September 27, 1968: McGill University, Montreal. Dr. Alec Grimison 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 x 10^(-1) to 16 x 10^(-1) at a dose rate of 8.3 x 10^(-1) ev/ml hr using a Co-60 source. The main products are H2, 1,2-, 2,3-, 3,4-, and 4,5-dimethylcyclohexene, cotene-2, dimeric products, and isomerization. The trans compound shows a greater decrease in G(olefin) with increasing dose than the cis isomer. Iodine (2 x 10^(-4)) reduces G(olefin) in the trans-1,2-dimethylcyclohexane from 3.54 to 2.36 (He) = 1.8, but in the cis isomer, the G(olefin) is only reduced from 3.70 to 3.05 (He) = 0.65. Our results suggest that the difference of unscavengeable 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 scavengeable hydrogen atoms. A similar behavior was observed with cis and trans-decalin.

b) **Radiation-Induced Addition of Thiophenols to Indene** (I. H. Szmant 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 x 10^(-5) 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 are 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 indene, 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. (c) Tritium Recoil Labeling (J. P. A. Castrillón). The analysis of samples of Lithium phenylacetate following neutron irradiation is well advanced. An alternative method of analysis via the nitration of the labeled acid is being studied. Work has begun on the steric aspects of recoil labeling, and for this purpose, p-phenylbutyric acid is being resolved into its enantiomers. Graduate student trainee: Agnes Costa. 32 ---Page Break--- (4) Matrix Isolation Studies of the Gamma-Radiolysis of Heterocyclic Molecules (A. Grinison 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 Sanches, Francisco Bernascon, José Revuelta. (e) Radiation Damage in Organic Crystals (A. Cobas, B. 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 Arzcla. 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. a) Oxidation of Diarylethanes (J. P. A. Castrillén). The individual steps in the synthesis of 1,1-diodo-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. Colén. 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 Cl g-spectra toward lower energies, a variable Giserixinator was calibrated using several internal conversion electron emitters. Several compounds of chosen structure have been synthesized: p,p-diacetyldianino benzophenone, p,p'-dianinobenzophenone, p-nonoiodide 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-dihalogen compounds is double that of corresponding perhalogen 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 moles 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 Lactam-Lactim Tautomers (M. K. Eberhardt). Huckel MO calculations have been made on a series of lactam-lactim tautomers. These results can be related to the ability of these compounds to undergo an aminomethylation reaction (Mannich reaction). b) Molecular Orbital Calculations on Aminophenols and Aminothiophenols (A. K. Boerbardt and A. Grinison, in collaboration with Dr.

Gebriel Chuchant, IVIC, Caracas, Venezuela). Huckel MO calculations have been made on 2,2'-bipyridine and phenylphenol, and o-, m-, and p-aminothiophenol to explain the differences in electrophilic substitution with triphenylmethyl carbocation. (c) Thioxanthone and Related Compounds (J. P. A. Castrién), 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 forms 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 compounds are being studied. Graduate student trainee:

Sonia Vazquez. (S. Romison and W. Adan). Nuclear Spin-Spin Coupling Constants (A. Grimtzon and collaborators) have been made of the nuclear spin-spin coupling constants of various small molecules. Only the dominant Fermi contact term was computed, during the complete perturbation expression, as well as various approximations. The best available self-consistent field wavefunctions were used. Graduate student trainee: Philip Sprangle. Calculations of C3 Chemical Shifts (A. Grinison and W. Adan). The carbon-15 chemical shifts of the six-membered heterocycles, pyrazine, pyrimidine, pyridazine, s-triazine, s-tetrazine, and their cations and dications, and of the five-membered ring heterocycles pyrrole, imidazole, pyrazole, and their anions and cations have been calculated from various approximate perturbation theory expressions. The diamagnetic contribution to the screening 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 (EHT) were used, in non-orthogonal and in...

orthogonal form, The detailed perturbation expansion failed 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 ghost orbitals, does not improve the results significantly. Good agreement with Ciseri-Bent 18 is obtained by the judicious use of the average excitation energy, area distribution, and orthogonal wavefunctions. A normalized parameter calculated from the EET energy values reproduces (a) the displacement of the chemical shift to higher field in the Ssoelectronic series, (b) the allele placement of the chemical shift to lower field on successive nitrogen substitutions, and (c) the displacement of the chemical shift to higher field on excitation of the nitrogen lone pairs. The use of the x-electron anionic does not permit the latter correlation to be made with experimental tone. Graduate student trainee: Gladys Rodriguez. Hetaryne Intermediates (G. Grimicon and W. Adam, in collaboration with R. Hoffmann, Cornell University). The electronic structures of all or some possible 1,2-, 1,3-, and 1,4-didehydroaromatic intermediates derived from Pyridine and the diamines (hetaryne intermediates) have been calculated using the extended Huckel theory (BHT). The didehydropyridine is the most stable and the 26-didehydropyridine the least stable. Great relative stability is also predicted for 4,5-didehydropyrazine and 4,6-didehydromridanes. The complex computational trends in the hetaryne stabilities can be envisioned very well by simple molecular orbital considerations of the orbital interactions among non-bonding radical lobes and lone pair orbitals. A clearer interaction shows to be a nitrogen lone pair destabilization of nearby resonant tone. The calculated stability sequences and total electron distributions promote an excellent correlation of the available experimental data on relative stability and orientation effects in the hetaryne intermediates. ---Page Break--- TABLE 1 Participants in Basic Course in

Radioisotopes Techniques, 1968 Field of | Finatcat country Interest =~ Sponsor 1. Martínez-S., Rey WD. Spain Microbiology FRC 2. Jordan, C.F., Ph.D. United States Ecology FETC 3. Ramos-S., M.A. Puerto Rico (USA) Hematology FELT 4. Ramírez-S., C., M.D. Puerto Rico (USA) Surgery UPR 5. Pothier, L. United States Biochemistry Self 6. Rivero, F. Puerto Rico (USA) Odontology Self 7. Lu, Litteyuan, Ph.D. China Biology Self 8. Gerardo Rfo-R., M. Puerto Rico (USA) Microbiology Self 9. Rodríguez-A., D.C. Dominican Republic Nuclear Medicine FELT 10. Osorios, R. Cotesbiology Musculoskeletal WO 11. Múzger-R., J.A., M.D. Puerto Rico (USA) Radiology UPR 12. Coldnealy, Joke Puerto Rico (USA) Biology PAC 13. Soto-G., C.H., M.D. Puerto Rico (USA) Radiology P.R. Medical Center P.R. Puerto Rico (USA) Biology P.R. Health Department Vette, C.O. Colombia Microbiology TKIA M.A. Thesis Research Supervised by Division Personnel During 1968 Student Country of Origin Supervisor 1. Arzola, Eva Puerto Rico 2. Weisz, A. Cobas 3.

Bernasconi, Francisco Chile 4. Grimson, G.A. Simpson 5. Birke, Arnoldo 6. H. H. Semant 7. Cañizo, Zatth Puerto Rico 8. P.L. Castritién 9. Castellanos, Jaine Colombia 10. Welae, A. Cobas 11. Colén, Jaine Puerto Rico 12. P. Castriniéa 13. Costa, Renes Puerto Rico 14. P. Castritién 15. Fernández, J. 16. Cube, X. War 17. Génez, Fite Venezuela 18. P. Castritién 19. Mata, Alfonso Costa Rica 20. H. Semant 21. Rechant, Flo Puerto Rico 22. M. Mite 23. Riqueine, Ida Cuba 24. H. Semant 25. Rodríguez, Gladys Puerto Rico 26. A. Grimison 27. Revuelta, José Cuba 28. K. Grimison 29. Trujillo, Wyrthe Cuba 30. K. Grimison 31. Sprangle, Philip United States 32. K. Grimison 33. Zea Ponce, Irna* Gustenaia HLF Semant, M. Poerhardt Les degrees awarded during 1968. ---Page Break--- ---Page Break--- RADIATION CHEMISTRY PROJECT: MATRIX ISOLATION STUDIES OF PRODUCTS OF GAMMA-RADIOLYSIS OF HETEROCYCLIC MOLECULES. * The project aims at trapping and subsequently characterizing the 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 γ-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 (Hand H) (University of Bristol) have reported the radical anion spectra produced by chemical reduction with metallic sodium in methyltetrahydrofuran at room temperature. Kinnel and Strauss (K and S) (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 γ-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 x 10? 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 is 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 our more detailed studies) is that the observed thermoluminescence is due to the normal phosphorescence of the unirradiated molecule.

Thermoluminescence BSR Signals following Radiolysis at Room Temperature, in conjunction with Dr. Gesdki (Instituto Venezolano de Investigaciones Científicas), comparative studies were made of the ESR signal and the luminescence following room temperature radiolysis of bioluminescent

compounds. Figure 1 shows the ESR spectrum obtained from irradiated compounds associated with thiocompounds. The absence of detail is characteristic of powdered samples. The g-value suggests a neutral radical with the impaired decoupling of a carbon atom joined to two hydrogen atoms. A similar spectrum was obtained from irradiated uracil; the frequency of these radicals is present following irradiation, the efficiency of production of radicals is on the order of 10^(-3) radicals per 100 eV detected. Following irradiation of thymine, cytosine, adenine, purine, guanine, or uracil to doses up to 6 x 10^4 rads at room temperature, thermoluminescence was produced with a yield approximately one-ten thousandth that from a lithium fluoride sample.

2ineur with dove in the range ecitie, | For cytosine and uracil the maximum thermoluminescence is obtained free 6a | 155°C, which suggests a trap depth of about 1 eV. | If it is assumed that the trapped species giving rise to the thermoluminescence 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, Photons Several mechanisms of photoionization 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, optically 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 phosphorescence 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. | Farris-Farr-Pople calculations have been carried out on the potential neutral molecules and their radical anions and radical cations: pyrrole, furan, thiophene, pyridine, piperidine, pyrazine, and pyridazine. These calculations included limited configuration interaction and used the computer program derived in the previous Annual Report. The agreement obtained with the well-characterized absorption

spectra of spectral molecules was very good. In harmony with recent theories, the use of a very limited configuration interaction widens the agreement with experiment.

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‘ou 1 ‘Transition Energies (eV) For The Pyridine Anion By experimental values we have: 1 246 (00) sar any 325 (on hs (2) oa 3 3.08 (a) 833 5.28 (on ney) KAS This was ‘Rus were 2s 0.43 (000) 2.90 (.066) 2:38 (18) 3.4 (.07e) 3.58 (om) 3.65 3s (.053) 10 (253) 3.6 (.25) 898 (205) 5.21 (2) 5.22 (123) 5.54 (28) ae aa ae 3 transition energies (eV) For The Pyridine Anion Experimental Values Calculated Values Transition energies (eV) For The Pyridine Anion are: 23 (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 Thermoluminescence Compound Observed Intensity Pyridine Strong Adenine Strong Anthracene weak Ascorbic acid Weak Benzimidazole

Strong Benzotriazole Weak Strong Strong Weak Tonic one oak Hematoporphyrin weak L-histidine weak Indole weak Tryptophan weak Indazole weak S-methylcytosine weak L-phenanthroline weak Pyridine Strong Pyrazole weak Byrianine weak Byrianine Strong Sodium chloride weak Sucrose Weak Tetraphenyl pyrrole weak Tryptamine Tryptophan 2,6-di(triphenyl imidazole (TPr) Thymine Uracil Xanthine

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TABLE 6 Compounds Undergoing Photoinitiation At TIX In MIKF In Order Of Decreasing Efficiency Compounds Irradiated (Seconds) Indole Tryptophan Indazole Tetraphenylpyrrole

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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 10^5 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. Electron Spin Resonance (ESR) Measurements in Anthracene C14 and Deuterated Anthracene C12D. Several types of damage centers are introduced by irradiating anthracene with gamma rays. These defects are detected by different methods such as delayed fluorescence, fluorescence, optical absorption, space charge limited currents (A description of detecting radiation by these methods is given in PRIC-58 and PRIC 107.) and electron spin resonance. Crystals irradiated with doses up to 10^7 rad were dissolved and analyzed by thin layer chromatography but no traces of impurities could be found. In spite of the extensive study of the radiation damage in anthracene until now, only the nature of the paramagnetic centers could be revealed. It became possible to identify these centers by studying the ESR spectra of gamma irradiated anthracene and deuterated anthracene. Doses up to 7 x 10^7 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 intensity ratios and hyperfine couplings are approximately the same as for the methyl radical. Blum et al. suggested that the spectra results from the hyperfine interaction of 3 equivalent protons on a linear segment of a dimeric anthracene radical. It was anticipated that if the proposed cross-linking between the anthracene molecules is indeed produced, then the spectra of the paramagnetic centers

produced on irradiation of deuterated anthracene will be considerably narrower. They would be less than 1/3 of the methyl radical and have a line structure with intensity distribution of 1:3:6. Spectra obtained in gamma irradiated deuterated anthracene was very close to the predicted one. A small excess in the width of the spectra is thought to be due to the partially deuterated anthracene C■■D■■H■ which is nominally present in the sample. Since the C■■D■■H■ has only one hydrogen, at low concentrations all the nearest neighbors in the crystal lattice would be fully deuterated and the resultant radical could have no more than one hydrogen. Hence, the spectrum

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. As described in HACE and PRECLUTS, radiation induces 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^{1}■ W/en-^{3} 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 temperatures 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 photon-enhanced electron space charge limited currents in anthracene can distinguish between the two processes. The measurements are made on solution grown crystals. Sodium analog is used as the electron injecting electrode. It is found that electron traps were induced in anthracene by gamma rays. For radiation doses higher than 10^6 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 analog 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. 45 ---Page Break--- ---Page Break--- 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 disease. 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 that 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 technology student is thus offered the opportunity to learn about this discipline and is encouraged to extend training in this field. Informal Courses acquiring practical laboratory experience.

working with patients under the guidance, clinical and other references are available in thyroid. See ear, sia, eope localization stniee, there were 43 participants in the nuclear medicine course for medical tech. Notogitre “Higy'3 orttctrants 32 Minare were participants in our other solorets. They TEESE 1b Gk1e, 5) and those professional background and countries of origin appear in Table &. The various teaching & diagnostic or therapeutic procedures done for or by Bee ee ei ree ee ee ete Sr Ree sere Zcaatttnce the division during past years. RESEARCH IN PROGRESS Evaluation of antithyroid effect in hyperthyroid patients with Radioiodine Seats 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 the 3-hour uptake, also under this drug, or with the 24-hour baseline values. When she EERE Glseinzge test was given, 6 patients medicated with propylthiouracil, 4 strong responses were observed in 3 of them. The detection of response by the HOIS discharge method is related to the fact that the presence 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 cheer section, one would anticipate a similar effect as that observed at the 3-hour statement. The next group of patients will be studied with this regimen. Organ Scan and Tumor

Localization Radioisotope localization of thyroid, brain, liver, and kidney constitute the major organs studied, with the exception of lung scanning studies which were done primarily to detect pulmonary embolism. Clinical and histopathological 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. Radioniodine studies of uptake, PBI 131 Conversion Ratios, and PBI 131 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 radioniodine showed a consistent tendency to depressed values except in two patients who had no change. Both the PBI 131 Conversion ratios and PBI 131 plasma levels showed.

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 time of last observation were as 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 liter of plasma. Results in this group would indicate that after the initial phase of depression reported in last year's annual report, there follows a 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. Renal toxicity 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 (Bromosulphthalein 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 para-aminohippuric 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 exacting nature, it remains the method of choice as a standard reference. Recently since the advent of radioactive labeled substances appropriate for

renal works a group of clearance techniques have been proposed for the determination of renal blood flow. Diodrast and Hippuran labeled with radioactive iodine (131) have been described as effective tools for this determination. Three techniques have been described: (a) infusion method with catheterization of the urinary bladder; (b) infusion method without catheterization; and (c) a single injection 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 by 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-131 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 this 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." ---Page Break--- Two Month Training Program on Clinical Applications of Radioisotopes LIST OF STUDY "AVERAGE NUMBER OF PROCEDURES PER TRAINEE" ——— Thyroid Function % Routine uptake measurements (as) Assay of radioactive thyroid hormone levels in blood (as) Modified tests of thyroid function (5) Dynamic functions of the hepatic, renal, and vascular system H ontologic applications of radioisotopes 5 Tumor Localization studies 20 Gastrointestinal absorption 5 Electrolyte and fluid balance 6 Therapeutic procedures 3 TOTAL 46 BASIC COURSE IN CLINICAL APPLICATIONS OF RADIOISOTOPES January 2 to February 23, 1968 1. Zobeida de Jess Malpas Venezuela 2. Maria de los M. Thiguee Dom. Rep. 3. Ricardo Socoleky Argentina 4. José R. Mariacn Bolivia July 15 to September 7, 1968 1. Dinorah C. Rodríguez Dom. Rep. 2. Gerhard B. Ramírez Puerto Rico Special Training Tumor Localization and Organ Visualization September 1-30, 1968 1. Rodrigo Fierro Benitez Ecuador 2. Medicine Puerto Rico Puerto Rico ---Page Break--- (Orientation in Nuclear Medicine, continued) 3. Cabrera Rivera, Olga Puerto Rico 4. Colón Veldzquez, Carlos M. Puerto Rico 5. Correa Colón, Wanda Puerto Rico 6. Cruz Colón, Gloria Maria Puerto Rico 7. De Armas Vazquez, Lillian Puerto Rico 8. Fernández Vives, Aida Dominican Rep. 9. García

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, Lus 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 Josefine Puerto Rico 35, Santiago Becerra, José Puerto Rico 36, Setlés Hernández, José Puerto Rico 37, Sobrino Fortes, Wonda Puerto Rico 38. Tapia Cruz, Gladys Puerto Rico 35, Texidor Carmona, Migdalia Puerto Rico 3g, Trinidad Salgado, Irma Puerto Rico IQ! Yetlectiio Euanvelli, Priscilla Puerto Rico 12, Verges Ronos, Wilda Puerto Rico Puerto Rico 43, Urdaz Alvarez, Vivian ---Page Break--- TABLE 3 Number of Trainees Te oF Taber xD. 5 Medical Technicians 2 Medical Technologists 8 3 ee _ Puerto Rico 43 Latin

America 7 Argentina (2) Bolivia (2) Dom. Rep. (3) Ecuador (1) Venezuela (1) w TABLE Procedures completed, observed or discussed by students TAADEE cours aef¥ea pone GEfS'SeesShe TOTAL 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. Rodríguez 5 9 " "8 1352 385 Gerhart 5. Ranfrez es "8 1% 62 383 Rodrigo Fierro Benítez Sp. training Tmor = — 97 - 7 Loc. and Organ Vis. TOTAL, aso am TABLE 5 Bingnostie and therapeutic

procedures Carried Out During 1968 Thyroid Studies 1938 Liver Studies 132 Heart Studies 31 Kidney Studies 2 Gastro-Intestinal Studies a Blood Studies 18 Tumor Localization Training Procedures 2591 TOTAL 3B ---Page Break--- ---Page Break--- RADIOTHERAPY AND CANCER The Radiotherapy and Cancer Division has a three-fold objective: education, research, and service. The Division functions as part of the radiotherapy department of the I. Gonzélez Martinez Oncologic Hospital, adjacent to the Biomedical Building at the Puerto Rico Medical Center. The Oncologic Hospital provides some of the paramedical personnel, equipment and space, operating rooms, hospital beds, outpatient facilities, clinical laboratories, and medical services essential to the care of cancer patients. The hospital renders services to over two-thirds 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 roentgentherapy machines of various voltages, cobalt and cesium teletherapy units, and the interstitial 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 previous radiotherapy experiences. Participants may engage in research to participate in all training entities of the division; however, they are extended the privilege of patient responsibility. "A minimum of one month” 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 Aivieion (PRNC treatment area, Oncologic Hospital treatment area, Curietherapy 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 Vaksanovie, 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 our divisions of PIE and in the weekly Tumor Conference of the Hesies! school, in the 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 this year. "STAFF At year's

end, the Radiotherapy Division had four radiotherapists, one physicist, an assistant physicist, and a biostatistician. The services of a research medical records librarian, three graduate nurses, three clerical persons, and a photographer-electronic technician were also available. Personnel is still insufficient for the needs of the division, particularly at the radiotherapist level; the present patient and teaching load requires at least six radiotherapists.

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.

Name 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. In Ook 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. Aristizábal, from Colombia, spent three years of training as resident in radiotherapy at our Institution, from July 1965 to June 1968. Doctor Aristizábal 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.

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 Jane 168 Arturo A, Yarach Puerto Rico Tune-ruly 18 Jerone ligangane Nigeria Tune-duly 100s Char Salacar Cuba Sune-July 146 José M. Sobrino Puerto Rico Tunes LAS Sous F. Irizarry Puerto Rico Sunengaly 08 José R, Hernanies Puerto Rico Sune=July LS Prank Rodrfauez Puerto Rico Sune-Iuly LOS Francisco Robert Puerto Rico Suneaginy 1008 Noraina M. Laniraa Puerto Rico Suneonay D8 oT ---Page Break--- (In-service Cancer Training, continued) José victor Figueroa Puerto Rico duty Sent. 1969 ieving app tev Yore Septcbes. 1368 Irving Kapp RESEARCH PROGRAM A. Current Research Projects at Ent of Year sasaiono eaten se at re 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 cance: 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 carcinons 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 (Niational Study). (Discontinued-See annual report 1967, page 63). 7. Study of Optinal irradiation in carcinoma of the esophagus: of irradiation 2 weeks post-radiotherapy. A boost, 8, Fractionation in radiation therepy of post-surgical breast cancer: 3 ve 5 fractions per week. 9. Study of tunor regression in carcinona of the cervix. B, Projects Terminated During the Year 1. Fractionation in radiation therapy of heed and neck cancer: 3 vs fractions por week, this project, previously described alae st-ecepeeieg tunor and norsal tieoue effect of irradiation of head and neck cancer using tvo fractionation regines of the sane weekly dose (3 vs 5 fractions). The stuly 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, Plot Study of Split-Course Irradiation in Carcinoma of Base of Tongue. This project aims at a comparison of radiation dose fractionation schedules 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 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 normal tissue damage, and the results will

be presented at a national science meeting in Philadelphia in April 1969. 3, Review of Clinical Experience with Carcinoma of the Uterine Cervix = Year 1962. This is a retrospective clinical study of tumor control and the resultant 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 in patients treated at the Radiotherapy Department of the I. González Martínez Hospital during 1955-1965. The combination of external irradiation followed by intracavitary brachytherapy 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

Radiation Society at Miant 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 Martinez Oncologic Hospital during 1941-66. 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 - 1941-66. This is a retrospective study of the clinical experience with brain tumors at the I. González Martinez Hospital conducted by Doctor Aristebal, 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 Martinez Hospital during 1955-67 conducted by Doctor Arenas, a trainee, who is preparing a paper for publication on this work. SAFETY 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 a member of the Safety Committee of PRIC and Chairman of the Committee for Human Uses of PRNC. 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 Oncology 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 Inter-American College of Radiology; Counselor for P. R. to the Radiological Society of North America; Member of the U. S. Committee for Radiation Therapy Studies; 59 ---Page Break --- Member of the Task Force for Cancer Data Coding; Member of the Cancer Commission, American College of Radiology; Member of the organizing committee of the Tenth Inter-American 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 Carmel, California in September 1969; Project Director of the Split-Course Radiotherapy of Cancer - Clinical Trial - a national study. During the year Dr. Joos M. Toné held the position of Chief Scientist I 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 Inter-American College of Radiology. Dr. Jeanne Ubifias held the position of Chief Scientist I at the Radiotherapy and Cancer Division of the Puerto Rico Nuclear Center. She was a 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. Dr. Antonio Bosch held the position of Chief Scientist I at the Radiotherapy and Cancer Division of the Puerto Rico Nuclear Center and was a Member of the Emergency Committee of the Puerto Rico Medical Center. Dr. Guillermo Génez-Cirdenas held the

position of Visiting Radiotherapist at the Radiotherapy and Cancer Division until May 1968. VISITING SCARWUSSTS 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. orsl = Dr. Chahin Chabbasian, Radiotherapist from the Penrose Cancer Hospital, Colorado Springs, Colorado = Consultant under the Training Grant. June = Dr. te Gr Lajtha from the Christie Hospital and Hole Reston Institute, Manchester, England = Lectured on Stem cell studies at the Paterson laboratories in Manchester. November ~ Dr. Ruberi Peres Tamayo, Chief of the Radiotherapy Department, Ellis Fischel State Cancer Hospital, Columbia, Missouri = Consultant under the Cancer Control Program, Department of Health, December ~ Drs. John Z. Ulteann, Associate Professor of Medicine, University of Chicago, formerly with the Francis Delafield Hospital, acts as Consultant under the Training Grant. SCIENTIFIC TRIPS OF STAFF 1. Dr. Jeanne Ubifins: April 18, Visiting Professor at Ellis Fischel State Cancer Hospital, Columbia, Missouri. Four lectures were presented. November 20-23, Houston, Texas - M.D. Anderson Hospital and Tumor Institute. Attendance at "Symposium on Carcinoma of the Breast." 2. Dr. Antonio Bosch: November 20-23, Houston, Texas - M.D. Anderson Hospital and Tumor Institute, Attendance at "Symposium on Carcinoma of the Breast." 3. Mrs. M. M. Palacio: January 7-13, Visit to the Radiological Physics Department of the M.D. Anderson Hospital, Houston, Texas; November 30-December 5, Attendance at the Annual Meeting of the Radiological Society of North America, Chicago, Illinois; December 6-14, Visits to the Mayo Clinic (Rochester, Minnesota); University of Rochester (Rochester, N.Y.); Cornell University (Ithaca, N.Y.); Brookhaven Laboratories (New York, N.Y.); Naval Medical Center, Walter Reed Hospital and National Institute of Health (Washington, D.C.)- 4. Miss Zenaida Frias: May 17, Attendance

and participation in a meeting of participants in the Split-course Project, National Cancer Institute, Bethesda. 5. M.D. José M. Tord: November 14-17, Presentation of a paper at the Annual Meeting of the P. R. Medical Association; December 1-6, Attendance at 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 San Jorge, Pereira, Colombia, with presentation of two lectures; April 6-13, Attendance at the Annual Meeting of the American Radium Society in Miami, Florida, with presentation of a paper; Sept. 25-30, participation in the "DX Jornadas Radiclégicas Colombianas", Medellín, Colombia, with presentation of four papers and two round tables; Oct. 12, Presentation of a paper at the "Convención Anual del Colegio de Farmacéuticos de P. R.", Hotel Dorado Hilton, Puerto Rico; Oct. 31 to Nov. 4, Attendance at the Annual Meeting of the Association of American Medical Colleges, Houston, Texas; Dec. 1-6, Attendance at the Annual Meeting of the Radiological Society of North America, Chicago, Illinois. Other Activities: Mrs. M. M. Palacios 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.

‘Ac ttrioetion Wy alte of He Cane Reated = January to December 3968 2, elepharary Aytreatations.. Erg ar es) ‘werucevitary aod Interstitia. thers a ---Page Break--- ---Page Break--- 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 were one of several subjects emphasized in lectures and laboratory exercises. Phylogenetics - Dr. J. Ferrer-Monge. Serves as core for one of the three areas of investigation chosen for emphasis in the graduate program by the Biology Department in Mayaguez. Food Chemistry - Dr. B. N. Deshpande. A new course, designed to initiate in the College a Food Science curriculum which may interest graduate students in research on radiation preservation of food. Nuclear Techniques in Biological Research - Dr. J. Ferrer-Monge, Dr. B. 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. B. N. Deshpande, Mr. J. Cuevas, Dr. J. Ferrer-Monge, 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 research on special topics in biology. Biology: Research and Thesis - Staff. For students doing M.S. thesis research in biology. Agronomy: Research and Thesis - Staff. For students doing M.S. 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 radiochemistry, and PRNC courses in radiation biology and tissue culture. Graduate Research A number of graduate students were active in thesis research for degrees in biology or in

Agriculture under the supervision of the Division. Research topics reflected the broad interests of the Division. During 1968, five graduate students completed their theses. A. Thesis research completed 1. Combined effects of chemicals and gamma rays on the production of chromosomal aberrations in Tradescantia pallida (Puerto Rico). Three chemicals (G-ethoxy caffeine, 5-fluorouracil, kinetin) and gamma radiation have been used separately and in combination to produce chromosomal aberrations in Tradescantia pallida root-tips. When the chemicals and radiation 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 may be attributable to either an increase of interaction between chromosome breaks produced by the two agents or an increase in the number of breakages per cell, thus resulting in more interchanges. Research was performed under the direct supervision of Drs. F. K. S. Y. Hoore. 2. Effects of ionizing radiation on o-diphenol: oxygen oxidoreductase - Aida G. de Fournier (Puerto Rico). Estimation 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. A. Luse. 4. Preferred host plants of the sugarcane borer, Diatraea saccharalis - Victoriano Quinones (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 and other inherent cytological anomalies in Pallcouren riparia ~ Robert €. Venst0r (Puerto Rico). This understory 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. S. Koo's supervision, ---Page Break--- B, Thesis research in progress 1. Effect of temperature on the mitotic cycle of Vicia faba - carmen 2. Cinten Gusto Rice) The observations indicated that: (1) with temperature 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 meiotic index among the tested seeds at given temperature. Completion of this study is expected in March, 1969. (Advisor: Dr. J. Ferrer-Monge) 2. Influence of ionizing radiation on methionine utilization Escherichia coli strains as Rushford Gusheo is being studied as to their ability to incorporate 2g-labeled methionine into cell constituents. Results are expected to be completed in 1969. (Advisor: Dr. S. 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 mangoes, experimental design, irradiation operation, dosimetry, post-irradiation storage, visual observation and testing by instrument, biochemical analyses, 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 Jiravatana 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 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 infrared 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 Corn Market 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. Luce Food Preservation by Radiation and Radioisotope Techniques D. We Walker Insect Control by Radiation Sterilization Carmen Asencio Food Preservation 6 ---Page Break--- 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 numerous 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, 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 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, disease-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 flat components, mango and papaya macerates were extracted for the analysis. For mangoes, solvent extraction with chloroform was attempted. The papaya, saccoates, on the other hand, were subjected to extraction.

by means of an example apparatus for isolation of the volatiles. This assembly utilized the principle of flash evaporation and vaporization from a continuous thin heated fleet. Water and vaporized food

constituents were recovered by condensation in a series of cold traps cooled by liquid nitrogen. Dry test unt eestor 6 ---Page Break--- cutetes were used to aid in the recovery of vapors. 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 the 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 uronide content and methyl 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, suggested 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 dosage (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 inactivated 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 ---Page Break--- Further studies of the low-energy sonochromatic x-ray effect on genomic material treated with S-tronodecsyruine again confirm that photons with K-absorption edge energy of the target atom bromine are capable of inducing mutations at a much enhanced rate not known with any other radiation types, high-energy photons. In the past year emphasis has been placed on the construction of the action spectrum studies for mutation induction in Bechert's target Cometastertun equi. The workability of irradiating bacteria

with intensity by means of fluorescence line irradiation has been investigated. Alteration action on molecular lesion induction has also been studied. It is generally believed that, among the x-ray induced DNA strand breaks, only the single strand breaks are amenable to repair; double strand breaks are lethal, and the repair efficiency for the x-ray induced lesions is very low compared with that for the ultraviolet induced lesions. These generalizations are being investigated with low-energy monochromatic x-rays. 2. Biological studies of seeds. To further a worldwide program on seed irradiation organized by the International Atomic Energy Agency, the Division has begun investigations of the gamma radiation effect on soybean seeds with different 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-thymidine labeling study of chromosomes.

treated with radionuclide chemicals; and (c) breaking of dormancy and mutation induction by radiation in the root crop yautias (Xenotrichia atrovieirens). 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 a 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 College of Agriculture and Mechanical Arts, U.P.R. in Mayagüez. Dr. Meer was appointed Professor of Biology in the Biology Department and Dr. Dockentie was appointed Professor of Chemistry in the Chemistry Department. Also, Mr. Cuevas received an Ad Honorem appointment as Assistant Professor for (some subject) at CAAM in Mayagüez. 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 Llanos 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

agricultural development in the Llanos. On October 6-10, Dr. Koo visited the Instituto Centro Americano de Investigaciones 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 "Technological Aspects of the Application of Ionizing Radiation to Food Preservation" sponsored by the Joint FAO/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 a group drafting recommendations on Food Irradiation. He also attended the IAEA Panel on "New Approaches to Breeding for Plant Protein Improvement" in Svalöf, 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 an invited participant at 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 10th 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 in Belis, 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. ---Page Break--- SUGARCANE BORER CONTROL PROGRAM (Feb.) (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, Diatraea saccharalis, is the principal research objective, which includes 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 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. B. 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 have a 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 to complete 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 evaluated. Thus, we are very interested in achieving the necessary efficiency from 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 method that produces sterile insects. This might be possible by liberating genetic numbers of P generation sub-steriles that outbreed with the local population and produce a large number of F1 larvae that survive to emerge as sterile F1 adults. The application ratio is expected to be on the order of 10 times, i.e., ten times as many sterile F1 adults as were released. Factors are heritable through continual outbreeding.

measured by generally the best plant red stage larvae oviposition response to the corn and overall suitability as hosts, sources of larval food. To prepare for liquid scintillation counting, Miss Angélica Muñiz is delivering fractions onto paper discs following sucrose density gradient centrifugation of B. 80 in a study to determine the effect of low-energy x-rays on DIA st ---Page Break--- PRESERVATION OF TROPICAL FOODSTUFFS BY GAMMA IRRADIATION. The study of radiation preservation of fresh mango fruits was continued. The Elon, Buty Sensations, and font 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 carried out 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, observations were made for blackening or pitting 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 affected a delay in fruit ripening. At 150 kilorads, the fruits showed

Skin discoloration, ripening, and softening ceased 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, Rub mangoes showed a ripening delay of five days. Generally, the biochemical study of the 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 of 8 days at doses of 50-100 kilorads. ---Page Break--- Photometric setup ---Page Break--- ---Page Break--- 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 Schistosomiasis mansoni. 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 infections (Proposal in study in the DM) EDUCATIONAL ACTIVITIES 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, Participants were: Miss Rachelle Evenchick (7/22-8/30/68), U.S.A., and Dr. Abdel Arandia Patraca (8/19-8/27/68), 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. Colén, Associate Scientist (ad honorem) & Professor of the School of Medicine. The participants were: Kane Country, Felicita Gotey Puerto Rico, Carlos Roberto Lau Puerto Rico, Victor M. Gotay Puerto Rico, José A. Licha Puerto Rico, Héctor Gotay Puerto Rico, Enrique Reynold López Puerto Rico, Angela 7. Hernández Puerto Rico, Rachel López de Suárez Puerto Rico, Cristóbal Jiménez Puerto Rico, Agapito López Rivera Puerto Rico, Citrajanes Ell Guyana, Charles Lowry Phillips United States. 3. Radiation Biology (PRINS 510). Given for academic credit by Doctors Jonge and José Ne Correa, members of this Division. The following students attended: Aquiles Santana, from Colombia, Talía Rodríguez, from Ecuador, and Renén 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. Oscar Juliao Colombia Virologist at the Microscopy National Institute of Health in Bogotá, Marcela Estrena-Pert Med. Technologist, Microculture 5/5/68, Radioisotopes 10/18/68 techniques with Brail MD. Se histo ronas t 10/7- Hostal Hate Use of radioisotopes for testing (aruge) 5. Special Training in Radiobiology for Radiotherapists. Special training in basic radiobiology, with lectures and laboratory exercises, was offered to Dr. Silvio.

Aristizabal of Colombia by Division staff member Dr. Ramiro Martinez-Silva, Dr. Julio I. Colén, Dr. Jorge Chiriboga, and Dr. José N. Corres, 6, Orientation on PRIC Program in Tropical Ithellear Biology and Medicine Course. "The following postgraduate fellows who attended a Tropical Medicine Course at Louisiana State University were given a special orientation: David Dennis, N. D.; Gerald V. van der Viugt, M. D.; Clarence A. Parker, Ph. D.; Clayton R. Page, Ph. D.; John W. Rippon, Ph. D. 7, Orientation in tissue culture and radioisotope techniques, given to the following professors from the Faculty of the Central University in Venezuela: Miss Mercedes U. de Montalvo, Miss Hosaura Belto, and Mrs. Mireys de Gugig. 8, Summer studies. Gerald M. Kidder and Roger Arnold Pedersen from the Graduate Program of the Biology Department of Yale University studied molecular biology here in the summer, using radioisotopes of marine specimens. They were referred to PRIC by the School of Medicine (UPR). 9. Thesis research. The following students continued their thesis research: Name Country Degree Source of Sponsorship Title Carmen Rivers "F.P.R., Master The Effect of Irradiation on Interferon Levels 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 following divisions: Physical Science, Health Physics, and Clinical

Applications. 2. Research cooperation with Agricultural agency involving a request for analyzing both the temperature and mercury density readings. Pevstsoes, bacntguet EX SSIES DO AEG ts Sroe Smet orattente ar aos ea dMepee cv fuscia bon ted eaettin er wih Be Hy of Breton of 9 tena veil Zooper, are tl once relent it then be unt a sopee On atacl® EAL Ok, Scrae ently There te perdieies igteetfreaticion ten, substitution. ---Page Break--- 3+ School of Medicine UPR, a, Department of Microbiology = Dr. Julio I. Colén, Virologist.

continues as an "ad honorem" member of the PRIC staff b. Department of Parasitology - The interchange of Information and biological material with this department has been continued. c. Department of Biochemistry and Nutrition - Dr. E. Toro Goyco, Associate Professor of Biochemistry and Nutrition, continued to study the biochemistry of Schistosoma mansoni eggs; he is receiving help from the Division. d. Dr. Jorge Chiriboga, Professor of Biochemistry (ad honorem) at the UPR School of Medicine, has lectured at the Department of Biochemistry. e. 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. Chiriboga, through which the bilharzia laboratory of the Department of Medicine will be used for PRIC research programs. In return, PRIC will provide antigens for clinical and epidemiological studies of bilharzia. f. 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 Se to study the cercariophagic 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 PRIC. 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 Yéndez Cortada, Associate Chief of Staff of the Veterans Administration Hospital, and members of our Division have begun a time-lapse cinematography project on the penetration and development of T. cruzi in 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

dots Torisontes Brasil, spent two months with PRIC in the Schistosomiasis group. 7. Walter Reed Army Institute of Research. Dr. Lawrence 8. Ritchie of the Walter Reed Army Institute, who had been assigned to the Schistosomiasis 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 Encarnita Conde, from the Medical Research Center, in the mechanism of action of hemolymph of Biomphalaria 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. ---Page Break--- [RESEARCH ACTIVITIES [RESEARCH ACTIVITIES activities offered at biological training activities done to elucidate the interactions between animal, cell, and subcellular systems regarding parasite relations and the effects of radiation on various biological systems. Research organized by sections - DEETHNTATION OF COCAINE AND NEUROLOGICAL STATUS. Spie. Raoce Allee) cocaine metabolite in mice live geographic differentiation of cocaine in Gas Chromatography. Different systems when cocaine was introduced. The supernatant along with the sample was analyzed with microscopy. The presence of 0.5 stoichiometric amount of Trini, regenerating tYignide were found as the only metabolites in the liver. Feat ts coe abing the cocaine

system, benzoylecgonine — not norcocaine. With the introduction, it was found to be the metabolite. On examination by paper chromatography and thin layer chromatography, the standards synthesized in the experiment produced metabolites to prove identity.

in a number of different solvents. laboratory were compare RE of the Metabolites of Coc Salen i solvent oe eareet as PARE andard UaapIa Steer Baan Cocaine 66 .6T -Tl 67 89 “73 *orcocaine +200 20 3 +35 +72 3 *Bonsollecgonine 0 m 9 OK = ne 1 56 *Eegonine ¥ Prepared in the laboratory. ** Extracted fron the incubated media and chromatography. b, Distribution of N-demethylase of cocaine in different tissues of aifterent animals, Brain, kidney, liver, heart, an intestinal mucosa were ‘ested in the sane fashion to see if N-demethylation of cocaines to produce formaldehyde and norcocaine occurred only in the liver. The enzymatic system was mixture of microsones + soluble fraction and TPWiip regenerating systen. 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 systen produces benzoilecgonine, but not nor-cocaine, ¢. Enzymatic induction of cocaine Nadenethylase by the substrate. TWo Groupe of anfnais, one with @ romal defined diet (23% protein), and another {in which the diet'was 54 corn protein, were subdivader:® one in-ahich the diet contained 15 ng of cocaine/i0gn of food ani the other served as conerols APY four veoks, all. groups were sacrificed and the rate of Mdonotiyiarion of cocaine vas tested in vitro. In the group that neceived a normal diet end GMB A glenisicant’ Tnerease in the enzymatic rates in the Liver vas observed 05), but no inorease vas observed ven a low corn protein diet was used. 4. Bffecte of cocatne on the incorporation of cl4 2c to chleine in sate with citverest metniGion? Ste oe Cee wae to choline in rate vith diftereie ees Sates ee SE as #5 PR est the hypothesis that’ cocaine could serve as a retiyl donor in animal: cocaine. Because cocaine labeled in the tertiary Nedemyl was not 8 ---Page Break--- ere prorsee Sou'and EiaTarachtie actaviay cP casey fee eathtone abated tn tbe eat i enperisant wee conusieg"in tantttsttte reser nce gece land datvorentlnnee our

Sources indicated different data that were with SOE's tonal Gitots “toverers than expectations. The activity of choline in its corn diet (5% protein) (See Table 2) was not found in animals that were subjected to the examination of acetylation and cocaine in the geognostics (tiny stimulation). The rate of acetic acid utilization (HOS) was decreased in the liver homogenate of the serum tested in vitro.

TABLE 1. Incorporation of Methyl Groups from Methionine into Choline Phosphatidylcholine in Liver of Rats Fed in Different Nutritional States* specific activity in c.p.m./mg. of choline* — the after 0 hours after 17 hours after PURINA DIET Top com Porez omer [injection] injection Injection per me. | GERM feline | Cosette LcSeatne | BGeNNS | cBtkine | 16st | error] cores 2 19et 1,374 3 * Methionine labeled with C in methyl group used as precursor.

The values are averages of duplicate determinations after the intraperitoneal rca apes.

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SCHISTOSOMIASIS PROJECT MAINTENANCE AND USE OF THE LIFE CYCLE OF 8, MANSONI. New aquaria for small-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 paper 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.

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 ammonia were present in the air of the infected animal rooms due to decomposition of house 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 ammonia fumes. The resulting infections were normally leaving us without any explanation for the infection failure. Our worm recovery rates are now generally 40 to 50% of the cercariae used in exposures. Uniformity of individual worm burdens seems 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 Peru reveal that the prevalence of Fasciola hepatica is high. The occurrence of infection is reported to be 80-90%. Moreover, as shown in reports of task force be guidelines MY A 29H OF stock chicken in 10 of several conelages, the mass of information on schistosomiasis and Fasciola hepatica has been established in our laboratory. The life cycle of the snail vector Aquaria with connection to Biomphalaria has been successfully cultured. Tray contains about 25 worms, CHNPENE provided mature snails in one month and young in 3 months. The phenomenon of crowding may have a ---Page Break--- Page, Gea of a Ho. fish: & Condition | tested worms | 24 Hr(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 the test, 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. Familiarized Not Familiarized (a) Familiarized Not Familiarized (b) Familiarized Not Familiarized * Trials 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. 62 ---Page Break--- their number 12 excessive site mark avis) 122 f004 formula used for Biomphalaria glabrata ymanses. ‘To expose snails, eggs of F. nepatica were obtained from livers of infected snails. Most snails were infected after captures to 55 cercariae, setee peete netaserceraem the MALLE after 50-60 days and encysted closet tsenaieteay Infections in mice provide eggs for completion: re Laboratory. ‘Completing the life cycle in the The duration of infectivity of the metacercariae is being determined by exposing mice partially. The latter cannot tolerate ereeg eee ee oan Bioras. The course of the infection in this nest fe eter eet arene erison with published reports, Studies on biological serene eee ae eee being progress. Sero-diagnosis and vaccination Siich tee ties ee GF sevailation si2l get ently considera 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 cercariophagic activity of guppies using cercariae labeled with radioactive selenium (75Se). Attempts were made to show whether the cercariae were consumed through a predacious 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 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 the highest radioactivity were decapitated, and the intestines were removed from the body. The difference between head and body was sizable, while the relatively small intestine had about half the combined activity of 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. 83 ---Page Break--- The in vitro effect of the hemolymph of B. Glabrata on the metabolism of S. Mansoni worms Fig. 1 Fig. 2 Effect of whole-body radiation on host-parasite relationship involving mice infected with ---Page Break--- 1w ress UF WHOLE-BODY RADIATION (609) ON THE HOST-PARASITE RELATIONSHIP INVOLVING MICE INFECTED WITH SCHISTOSOMA MANSONI Acquired resistance against S. mansoni has been conclusively demonstrated, but the mechanism

involved remains inert. ‘Investment 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 disassociate these two 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 sub-lethal 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. [DOUNOLOGICAL 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 by 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 C14 pyruvate by the worms using the techniques outlined above (Fig.2). It was established that the hemolymph inhibited the metabolism of C14 pyruvate by the worms and that inhibitory activity was stable upon storage at 4°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 with infected mice demonstrated that both the dialyzed hemolymph and whole hemolymph reduced the worm burden of the snail by over 90%, whereas the ultrafiltrate gave a 22%

reduction. It appears that one must invoke some mechanism other than that of an anti-metabolite to explain the effect of snail hemolymph upon mice infected with Schistosoma mansoni, DESTRUCTION OF SCHISTOSOMA MANSONI IN MICE BY THE HEMOLYMPH OF ITS SNAIL VECTOR, BIOMPHALARIA GLABRATA After Oliver-Condelez observed that mature worms of S. mansoni in mice were killed by the hemolymph of its snail vector (1968, Proc. Soc. Exper. Biol. Med. 125, 1029), we demonstrated that the rate of metabolic degradation of pyruvate by the worms was less when they were incubated with the hemolymph and the ultrafiltrate thereof, but not by the dialyzed hemolymph. With these three materials, we carried out in vivo tests in mice, following the experimental plan of Oliver-Condelez. Whole hemolymph (16.66 mg. protein per ml) and dialyzed residue were injected 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 in saline); and 0.2 ml of the ultrafiltrate was injected on 3 consecutive days. Worm counts were made 1 to 20 days after injections in comparison with mice injected with saline. With the whole hemolymph, worm burdens were reduced about 50% after 5 days and 90% after 20 days, confirming the results of Oliver-Condelez. The dialyzed hemolymph reduced the worms 60% and 90%, respectively, after 10 and 20 days from the last injection. In the case of the ultrafiltrate, the worm burden was negligible (Fig. 3) 15 days after the last injection (Table 3). These results of dialyzed hemolymph and the ultrafiltrate are the reverse of those obtained in biochemical tests.

TABLE 3 [EFFECTS OF HEMOLYMPH OF BIOMPHALARIA GLABRATA SNAILS ON INFECTIONS OF SCHISTOSOMA MANSONI IN MICE]

Worms Recovered Days After Injection | Control Mice | Reduction

1 | 8 | 40%

2 | 8 | 60%

3 | 8 | 75%

Figures in parentheses indicate the number of mice involved.
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Fig. 3 Metabolic release

of CO; 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 incubated with °C glucose for 3 hours at room temperature ---Page Break--- evolution by varying numbers pyruvate 2-“C Incorporation 8 Metabolism of pyruvate-2- C, acetate-1- "'C and glucose- “C by cercariae of S, Fig. 8 Kinetics of pyruvate 2-4 cercariae of ---Page Break--- METABOLIC utilization of Pyruvate 21% and glucose 1e ‘BE MATURE WORMS OF Schistosoma mansoni Metabolic utilization of pyruvate and glucose by mature worms of Schistosoma mansoni was determined by means of reticulated cercariae. Measurements of labeled CO were made by the method of Chiziuoga & Roy (1962) Mature 103, 684), modified. “Amount of lactic acid resulting from glycolysis were also quantified. “Varying numbers of worms were incubated with each substrate, and relative amounts used by male only female worms were determined. When the same numbers of worms were incubated with pyruvate and glucose, each with a radioactivity of about 0.5 nCi, CO evolutions of 80,000 and 26,000 pm were obtained, respectively. Deadly 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 dp releases giving 27,700, 60,700, and 80,300 cpm, respectively (Fig.3). When the pyruvate activity was varied, using about 0.125, 0.25, and 0.5 μCi, the corresponding counts were 15,300, 19,200 and 60,700 (one); for dead-work 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, a gradient of lactic acid production was obtained (Fig.5)- utilization of pyruvate 214C, acetate 14, and glucose Me ‘BY CERCARIAE OF

SCiLISTOSOMA MANSONI Bruce (personal communication) found that cercariae of Schistosoma ni, while free-living, incorporated and metabolized radiolabeled pyruvate and glucose. Certain aspects of this problem have been studied in our laboratory, using pyruvate 2C, acetate 1-""'C. To date, the investigation has involved only the evolution of CO2, but it is intended to determine whether the cercariae degrade glucose to lactic acid. It was shown experimentally that 1.0 and 0.5 of glucose or pyruvate were optimal for testing. A direct relationship between the number of cercariae and the amount of CO2 released from pyruvate was demonstrated (Fig. 6). Larger structures of CO2 were released from pyruvate and acetate than from glucose. On the other hand, more glucose accumulated in the cercariae (Fig. 7), suggesting that metabolic degradation of glucose by cercariae may be incomplete (Ginereste). With temperatures of 10, 20, and 30°C, cercariae gave a progressive increase in CO2 evolution, while at 40°C a sharp decrease occurred. When cercariae were incubated in pyruvate and glucose for periods of 15 hours, proportional increases in labeled CO2 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, ---Page Break--- ---Page Break--- TRYPANOSOMA PROJECT 1. Effect of whole body irradiation on Trypanosoma rangeli infection in mice. “Is: how is the HOT haunt report Cnt wots tooyteradtatTon (500 RADS) administered to mice infected with f. cruzi produced greater parasitemia. There was extended organ invasion and death of the unirradiated at an earlier period than those non-irradiated. It was of interest to see whether similar effects were seen in mice inoculated with Trypanosoma rangeli, a parasite often found together with f. cruzi in human beings. New-born mice were divided into two groups, one receiving 400 rads, the second one without radiation. 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 a vaccine, a culture of T. cruzi (strain Bertoldo) was exposed to the Co^60 source. The cultures were diluted to the logarithmic phase of growth, and the doses administered were 100, 1,000, 10,000, and 50,000 rads. After radiation, the trypanosomes were inoculated i.p. in groups of 21-day-old mice; the medium was replaced by a new one and further incubated at 26° during 21 days, when the irradiation was repeated. In all, the different doses were administered 4 times at daily intervals. The mice were searched for trypanosomes in blood and when found, a hemoculture was made in liquid medium. Subcultures were made twice in Yaeger's medium and then titrated for virulence and infectivity in mice and tissue culture. Four weeks later, the mice were challenged by the i.p. route with 1,000 blood forms of T. cruzi (Tulahuen strain). (See table) The mice data seem to indicate that better protection can be obtained when the microorganisms have been subjected to frequent exposures. ---Page Break--- Twenty-four days after inoculation, mice were challenged with 50 ml of the cultures, they were with the trypanosomes, with 10^9 blood forms of the virulent strain. Concentration Infectivity Lethality Ratios: 2,000 2 2.26 x 10^7 6/6 1,000 2 1.82 x 10^7 1/6 3/6 10,000 3 0.81 x 10^7 4/6 50,000 3 2.12 x 10^6 2/6 0/5 5/5 4/6 6/6 1,000 2 2.06 x 10^7 2/6.

Of 6 36 26 6 of 6 6/6 5/6 6 20,000 R 2.85 x 10^7 Y's o/s 5/5 2/5 6 oe 6/6 3/6 5 i st 7 10,000 R 3.41 x 10^7 3/5 o/s 3/5 5/5 26 oe be 2 3. Sensitivity of T. cruzi-infected cells to sin. The metabolism of T. cruzi-infected cells is very different from those that are not infected. It is of interest to compare the metabolic pathways of normal and infected cells. It is necessary to obtain almost pure populations of both types. Cultures of cells were infected with a fluid medium containing 10^6 T. cruzi parasites. Starting the 4th day after inoculation, a set of 4 tubes was separated and treated for 2 minutes at room temperature with trypsin and with Hank's saline solution. This treatment was repeated at different time intervals with the following result: Rate of Infection by T. cruzi in Cells Treated with Trypsin TREATMENT Day. None 0.25 trypsin (0.12% trypsin 0.025% trypsin) 2.38 3.7% 4.66 2 3 3 38 56 1 12. 3.2 So 67 ---Page Break--- Further studies are underway 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. The effects of T. cruzi infection in different cell lines. Temperature is one of the factors influencing the growth. A preliminary experiment was designed to see whether other factors (type of cell, strain of T. cruzi) could play an important role. Dog cells (reported in FRC final report 1965) and monkey kidney cells were infected with T. cruzi cultures. The tubes were divided into two groups, one inoculated at 26°C and the second one at 37°C. Every 2 hours one tube of each group was removed from the incubator and examined microscopically for the presence of

Leishmania forms inside the cells, with the following results: Intracellular Infection in 2 Cell Lines Incubated THE OF CHS Monkey Kidney Cells Per Cell Day 26° 28° 30° 32° 34° 36° 38° 40° 42° 44° 46° 48° 50° 52° 54° 56° 58° 60° 62° 64° 66° 68° 70° 72° 74° 76° 78° 80° 82° 84° 86° 88° 90° 92° 94° 96° 98° 100° 102° 104° 106° 108° 110° 112° 114° 116° 118° 120° 122° 124° 126° 128° 130° 132° 134° 136° 138° 140° 142° 144° 146° 148° 150° 152° 154° 156° 158° 160° 162° 164° 166° 168° 170° 172° 174° 176° 178° 180° 182° 184° 186° 188° 190° 192° 194° 196° 198° 200° 202° 204° 206° 208° 210° 212° 214° 216° 218° 220° 222° 224° 226° 228° 230° 232° 234° 236° 238° 240° 242° 244° 246° 248° 250° 252° 254° 256° 258° 260° 262° 264° 266° 268° 270° 272° 274° 276° 278° 280° 282° 284° 286° 288° 290° 292° 294° 296° 298° 300° 302° 304° 306° 308° 310° 312° 314° 316° 318° 320° 322° 324° 326° 328° 330° 332° 334° 336° 338° 340° 342° 344° 346° 348° 350° 352° 354° 356° 358° 360° 362° 364° 366° 368° 370° 372° 374° 376° 378° 380° 382° 384° 386° 388° 390° 392° 394° 396° 398° 400° 402° 404° 406° 408° 410° 412° 414° 416° 418° 420° 422° 424° 426° 428° 430° 432° 434° 436° 438° 440° 442° 444° 446° 448° 450° 452° 454° 456° 458° 460° 462° 464° 466° 468° 470° 472° 474° 476° 478° 480° 482° 484° 486° 488° 490° 492° 494° 496° 498° 500° 502° 504° 506° 508° 510° 512° 514° 516° 518° 520° 522° 524° 526° 528° 530° 532° 534° 536° 538° 540° 542° 544° 546° 548° 550° 552° 554° 556° 558° 560° 562° 564° 566° 568° 570° 572° 574° 576° 578° 580° 582° 584° 586° 588° 590° 592° 594° 596° 598° 600° 602° 604° 606° 608° 610° 612° 614° 616° 618° 620° 622° 624° 626° 628° 630° 632° 634° 636° 638° 640° 642° 644° 646° 648° 650° 652° 654° 656° 658° 660° 662° 664° 666° 668° 670° 672° 674° 676° 678° 680° 682° 684° 686° 688° 690° 692° 694° 696° 698° 700° 702° 704° 706° 708° 710° 712° 714° 716° 718° 720° 722° 724° 726° 728° 730° 732° 734° 736° 738° 740° 742° 744° 746° 748° 750° 752° 754° 756° 758° 760° 762° 764° 766° 768° 770° 772° 774° 776° 778° 780° 782° 784° 786° 788° 790° 792° 794° 796° 798° 800° 802° 804° 806° 808° 810° 812° 814° 816° 818° 820° 822° 824° 826° 828° 830° 832° 834° 836° 838° 840° 842° 844° 846° 848° 850° 852° 854° 856° 858° 860° 862° 864° 866° 868° 870° 872° 874° 876° 878° 880° 882° 884° 886° 888° 890° 892° 894° 896° 898° 900° 902° 904° 906° 908° 910° 912° 914° 916° 918° 920° 922° 924° 926° 928° 930° 932° 934° 936° 938° 940° 942° 944° 946° 948° 950° 952° 954° 956° 958° 960° 962° 964° 966° 968° 970° 972° 974° 976° 978° 980° 982° 984° 986° 988° 990° 992° 994° 996° 998° 1000° 1002° 1004° 1006° 1008° 1010° 1012° 1014° 1016° 1018° 1020° 1022° 1024° 1026° 1028° 1030° 1032° 1034° 1036° 1038° 1040° 1042° 1044° 1046° 1048° 1050° 1052° 1054° 1056° 1058° 1060° 1062° 1064° 1066° 1068° 1070° 1072° 1074° 1076° 1078° 1080° 1082° 1084° 1086° 1088° 1090° 1092° 1094° 1096° 1098° 1100° 1102° 1104° 1106° 1108° 1110° 1112° 1114° 1116° 1118° 1120° 1122° 1124° 1126° 1128° 1130° 1132° 1134° 1136° 1138° 1140° 1142° 1144° 1146° 1148° 1150° 1152° 1154° 1156° 1158° 1160° 1162° 1164° 1166° 1168° 1170° 1172° 1174° 1176° 1178° 1180° 1182° 1184° 1186° 1188° 1190° 1192° 1194° 1196° 1198° 1200° 1202° 1204° 1206° 1208° 1210° 1212° 1214° 1216° 1218° 1220° 1222° 1224° 1226° 1228° 1230° 1232° 1234° 1236° 1238° 1240° 1242° 1244° 1246° 1248° 1250° 1252° 1254° 1256° 1258° 1260° 1262° 1264° 1266° 1268° 1270° 1272° 1274° 1276° 1278° 1280° 1282° 1284° 1286° 1288° 1290° 1292° 1294° 1296° 1298° 1300° 1302° 1304° 1306° 1308° 1310° 1312° 1314° 1316° 1318° 1320° 1322° 1324° 1326° 1328° 1330° 1332° 1334° 1336° 1338° 1340° 1342° 1344° 1346° 1348° 1350° 1352° 1354° 1356° 1358° 1360° 1362° 1364° 1366° 1368° 1370° 1372° 1374° 1376° 1378° 1380° 1382° 1384° 1386° 1388° 1390° 1392° 1394° 1396° 1398° 1400° 1402° 1404° 1406° 1408° 1410° 1412° 1414° 1416° 1418° 1420° 1422° 1424° 1426° 1428° 1430° 1432° 1434° 1436° 1438° 1440° 1442° 1444° 1446° 1448° 1450° 1452° 1454° 1456° 1458° 1460° 1462° 1464° 1466° 1468° 1470° 1472° 1474° 1476° 1478° 1480° 1482° 1484° 1486° 1488° 1490° 1492° 1494° 1496° 1498° 1500° 1502° 1504° 1506° 1508° 1510° 1512° 1514° 1516° 1518° 1520° 1522° 1524° 1526° 1528° 1530° 1532° 1534° 1536° 1538° 1540° 1542° 1544° 1546° 1548° 1550° 1552° 1554° 1556° 1558° 1560° 1562° 1564° 1566° 1568° 1570° 1572° 1574° 1576° 1578° 1580° 1582° 1584° 1586° 1588° 1590° 1592°

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also suggest that the principal factor affected by the temperature is the period of adsorption penetration. 5. High temperature effect on 7. cruzi infection at cellular level, Cp cells, Clone I, were inoculated with T. cruzi. After inoculation, and every 2 hours thereafter, 4 tubes without inoculum and 4 of the inoculated group were transferred to a 40°C incubator. After 7, 5, 4, 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 40°C. Neither showed growth. No intracellular parasites were observed even when the tubes were brought back to 37°C for further incubation. For complementing the experiment, 18 roller tubes were inoculated with 7. 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 to 37°C. The tubes removed from 40°C after 7 days of incubation had large amounts of trypanosomes, but those incubated longer were negative. To see whether those tubes had intracellular parasites, the cells kept at 40°C during 7, 8, 9, 10, and 22 days were trypsinized, gently ground in a tissue grinder and titrated in Cp cells. B ---Page Break--- Day After Inoculation showing Trypanosomes. DILUTIONS OF THE INFECTED MONTAYER. 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0. Day After Inoculation Showing Trypanosomes in the Medium Day After Inoculation Showing Trypanosomes. Brain 4 7 8 9 13 Spleen 4 4 7 8 9 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 Trypanosomes.

Crust infection in mice, Poly I.C., Inducer interferes as an antagonist. To determine whether the ester of the vet takes effect in by Trypanosoma cruzi, five groups of mice (29 days old) received some Green e1c; the 0.5 af Wn tip, route. Five groups of treated entities were controlled; one day later both groups were inoculated with the crust strain, in dilutions 10^2 to 10^6. Poly I.C. was administered 3 times a week for 2 weeks, in 1001 aon.

Effect of Poly I.C. on mouse lethality by T. cruzi dilutions of T. cruzi — 20-2103, 10^-4, 10^-5, 10^-6. Mice were 5/5 to 375. Mice without Poly I.C. 5/5, 5/5, 5/5, 3/5, 0/5.

A small degree of protection seems to exist in the group given Poly I.C. and further experiments are underway to ascertain if this is significant.

Effect of Poly I.C. on Trypanosoma cruzi infection in cells, a similar experiment was set up. A certain amount of 100; after 2 hours a titration of T. cruzi was made. The medium was changed 3 times a week and at these intervals, 100 µg of Poly I.C. were added. Observations were made daily by inverted microscopy.

Dilutions of T. cruzi: 10^-2, 10^-3, 10^-4, 10^-5, 10^-6. Cells + Poly I.C.: + + +; Cells No Poly I.C.: + + +. The effects of Poly I.C. on the growth of T. cruzi in vitro were studied. To it, medium, 10, 100, and 500 µg of Poly I.C. with T. cruzi was added and then inoculated.

Effect of Poly I.C. on the growth of T. cruzi in 100.

Growth + + +; Titer in cells/ml: 205, 205, 105, 105.

Adsorption and penetration of T. cruzi into cells: To determine the time necessary for T. cruzi to penetrate cells, the cells were grown on cover slips in Petri dishes in CO2. Once confluent, they were inoculated with 10^7 (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-f. 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 on the 7th day the coverslips were removed, fixed with methyl alcohol and stained with Giemsa. Number of Infected Cells in Monolayer Inoculated with T. cruzi and Washed at Intervals Thereafter. After 17 hours, cells were washed. 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. To test whether DC2 cell receptors were destroyed by T. rangeli, cells were inoculated with 10^7 forms from fresh medium and incubated at 37°C during different periods of time. The monolayers were washed 3 times with Hank's saline solution and then inoculated with 10^8 and 10^9 of T. cruzi with 2 tubes left as controls. The cells were incubated at 37°C for one week with medium changed every 2 days. T. cruzi in Cells Previously Infected Intracellularly by T. rangeli. To evaluate the crust infection: 10^8, 10^5, 2 of 10^5, 4 of 10^3, 10^5, and 5 of 10^7 were used. These results show that cell receptors are not affected by T. rangeli. Trypsin action on cell receptors. The medium of DC2 cell growth in roller tubes was changed and replaced by a new one to which trypsin was incorporated at a final concentration of 0.0025%. The cells were further incubated at 37°C and at different intervals inoculated with 10^7 T. 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 2. cruzi 'HOURS OF ACTION ° 2 2 2 fe) ape) ae GY 27 3; A Talis treated and inoculated Gelis treated Celis inoculated ---Page Break--- to trypsin action was observed on the cell receptors by the different periods, at least with this concentration. “ " Others 12. Resistance of 7. cruzi to temperature. To determine the resistance of 7. cruzi to different temperatures, blood of an infected mouse with a concentration of 32 x 10^7 parasites per ml was diluted 1/1 in Trogers

medium with 50 units of heparin. This mixture was divided into 3 tubes, one left in the refrigerator at 4°C, the 2nd, at room temperature (21°C ± 2°C), and the third one at 37°C. At different intervals, 0.1 ml of the blood was taken and titration made for 10^2 cells. The results: “Effects of Temperature on the Inactivation of 7. cruzi TSPRTRE Deve ko ate are 1 x 10^8 2 x is 16 3 205 18 108 é 10 is a 7 108 108 108 3 x if i % i 1 8 a 10° 10! 10° ‘The great resistance of 7. 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 7. cruzi infected cells by centrifugation to separate the various components of trypanosomal DNA started to separate the several components of trypanosomal DNA by gradient centrifugation in CsCl. 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. ---Page Break--- ---Page Break--- The irradiated inoculated controls were also included in the experiments. ‘The animals were bled daily. These animals were bled daily and the virus content of the blood was determined in | sin HT gos I rts te ep to ttn ih Sasa

Sec cee SBS Sn ale Starnes eae Marat nviandltetG thr wns oti ty ae eee sri nite ats ee are t ELS Sens ane iene, erat tetas entrain Sats hee Sree Sedair sas pate: Sacrierme at hater, Sere pte Se ay git teenies cit Seneca Sern ee ec Ey digs aecelein'is tien hater are en Se ic ee tee a a iets de Semeur So a Pl SEs SSN ee SP ae eas BE aie Fa ite cera fare Bes at SL SOE Latte, eS aoe a the irradiated animels. vanes S sisiowying & Results obtained with wild rats are very sinilar to those obtained previ- ously with adult white mice. Rate irradiated with 400 Rads and inoculated with virus shoved a significantly high concentration of virus in the blood fron the first to the Tth dey. Rats irradiated with 600 Reds and inoculated with virus shoved virenia on the 1st day which lasted for sore than 7 days. Although not gg.vezy high titer, virus aeons to pereiet longer in eninaie irradiated vith B, Activation of coxsackle virus by radistion, 1. In Adult Mice, A selected munber of mice of sintlar age (26-30 weeks) and weight average Of 22 grans vere divided into 7 groups of 26 mice each. They were irrediated as follows: Group I was kept as unirradiated control, Group TI vith 100 Rads, Group III with 200 Rade, Group 1V with 300 Rade, Group V with loo Rads, Group Vi with 500 Rade, and Group VII with 609 Rads. "Each Group was then divided into’ 2 sub-groups, each one containing 13 mice. One sub- Group was Kept_aa irradiated control and the other was imediately inoculated Ppaitn "796 1D50 suckling mice coxsackle ALO virus. At previously reported, ann sain in thie experizent, aninals that vere irradiated and inoculated with the virus shoved a virexia that lasted for several days, depending on the Faitation dose, No viral activity was found in the irradiated uninoculated group. After 16 days, aninals were bled again and no viral ectivity was found frthe blood, 22 days after irradiation and inoculation, no viral activity was found in the blood er in selected organs of aninals that were sacrificed. A second dose of irraitation (400

Rade 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 600 Rade. 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 serum took effect, virus was isolated from groups of mice that just previously had shown no virus in the blood nor apparently in any of the organs tested. Either the active virus had been present in very low concentration and was not detectable by our methods, or the virus, in a latent state, was activated

by radiation. ---Page Break--- It was a rat (Rattus rattus) from El Verde forest. In wild rats, only one animal showed virus in the body, diarrhea, and died two days later. The virus was isolated in 1969 from rats. In the same study, isolated by Rosenberg in 1905 from humans, were used in these experiments. This again indicates activation of latent infection by radiation. In the tissues of adult mice and adult wild rats: (1) a significantly greater incidence was noted.

Sane Stee ee oe bien, i ree oval we th Searels ee ian wre ing dition i lee hte jexcersneea ee used the Power strain of coxsackie virus) or to the fact that mr ae toca vis) orto ac Cat" etnies Heute ie i yo late ad a See cites ete, le Fem vr eerie sel eres 2 i le evga Inti TSNEY Ete Baro et tthe es Ace 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 vs by Lerslating Tp. 0.2 nl of'e vine allution containlag aof-¥ iso sucking nice on three occasions at T day intervala;" Inecatenes 2p eet Soa ice a gt utr, ee fo 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) Aamuntzed not irradiated; (2) immunized irradiated with 409 dale oes Smmuntzed Srradsated with 600 Rade, Hion-inmune aninals of the eee gee (3) algo divided into 3 groups to serve as controls; (1) noncinmure nat serge ean, {2 nonetmune trradiated vith 100 Rade and (3) non-tnmune Inradered ease + he aninals vere bled imediately after irradiation act actes t5 00 ---Page Break--- 'hours, wheroupon the animals vere sacrificed and several of the organs harvested and tested for the presence of virus. Coxsackie virus type Al vas isolated fron mice that were immunized and irradiated with 400 Rade, Io viral activity was found in the irsuntzed ant not irradiated, or in the not inmunized irradia fed, 'The aninals from vhich the virus vas isolated had denonstrated neutra Lseing antibodies, Here we have the case in which a virus poreiste in an Srenune host 2, Iasune Wowborn Rate, Nevborn rats inoculated i.e, with coxsackie virus type Aid'developed a very Intensive vizenia for 72 hours. After the virenia, the rats remained alive and after 18 days antibodies were recovered fron the ser, No active virus was found the

6th day. 'The mother of these newborns had no neutralizing antibodies. The rats were divided into two groups: (1) irradiated with 800 rads and (2) immune non-irradiated control. After irradiation, coxsackie virus was isolated from the immune-irradiated rats while none was isolated from the immune non-irradiated. ff viral and rickettsial diseases, Just as in some bacterial and fungal diseases, one attack almost invariably causes lifelong immunity; examples of these are smallpox, measles, mumps, polio, yellow fever, and epidemic flu. Most persons who recover from these maladies continue to have demonstrable specific circulating antibodies for many years afterward. One might account for persistent immunity on the basis of repeated contacts with the viral agents. On the other hand, this explanation does not account for persistent antibodies in persons who recover from yellow fever or typhus and then live for many years in areas where the disease is not endemic. It is often assumed in such instances that the agent persists in the recovered individual. In the experiments that have been described we have shown that the virus does persist in the immune 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 (Thesis of Mrs. Carmen Rivera). 'The effect of gamma radiation on the production of interferon (IF) by 20 day-old chick embryos induced by Newcastle disease virus (NDV) was studied. Embryos were treated as follows: Group I received no irradiation and no virus; Group II No Radiation; Group III 600 Rads; Group IV no irradiation and 0 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 plague inhibition test of Sinbis virus in chick embryo fibroblasts. Only small amounts of IF were produced at 48 hours in Group V. The allantoic fluid and the embryos of groups I, II, and III did not show TP at any of the time tested. The allantoic fluid and the embryos 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 60 and 120 units of IF, respectively. All embryos in Group IV died between 24 and 28 hours. Embryos in groups V and VI began to die at 48 hours. This partial protection could be related to the high concentration of IF present in embryos. Some complexed polynucleotides induced the production of IF, and 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 IF accessible to the ---Page Break--- ---Page Break--- 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-homogeneous L-77 reactor; (3) a cobalt-60 gamma irradiation post; and (4) high-energy neutron irradiators. The Reactor Division also operates and maintains all the auxiliary equipment associated with the reactor such as beam tubes, rabbit system, fuel element irradiator, 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 gamma 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 kilowatt 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 B.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. 103 ---Page Break--- ---Page Break--- ---Page Break--- ---Page Break--- HEALTH PHYSICS, The Health Physics Division, which deals with health and safety, 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 supplements the regulations; it contributes to PRIC's educational outreach programs. The services (see Table I) include consultation and supervision in all matters concerning safety and especially in radiation safety. To implement and

Enforcing safety regulations, the Division instituted regular safety inspections in addition to existing monitoring practices and established safety committees with members within each Division. Indoctrination 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: 1) 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 M.S. degree in Radiological Health at UPR, San Juan campus. This program 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 them were offered during the Fall Semester 1968. Four students were enrolled, two of them from Latin America. 4) Advice and supervision of student research theses. 5) Special training in Applied Health Physics, and 6) Basic research. Special emphasis was given this year in improving the PRIC safety standards and in developing the new program in Radiological Health. The progress so far in both areas is quite satisfactory. 107 ---Page Break--- TABLE I Moving services are offered by the Division to any other project at The following general laboratory safety recommendations include: a. Laboratory safety monitoring b. Calibration of radiation equipment c. Fire safety monitoring d. Consultation on matters concerning safety, especially on radiation & radioactive material handling e. Environmental surveillance f. Indoctrination of staff members in Health Physics, Industrial hygiene, g. Nuclear safety.

accident dosimetry + Industrial Safety and Fire Prevention. 1. Decontamination i. Waste disposal TTT and care The services of BOSS 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. González Martínez 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. New 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, and the system 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 emergency 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 improved. The program, except

For the film badge service, it includes regular radiation surveys at the wards and rooms used for patients with implanted radiation sources, advice and recommendations on radiation protection,

training in radiation protection for 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

Film Service to PRIC and BONUS for the year 1968:

Beta Gamma Neutron Total

Radiation Survey meters calibrated: 2 gamma 306 neutron % Total = 332

Area Monitoring Samples Analyzed:
a) sears
b) water
c) air

Environmental Surveillance samples analyzed:
a) water 48
b) soil
c) vegetation

Total 10 200

Review of questionnaires for reactor components 2h

Review of requests for use of irradiation facilities other than reactor:

Review of requests for radioisotope procurement:
Medical Dispensary - Total of cases seen:
a) minor accidents 28

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The new procedures for the procurement, production, and use of materials are being followed satisfactorily.

A new 4500 c4 60c0 source was ordered from ORNL to replace the old 60c0 source in Rio Piedras. A permit to transport the source was obtained from the Department of Transportation. The old source was transferred in Mayaguez and was placed in the reactor pool next to the gamma 7003. The gamma pool can be used as a new radiation facility for moderate dose rates. A special three-room storage building is being built behind the terminal, housing radioactive materials, flammables, and other hazardous materials will be stored there. The building will be ready in March 1969. Plans to construct a special irradiation room for the Texas Nuclear Neutrons Generator were made. The safety features for this room are being examined, and an emergency plan in case of any catastrophic event in Mayaguez was prepared. The plan, a general one, relates PRIC problems and

competencies to the surrounding community. Two committees were organized to deal with all safety problems. The committees have branches in Mayaguez and Río Piedras. The first consists of all Geston heads and one member from the Director's office. Through this committee, General safety policy and rules will be approved. The second consists of one brother from each division who has supervisory or technical background. Through the committee, follow-up of recommendations are implemented. Indoctrination of personnel is offered in two ways: first, through safety institutes in Mayaguez and Río Piedras in conjunction with the Labor Department of the Commonwealth 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 Río 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 the School of Medicine, Department of Preventive Medicine and Public Health (PMPH) 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 at UPR, Mayaguez; five were accepted in the Radiological Health program at 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 in San Juan, are regularly scheduled for students not specializing in the no ---Page Break --- Table m1 List of Students Name Country, Program of Course 1. Efigento Rivera Puerto Rico 2. Amalia Vélez Paradis Puerto Rico Doctorate in the Department of Biology, UPR-Mayaguez 1. Luis Rodríguez Ecuador M.S. in Radiological Health; Dept. of Medicine and Technology at UPR-San Juan 2. Ximena Aquiles Santana Colombia M.S. in Radiological Health Dept. of Preventive Medicine and Public Health, UPR-San Juan Daniel Torres Ortiz Puerto Rico M.S. in Radiological Health Dept. of Preventive Medicine and Public Health, UPR-San Juan 1. Heriberto Torres Castro Puerto Rico M.S. in Radiological Health Dept. of Preventive Medicine and Public Health, UPR-San Juan Agnes Wise Tarat M.S. in Radiological Health Dept. of Preventive Medicine and Public Health, UPR-San Juan Ignacio Valenzuela Mexico Applied Health Physics 1. Alice Ortiz de Caraballo Puerto Rico M.S. in Radiobiology 2. Michael Gileadi Israel 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 0 0 ‘ A. A. Flores Puerto Rico 5 5 5. J. A. Hegren Puerto Rico 5 6. R. Orta Allende Puerto Rico 5 7. T. R. Roarsuez Puerto Rico 5 8. A. L. J. Santiago Puerto Rico 5 9. R. Sánchez Valentin Puerto Rico 10. Jesus Léper García Puerto Rico ---Page Break --- The course covers topics such as the interaction of radiation with matter and the principles of handling instrumentation. A laboratory on Radiation Detection was included in all its aspects of radiation. 70% of Public Health aspects of radiation were emphasized. The course also included lectures from engineers. In addition, the "Maddolsotope Techniques" course offered four different sections. The students are engaged to work at a real research center.

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"adtshogial Dalen" van given fr Ne eae oe eet] it Research Status Genma-Rey Spectra Around the PRIC Reactor. Heriberto Cusbas. This work is sncouplatee 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 vere determined, utilizing themoluninescent dosinetry techniques. The date veil be Published as a PRIC report. ‘The New Progran In Radiological Health ‘The nev progran in Radiological Health is offered through the School of Public Health, which 4s considered by many leading universities in USA te be fhe natural environment for progran in Radiological Health~ All Cotes Sie {ron the Public Health courses are nev ones offered by PRNC, ant are specifically designed for the students of Radiological Healt The acadenic prerequisites for enrollment in the progran are a B.S, and 6 credit hours each of university level phyates, chenistey, bento act oat ‘The duration of the progran 48 one full year, incl nts of felt vent. etch SEE oe ettog 2 of tnd field practice was introduced since tt appears to be mane wen eee indents, "However, if there ie a future need for sore soplistirter teves (including thesis) a course can be offered to students who meen a soe career, | During the sumer the facilities of the Bloadicar Sita cons Ho Piedras are nade available for Hospital Piystea-ninted stuientar ates the

ne ---Page Break--- clear reactor and other facilities at PiCcMayagues are great and are available for students interested in studying paste in the stations and the country.” NE 4# strange according to the need ‘There is also a possibility for future expansion of the program so that it may serve as a core for an M.S. program in Radiation Biology and in Hospital. Most of the instruction is given in Spanish, (approximately 75%) with textbooks in English. This makes the program especially attractive for students from Latin America. 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 µM 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 µM. 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 reported when service of measurements were performed at the rainforest. The transpiration of tritiated water from the rainforest 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. ---Page Break--- Table IV List of courses offered for the M.S. Program in Radiological Health The Following are Required Courses! PRIC 501 Radiation Physics 2 PRIC 505 Radiation Chemistry 2 PRIC 510 Radiation Biology 2 PRIC 525 Radiation Effects on Animals and Humans 2 PRIC 520 Radiation Detection 2 PRIC 525 Radiation Dosimetry 2 PRIC 530 Radiation Hazards and Protection 2 PRIC 535 X-Ray Protection 2 PRIC 540 Decontamination & Waste Management 1 PRIC 545 Laws and Regulations on Radiological Health 1 PRIC 565 Basic Nuclear

Electronics 2 i FAPH 47 Environmental Health 3 I HMGH 5563 Industrial Hygiene and Industrial Accident Prevention 2 I Pik 50 Biostatistics 2 n FRNO 599 Field Practice 4 5 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 Chem. 221 Chemical Analysis 4 Chem. K65 Radiochemistry 4 Math. 152 Statistical Analysis 3 Math. 203 Mathematical Analysis 3 Math. 20 Mathematical Analysis 3 Math. 307 Ordinary Differential Equations 3 Net. 101 Introduction to Meteorology 3 Met. 103 Introduction to Climate 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 = Summer us ---Page Break--- 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 humidity was 60 percent. We cannot ascertain the exact correlation. Population exposure project. A study was undertaken on population exposure in Puerto Rico. Efforts were directed in measuring the gonadal dose to patients undertaking medical X-ray exposures. It was felt that this kind of exposure may be more hazardous to the public in Puerto Rico than any other exposure. The work was divided into two areas. Measurements of the exposure dose delivered to the patients during routine chest X-ray exposures were performed. The gonadal dose was then calculated. Secondly, direct measurements of the exposure dose and

the gonadal dose delivered to the patients during routine abdominal X-ray exposures was 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 were considered. The first part of the work consisted of data compiled throughout the western part of the island and included statistical variations. The results will be published as a PRNC publication. ---Page Break--- ---Page Break--- MARINE BIOLOGY The work in the Marine Biology Program at FRNC 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 shallow waters. The aims of the

program have not been changed in the last year. 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 radiological ecology 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 environmental 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, Y, Fe, Co, Ni, Cu, Ag, Zn, He, Al, C, Si, Po, N, P, Br, I, rare earths and U in rocks, soils, river and marine waters, 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 other spectrography. Measurements of concentration factors and turnover rates in selected organisms for given radionuclides in different forms. 3. Baseline marine ecology investigations. 14. Measurements 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 earth elements including river and marine water with sediments, and examining the hard and soft parts of marine invertebrates. ---Page Break--- 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 is 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 nearshore waters. A second area of study is on the south coast at Phosphorescent Bay in which 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 seawater for irrigation or drinking increases yearly and the use of nuclear

explo- Gives 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 some 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 cannot 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-90 and Cs-137 in sufficient quantities that man could be forced, to turn, in part at least, to marine sources of protein. Strontium-90 and Cs-137 are subjected to sufficient isotope dilution in seawater. Radionuclides like Cs-137, Co-60, Co-58, Pu-239, and Ru-106 could be introduced into estuarine and other nearshore areas by direct discharges runoff from rivers or by diffusion of contaminated ocean waters. All of these radionuclides are subject to rapid sedimentation in shallow waters and thus would be tied up in reservoirs of estuarine and be continuously incorporated into human food organisms of marine origin.

south fovrlon or Afvicn would also be trapped in cpclie sirenistion ayatens 0 tat hutldsup cf railonuelidee in the rush populations of sierkioe soa isn't sould occur with tine," Some molides would meserge raltosctive Govay and act be of Gensequence an Sontenionnta; ctbere, because of their theniea!' characteristic foul not be incorporated into food' vebe leading to mann At tenet onechelt of the ralfonuciider Listed above, however, have relatively Love snyeienl half 25008 tnd are eccunilated ty marine erganiens'to levels thet acy some contribute Significant radiation douee to populations aaing then te Foo" 'The more populated areas of the world, in general, border the major sess and oceans; man's principal point of contact with the marine environment is Ju '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 8 ---Page Break--- commercially important marine food animals, as well as the advite of otters Sneluding algae, mollusks, crustaceans and often Saeko sma of fe ogni of re mate Sp he sn sgl ihc Nene cs my ee fone ae cen teers ean Sees ere Saree ete nota coe te Rae, ere, ler een nameeec te tahaeae on ca ee Sei nt Halen it Sr at Se gence, Saari tier aie weer Sone ene ees imeem Sr oe oe a '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 affected mainly through their incorporation into fecal pellets by zooplankton with subsequent transport to the bottom. Significantly, all of these elements would exist as relatively insoluble salts in fecal 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, Ho, Ae, W, Sc, Re, Ca, Al.) Many of these elements, added to estuarine regions by terrestrial runoff, are precipitated or co-precipitated in areas of mixing of fresh and saline waters. Plant detritus in the bottom sediments of these areas often contains 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 basis 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 same system. ---Page Break--- ---Page Break--- DEVELOPMENT OF ANALYTICAL METHODS During the past year additional methods to original methods for neutron concentration analysis of water, plants, and animal sedimentary rocks and salts have been developed. For selective analysis of sediments, soils, and rocks may be done for strontium, potassium, iron, cobalt, and sodium in nine eagle tenant copper. Separation procedures for geologic samples using carbonate fusion followed by elution, adjustment of extraction with ammonium persulfate (APS) allows the analysis of copper, nickel, platinum, and cadmium with simple chemistry. A method for analyzing uranium content of biological samples of marine organisms has been developed utilizing neutron activation followed by chemical separation. Two hundred milligrams of irradiated (neutron flux 2 x 10^n/ex~/eee) fish is quickly dissolved and the uranium is coprecipitated with three 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 MeV photopeak of U-239 (1/2 23.5 min.) compared with that of a 2.10 µg uranium standard. The yield is about 90%. A method has been developed for measuring small amounts of silver in biological samples. Silver has been reported to be relatively volatile at ashing temperatures. In tests made on exoskeleton, muscle, gills, hepatopancreas, and gastrointestinal tract of spiny lobsters raised in sea water spiked with Ag^110m, however, the loss of this radionuclide from ashing at 550°C for 2 hours was less than 1%. In the analysis for stable silver one gram of biological ash is sealed, under vacuum, in glass capsules with alternate capsules containing 5 µg of Ag on low-ash filter paper. The samples and standards are irradiated.

for 10 days (60 hours). After a few days, silver carrier and a minimis amount of 6 203 18 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 TECH and precipitated as the sulfide which is washed with water and dissolved in boiling Riso. The solution is scavenged with ferric hydroxide, the precipitate rinsed and added to the supernatant and the pH adjusted to about 3 with HCl. The silver is extracted with dithizone in carbon tetrachloride. The sample is dried and counted for the 0.6576 and 0.0815 Ne photopes. Yield is determined by neutron activation of carrier silver. Total particulate and "soluble" zinc, manganese, and scandium in sea water may be analyzed with a relatively simple procedure. Twenty liters of filtered sea water (G05) are exchanged with 200 of "ai03" and carrier-free Zn, SEI CAT 6B" added for the determination of chemical yields. The sea water is scavenged with purified ferric hydroxide (100 ng Fe) at pH 9 during an 8-hour series. Half of the precipitate is irradiated 4 to 16 hours and allowed to decay for 3 weeks. The 0.6896 and the 1.1206 photpeaks of Sc are counted by coincidence spectrophotometry and compared with a 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 distilled water. One ml of the solution is irradiated for 4 minutes along with a 20y 6 Y comparator standard. The solution is scavenged twice with ferric hydroxide. The 0.6468 Ne photopeak is compared with that of the standard. Chemical yield is later determined from the results. The stable zinc-42 is analyzed by atomic absorption spectrophotometry and the yield is determined from the spike. a. ---Page Break--- Particulate zinc,

iron, manganese,

Calcium and strontium retained on micropore filters (pore size 0.45 μm) may be determined by atomic absorption spectrophotometry after ashing and dissolution of the samples. Fe and U 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 1000 psi 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 an appropriate volume and analyzed by colorimetry in an Autotechnicon analyzer. Tests of the accuracy of quantitative spectrography have been compared with analysis by neutron activation on sediment samples. The standard deviation of spectrography 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 spectrography and neutron activation have been started on biological samples. Development of methods for concentrating metals from biological material for use in 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 6293 by the marine chaetognath Sagitta setosa. No difference in uptake was observed in non-dividing cells under light and dark conditions, but dead cells accumulated twice as much ^60Co 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 on the effects of marine microbes in increasing the apparent uptake of Hg and other radionuclides in diatoms, marine benthic algae, and the clam 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 Amphistegina assemblage off the west coast of the island and include Amphistegina gibbosa, Archaias angulatus, Asterigerina carinata, and Rotaliella Fibsa. The distribution of these species totals the submerged Pleistocene reefs off western Puerto Rico with relatively high percentages of the organisms at two different levels representing submerged reefs and/or wave-cut terraces at 55 meters and submerged reefs at 85 meters depth. The dominance of this species in the relict reef fauna is an indication of temperatures colder than the present ones during the building of these reefs. The Amphistegina-benthonic foraminifera ratio is much higher if only gloconitized tests are considered, showing that the Amphistegina assemblage of the submerged reefs is older than the living assemblage. ---Page Break--- 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 the Caribbean and Pacific coasts of Panama and Colombia have been made. One of the principal factors causing differences in assemblages in the Caribbean appears to be that of local upwelling. During the studies undertaken 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 non-well-cemented grains, generally laminar. It lives in shallow waters. The new genus, Glaucoamina, 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 cemented grains, mainly of glauconite or calcite or combinations of these with other dark minerals, total carbon, hydrogen, and nitrogen content. In the leopard burying cottid (Hoore) and the copepod Pseudodiaptomus sinocerealis (Gonsalez) have been determined. Results show that the copepod contains 1.5% C, 6% H, and 11% N on a dry weight basis, and 30% O, 5.7% H, 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 minucerans; however, the ratio of the amount of C, H, and N to the organism's dry weight remains constant. The animal thus seems to be able to maintain a fixed percent 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 organism's 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 (e.g., 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 (e.g., calcium in bone or shell) and the other constitutes a trace element, the atom ratio frequencies are log-normal. BIOLOGICAL PRODUCTIVITY AND TRANSFER BETWEEN TROPHIC 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, Ne, Cu (for 20) C8) My Pei and Cov. The sea cucumber and starfish Asterias senegalensis eat the snail clans Tellina punicea and Milinia Fortoricen-‘ls. Preliminary investigations suggest a slight increase in the 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 influence 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.

Studies have been made on biological productivity in Phosphorescent Bay on the South Coast of Puerto Rico. One of the principal organisms in the Bay is the luminescent flagellate Gymnodinium bahamense. Plankton samples are also being collected in the Bay seasonally. 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 10^9 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 Gymnodinium, a culturing room with light source and temperature control has been constructed for raising the 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 catalyst elements will not occur.

during ‘the exponential growth phases. BACKGROUND MEASUREMENTS IN PHYSICAL,

CHEMICAL, ‘AND GEOLOGICAL, COASTAL GEOGRAPHY" 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 as 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 Se 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 Sc(OH)2* and SeP; 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 esc re ane ee eee gn ee eae ed on Tani Beach near the outflow of the Aiasce River have been serpeg celleied on tan seech pur te ctu fe, scFv be een hevacteriead by sire masts, fraeclwmt omen ae ums cert Ser lca ie ee re crater moe eS ah ---Page Break--- Collection of sediments for physical and chemical analysis were done and studies of pollen content in the water and sediments were i H of polten content in the water and sediments were determined as guide to a cooperative project in mathematical modeling has been started with zr, Aviva Gileadl, Department of nuclear engineering UFR tayapuety fn a cttort to develop methods for better pluming of field experiments, eeasire= ents and collections for use in defining the factors viien controh she use of the specific activity approach to predict hazards ‘Trex marine contamination with Faitomuclides, Gre model has been Geveloped for physical dilution of a plane source of Radionuclides introduced into a marine area with an upper mixed layer overlaying a well-defined pyenocline with a shear zone in between. A computer program has been written in which several variables may be altered, including the 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 yield determination have been made. Preliminary tests on the use of Sc as a tracer for yield determinations have been started. VISITING WESTGATORS eral visiting scientists worked with the Marine Biology Program during 1968, Financial and/or logistical support were provided for: Dr. Edward

R Tepline (Un 8, Naval Radiological Defense Laboratory, San Francisco, California), Tro developed a method and is measuring the amounts of palladium in sea water; we A "Gordon Pirie (Dept. of Geology, University of Wisconsin at Milwaukee) estimated 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. Gloosenko, an Oak Ridge Research Fellow at Florida State University, began phytoplankton cultures and investigated the impacts of mercury by phytoplankton; Hugo José Jiménez, a technician from the Delite 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.) started his thesis research on the distribution patterns of DNA in marine secret and; “Bests Tafelte and F. A. Cross worked on neutron activation analysis of marine organisms. Consultants visiting the Marine Biology Program during 1968 included Dr. Reiners Akin (State University of New York at Stony Brook), Dr. Bernard C. Patten (University of Georgia, Athens, Ga.) and Dr. Theodore J. Snyder (University of Rhode Island, Kingston). ---Page Break--- ---Page Break--- 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 tide of 1 Yunque mountain 2 Eastern 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 “mineral” or "biogeochemical" cycling studies); (3) and to study the basic biological 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 a 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.

CYCLING STUDIES

Over the past several years, there have been numerous tracer experiments to determine the 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 radioisotopes, as well as tritiated water. The quantity of stable elements in all major compartments was 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 underway. 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 ---Page Break--- Fig. 1, Schematic diagram of the tropical rain forest, showing storage compartments for isotopes (upper case letters: routes (lower case letters) important) and transfer of carbon. DET WOT DE TAN FEB WAR DR WAY GON TOL BO SEP Fig. 2. Rate of calcium movement through four transfer routes, on a monthly basis. Fig. 3. Rate of leaf fall on a monthly basis ---Page Break--- include: isotope movement from litter to soil; from epiphyll to leaf; and from passes 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 the 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. epiphylls.

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 the amount of calcium input into the system via rainfall and the 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 in itself 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. ---Page Break--- Fig. 4, Fig. 5. Fig. 6. 10 OF wowouaLs ol Fig. 7+ Fig. 8. : 3 : i Total amount of calcium input via rainfall per month minus total calcium loss via runoff. Specific activity of tritium in leaves of Dacryodes excelsa: function of days from date of injection of tritium into tree. General trends of ecosystem functions during secondary succession. Total population of tree species originating from seed.

After 15 in the radiation area, total information content in binary bits 130 ---Page Break--- Movement of isotopes through canopy trees, section, supporting portion of Fig 2, as the upward movement of isotopes through poise. To determine the rate of isotope movement through canopy trees, and to determine if the rate is affected by transpiration rate, the canopy tree was injected with a pulse of 137Cs, Sr, and O7Sr, simultaneously with a pulse of irrigated water. Preliminary content

indicates that upward movement of "vin," 88r, and 13Cs is very slow; 137Cs actually shows a marked downward movement through the phloem from the injection point. Stable Element Analysis of Ecosystem Components Concentrations of stable calcium, potassium, manganese, magnesium, sodium, copper, iron, cobalt, strontium, and cesium are being determined for the leaves, stems, roots, and litter, and exchangeable elements in the soil. Concentrations when multiplied times the mass of each compartment will give total elements in each compartment. Total quantity of elements in each compartment, when divided by loss rate for each element for each compartment, will give turnover time for the element in that compartment. Nitrogen Fixation by Epiphytes Dr. Joe Einstein and Mr. Michael Harrelson of the University of Georgia have determined unequivocally that certain algae and bacteria living on the rainforest trees have the ability to fix atmospheric nitrogen. The species with this capability that were isolated are species of the genus Nostoc. The isolated blue-green algae are species of the genera Heterocapsa, Bostrychia, Anabaena, and Calothrix. Specific Activity Approach Whether or not the specific activity approach is valid is one of the most important questions regarding the methodology of studies that predict ratios, important issues in ecosystems. The specific activity approach is based on isotope movement that the measurement of the distribution pattern of isotopes and the presence of stable elements in the organisms.

their environments. Ay Pe cay etict the approximate distribution patterns of introduced species. (1) that if the specific activities (activity isotopes of the "Sorg" gran of corresponding stable elements) of the ecosystem are of radioisotope per allowable specific activities for those elements 22 Tues youy (ar dm iniran food), no individual can obtain more than the allowable human body (or in human from these sources. While there is little doubt that the amount from feet sais valid for the tropical rain forest ecosystem, the second premise will hold. The answer will not be forthcoming, as the approximate of the model is completed. But loggings continue until the rates at which isotopes are leached from leaves and trees are taken up by vegetation. It seems likely that most, if not all, will decompose to background levels before reaching the equilibrium of the stable isotopes in the ecosystem.

SECONDARY SUCCESSION succession (967 Rain Forest Project Annual Report) has stated that secondary 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 excess radiation from sources 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 emitting source, the radiation was stopping if there was no further allotropic energy input into the system. But if large doses of radioactive debris are dumped in an area, the disruptive energy may persist in the ecosystem for hundreds of years, depending, of course, on the half-life of the isotopes involved. Therefore, the real key to understanding long-term disruptive effects 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 the 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 the 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 satisfaction.

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 0.5 feet high.

Fig. 11. Leaf Area Index. Fig. 12. Diversity structure in tree species of new vegetation after radiation. Slope is indicated in species per decade. Fig. 13. Relationship between the ratio of light at 800 and 675 millimicrons on the forest floor and leaf area index of the canopy.

The successional study is also a productivity study, and thus will contribute directly to the overall mission of the International Biological Program, which is among other things, to determine the potential productivity of all the biomes of the world. Dr. Carl Jordan, who is involved in the productivity portion of the successional study, is a member of the Tropical International Biological Program steering committee.

DEVELOPMENT OF TREE COMMUNITIES Last year, detailed analyses of forest community structures were being made, both in the radiation recovery area and in the surrounding forest. A new technique for portraying community diversity has been developed, utilizing the large quantities of data collected yearly in the radiation recovery area, and drawn also from insect diversity studies which span several years. Recent techniques of diversity study, employing information 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 continuum of successional states leading up to the natural 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 1968. Diversity is the relationship of numbers of species to numbers of individuals of a 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 different symbol and the individuals of the sample comprise the "message." Total information content is log(W) - log(n) where W is the total individuals and n 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, i.e., 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 has been 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 information, however, and gives better resolution of detail. In all vegetation studied, the rate has been found to be a more or less linear function of log W, with a single change of rate in passing from abundant to less abundant species. Deliberate or accidental inclusion of more than one category of plants, such as trees and herbs, will exhibit two break points; one for each value sampled from more than one habitat type usually causes the break to appear much farther out on the curve. Figure 21 is the log W versus cumulative species curves for the relation recovery area samples. The 1966 modeling curve suggests that two habitats, one sunny and one shady, were sampled. The community development pattern that has emerged from these studies is 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 an increase in the 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, H2O, applied as a spray to the forest floor. ‘Tritium was absorbed by direct contact and respiration by insects, snails, frogs and lizards. No 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 bio-elimination studies of zinc-65 in a natural population of the snail Caracolus caracolla moved into the second year, with resolution of some of the mysteries of the first year. Area of home range in this snail was found to be a function of age, increasing until the second year after sexual maturity and decreasing after that. Adult size, previously demonstrated to be independent of home range area, is likewise independent of age, shell diameter 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 years of age. Growth in the past two years places confidence limits of plus or minus two years on those estimates. Insect diversity studies involved research on the methods of obtaining ant

expressing diversity measurements as well as the clock, continuing the job of separating and identifying species of some of the poorly known groups. In some groups, the known fauna of the island has been more than quadrupled in this 35 ---Page Break--- ---Page Break--- 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 own focus on all species, and by comparison to the natural concentration, to produce a curvature of near relationship between the number of species and log number of individuals. High 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 trees, a measure which is prerequisite to modeling biogeochemical cycles since leaves are an important ecosystem compartment (Fig. 1). The theory behind the correlation is that the forest canopy is relatively transparent to infrared 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. EL 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. 137 ---Page Break--- 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). Significant differences at indicated error level Test for Difference in Composition Across

Species Understory, clean - - : Species Understory plus epiphytes : : - Species Canopy, clean x 3 : Species Canopy plus epiphytes - : Site Understory, clean o : Site Understory plus epiphytes : a Site Canopy, clean : : Site Canopy plus epiphytes : Clean-epiphyte Canopy ~ - Clean-epiphyte Understory 05 05h Canopy-understory Clean - wh Canopy-understory Plus epiphytes 6 = 5 ---Page Break--- Table 2 Rate of water input into ecosystem via rainfall Average rate of water input, month 3/un/season October, 1967 B November, 1967 B December, 1967 So January, 1968 3B February, 1968 aot March, 1968, 525 April, 1968, 20 May, 1968, 13 June, 1968 33 July, 1968, 19 August, 1968, 83 September, 1968 as Table 3 Water budget 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 139 ---Page Break--- ---Page Break--- PRNC PARTICIPATION IN THE US AEC “ATOMS IN ACTION' EXHIBIT IN LATIN AMERICA Since 1965 the Puerto Rico Nuclear Center has been conducted in conjunction with the Atoms in Action exhibit in Latin America. The Oak Ridge Associated Universities is responsible for the Exhibit Training Program and the USAEC operates a Technical Library as part of the Exhibit. The Exhibit provides information on peaceful applications of nuclear energy to persons of varying backgrounds. The general public is given guided tours of special displays which demonstrate the nature, applications, and developments of atomic energy. Students, scientists, and physicians are offered demonstrations, lecture courses, and supervised participation in research involving 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, PRIC, Mayaguez Campus. (a) Catalysis 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 -- Page Break -- -- Page Break -- Nuclear Plants in the United States - Congress of Chemical Engineers Dr. David W. Walker - Associate Scientist, PRIC. (a) Nuclear Bomb Engineering - Specific Developments in Technological Resources - University of Los Andes, Merida; (b) Series and Subsequent Applications of Nuclear Energy - Faculty of Agronomy, UCV; (c) Project for Maintaining the Deformed Per Central University of Venezuela Dr. Alec Grintzon - Associate Scientist, PRIC. (a) Radiation Sources - HVI0; (b) Use of Radiation and Education Sources in Research - Faculty, Central University of Venezuela. Dr. Robert A. Luse - Associate Scientist, PRIC. (a) Application of Nuclear Dispersion Techniques - Associate Scientist, PRIC. (b) Radiation Effects on Respiratory Systems - Tropical Medicine Institute, Central University of Venezuela. Mr. Hector Barcelé - Chief

Scientist, PRIC. (a) Non-Destructive Testing and Quantitative Analysis in Sciences and Chemical Fusion - Metallurgical Department and Chemistry Department, UCV. Mr. Juan Stiva - Associate Scientist, PRIC. (a) Nuclear Reactor Instrumentation; (b) Uses of Radiation Sources - Exhibits; (c) Radioisotopes in Research - Exhibit. PRIC 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. Subsequent analysis of free sugar, starch, and ascorbic acid will be continued by IVIC to make comparative studies in relation to non-irradiated samples. Samples from a two-week crop studies in Yuca 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 esculenta). Twenty-four-hour crop samples were irradiated. Since this is the first time work on this product is being done, doses from 10 to 100 krads were used. In this first phase, satisfactory preservation was obtained by irradiating the products with doses of 60 krads. The experience was repeated with doses ranging from 60 krads and 100 krads; satisfactory results were obtained and will be published as soon as the experiments are completed. Qualitative tests were made to determine the presence of iron, copper, tin, and ascorbic acid. ---Page Break--- Laboratory studies will be made subsequently by IVIC. Genetics studies in black beans (Caraota), genetics studies of radiation effects in this species were initiated by the Center of Aeronautical Investigation in Maracay. Dr. Pedro Obregón was in charge. Studies in Corn (Zea mays). Genetics studies of 3 varieties were initiated by the Canes and Renewable Research with Dr. Obregón in charge. Studies in Tomato (Solanum lycopersicum). This program was initiated in collaboration with GEV Experimental Biology School; Drs. Lule Torres de Mastil were in charge. Microbiology Dr. Eddy Varsausky from the Department of Microbiology of the School of Biology 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, Frevious studies had been nade epplying 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 serpentine, by the Center' of Agrononicel Resourch wit wects on the Island of Margarita, 200 kms, Pilot scale by Iiberating sterilized in oii enezuela's coast. The Center for Agrononical Research for went Project, will visit FRIC installations. Badiochent etry Peeberation of Molybdenum -_99, The Departnent of Muclear Chemistry at # Molybdenun-99 in collaboration he IVIC reactor vas used, as ell es ort roe facility, since part of the samples vere first subject to the eftecte of 'the gamma radiation and then introduced in the feactor' this Sree tfeeee of underway, Ghentetry fectatton Ettects in Petroleum Derivatives. Dr. Sergio Flores 42 in charge of tu project, Walsh coutists of stulying the' effects of game' reatersey effect of oxygen vas also studied. Anivets of crude petroleum fractions. The Serta Peaster opiaries 48 being made by the Departaent of Raturel Proms Uov's Faculty of Sciences. Brn ---Page Break--- RESEARCH ACTIVITIES IN ARGENTINA Tue sane procedure used to establish the FRUC progran in Venezuela was followed in Argentina. os cea eae ™ The progran vas given in the Tational University of Cérdoba, and at the Catholic University. ad ty of Cérdoba, and The Chemistry Institute of the National University initiated works in Biology and Biochenistry using radioactive isotopes, and vorks in Physics and

Chenistry in the Faculty of Engineering of the Catholic University. Five scientists from the FRNC participated in the Exhibit. Conferences in Cérdoba In conjunction with the research progran the PRIC personnel

offered 22 Lectures, with 621 attending: Me, Juan Silva Parra ~ Director, Research Program STEMS in Action Exhibits. [Reactor did Teutonic Flow Delay and its Influence in Reactor Control, at the Reactor Instrumentation, Power Faculty of Engineering, Catholic University of Córdoba at the Exhibit. Dr. José A. Custrinas - 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 Córdoba. 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: Chemistry preparation of tritium-labeled Sphingosine and Acyl Sphingosine Sphingosine and Acyl-Sphingosine stimulate the transmembrane S-Of-F elucidation and cerebroide. It is not certain whether these compounds act as catalysts or precursors in this stimulation. The tritium label will enable the investigator, Dr. Curtino of the Department of Biological Chemistry of the Institute or 145 ---Page Break--- investigation was started (Granted Sciences, to answer this question. This 8

Co ‘the help of Dr. José P. A. Castrillén of the PRIC Physical Science Division and now continuing. Biochemistry of the action mechanism of Phaeophytin (PHA) using radioisotope labeling to obtain information on the action behavior of a variety of Phaseolus vulgaris cultivated in Argentina. The experimentation was carried out by Profs Beatriz Fushecg de Rupilyili fulfilling part of the requirements for a doctoral degree. Iron-°9 and tritium labeled guanyline and uridine are used. Work now continues at the Institute of Chemical Sciences. on the halogenation mechanism of phenylacetaldehyde with n-halogenated compounds. The injection of labeled acid into animals deficient in a specific copper increases P incorporation into the messenger RNA of the liver. This increase may be the result of a change in phosphate pools, a change in phosphate permeability, or it may reflect a stimulation of RNA synthesis. It is possible to study this problem by using FP and tritium labeled orotic acid or iodine. Dr. Seferiz of the Department of Biological Chemistry of the Institute of Chemical Sciences is carrying out this study. Dr. Jorge Chiriboga of the PRIC Directors' Office assisted Dr. Seferiz during the exhibit. Pharmacology study of learning mechanisms using radioisotopes. This project in the field of experimental pharmacology was started by Dr. Oeinger of the Department of Experimental Psychology of the Institute of Chemical Sciences to provide experimental information for a doctoral dissertation for one of his graduate students. Briefly, the project consists of studying learning mechanisms in laboratory animals and making observations by using labeled compounds. Physics 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 TGS 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 Gonzalo of the PRNC, Nuclear Sciences Division assisted with this project. During the Exhibit, a Technical Program was also carried out and is described below. Dosigatris Staly of the gamma facility, two students from the Engineering College of the Catholic University of Puerto Rico conducted a series of experiments at the gamma facility, plotting isotope curves for different neutron sources and calculating actual activity, until experimental data was accumulated and a report was prepared as part of their degree requirements. Use of isotopes in hydraulics, two students from the Catholic University carried out a series of experiments with hydraulic systems utilizing isotopes. Relevant measurements flow charts and methods used by the students will be used to prepare a paper for the upcoming conference.

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OFFICE OF THE DIRECTOR

The Director's Office, in addition to its tasks of daily administration, is concerned with planning and coordination of programs: 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 PRIC. 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 a Latin American student to study here unless some supplementary funds are available to cushion these costs. Latin American interest in PRIC 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 UPR Medical School to Rio Piedras. The Director's Office, with assistance from a PRIC-UPR Medical School committee led by Associate Dean Dr. Conrado Asenjo, is studying the changing nature and needs of the interaction between PRIC, 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 PRIC 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. ---Page Break--- ---Page Break--- ---Page Break--- 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 lowland 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—area. Of particular interest was a visit to Hacienda El Pinal, 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 PRNC 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 seeds. Anticipated future research on genetic and physiological effects of fast neutrons will be coordinated with the international IAEA program in genetic and mutation breeding. In a program receiving financial assistance from USAID, 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. EARLY in May, PRNC 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. ---Page Break--- ---Page Break--- In August, PRNC scientists took part in a Special Seminar on Food Production and Economic Development organized by UPR in Mayaguez, and attended by food science and nutrition specialists from Latin America, Haiti, Trinidad, Jamaica, England and the U.S. In February and September, the PRIC Advisory Committee met for its

two-day annual review of the Center's activities. visitors sent: Numerous visitors from different parts of the world came to inspect PRNC's installations in Río 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 Osredvar 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, Monaco Ville in Monaco, observed our Marine Biology and Terrestrial Ecology programs. In April, Dr. Walter Seelentag, Chief Medical Officer, Radiation Health, World Health Organization, Geneva, and Dr. H. Eisenlohr, 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 IAEA Vienna visited our Mayaguez laboratory. We were particularly gratified to learn of a letter written by William C. Johnson, M.D. of St. Mary'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, 1968 Hon. Craig Hosmer Member of Congress, House Office Building Washington, D.C. Dear Mr. Hosmer: 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 occasion. Following my visit to Washington, I spent some time visiting at the Puerto Rico Nuclear Center there, in San Juan, Puerto Rico, ash ---Page Break--- ---Page Break--- As you probably are aware, this is a medical unit operated by th

Puerto Rico for the United States Atomic Energy Commission. “I primarily intere in the clinical radiotherapy, nuclear medicine and radiobiology section. The group of very excellent clinicians headed by Dr. W. 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-radiotherapists, 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 stone-related progress (of which I believe you are a member) should be rightly commended for their foresightedness 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, William C. Johnson, M.D. Reverend Dr. Ignacio Cantarell, Associate Division, was named Citizen of the Year for the city of Yauco for 267 by Junko Chitaber of Comoree. The award was given for Dr. Cantarell's level and scientific contribution to the community through the creation of the Institute of Modern Science in Yauco. The Institute offers a graduate program in nuclear science, leading to an M.S. degree, in which 29 states meet in the Nuclear Sciences. Mr. Kal Wagenheim, part-time correspondent for the N.Y. Times in Puerto Rico, joined PRIC on July 2 with the title of Editor. His duties include the writing, design, and production of the annual report and other PRI publications, as well as assisting Latin American PRIC staff members in Spanish-to-English translation of their scientific material. 196 ---Page Break--- APPENDIX ot

---Page Break--- 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) Owen H. Wheeler, Associate Director, Mayaguez, D.Sc., 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. Barceló, 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 John D. Weaver, Chief Scientist I. Terminated before Dec. 31, 1960. 158 ---Page Break--- Nuclear Science Division Julio A. Gonzalo Gonzales, Head, Chief Scientist I. Ph.D., U. of Madrid, (Physics) Florencio Vazquez Martinez, Chief Scientist II, Ph.D. U. of Madrid, (Electrical Engineering) Rev. Ignacio Cantarell, Associate Scientist I, Ph.D., U. of Santiago de Compostela, Spain (Nuclear Physics) Rupert A. Lee, Associate Scientist II, Ph.D., U. of London (Chemistry) Baltasar Cruz Vidal, Associate Scientist III, Ph.D., Harvard U. (Physics) Josefa Elica Trabal, Research Associate I, B.S., U. of Puerto Rico (Chemistry) Miguel C. Milo Villanarin, Research Associate I, M.S., U. of Puerto Rico (Chemistry) Jou M. Rivera, Research Associate I, M.S., 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 II, Ph.D., U. of New Mexico (Geology) Braulio F. Mercado, Research Associate II, M.S., U. of Puerto Rico, Mayagüez (Electrical Engineering) Houghton Chemistry Project Owen H. Wheeler, Head (See also office of the Director) Josefa Elica Trabal, Research Associate I (See also Nuclear Sciences Division) Maria Luisa McClain, Research Associate I, M.S., U. of Puerto Rico (Chemistry) Nuclear Engineering Division Donald S. Sasscer, Head, Chief Scientist I, Ph.D. Iowa State U. (Nuclear Engineering) Aviva B. Gileadi, Chief Scientist I, Ph.D., U. of Budapest (Reactor Analysis) Phillip Y. Osborne, Chief Scientist I, Ph.D., U. of California (Metallurgy) Eldie Ortle Minis, Chief Scientist I, Ph.D., Texas A&M College (Physics) Jose L. Garcia de Quevedo, Chief Scientist I, Ph.D., Duke U. (Physics) Knud E. Pedersen, Associate Scientist II, Ph.D., Iowa State U. (Nuclear Engineering) Kenneth Solerstron, Research Associate III, M.S., U. of Florida (Mechanical Engineering) Fausto Núñez Ribadeneyra, 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, Mayagüez (Nuclear Engineering) Brick Méndez Veray, Research Associate I, M.S., U. of Puerto Rico (Nuclear Engineering) **Terminated before Dec. 31, 1968** On leave as of Nov. 30, 1968 159 ---Page Break--- Physical Sciences Division Fealor Cobes, Head (See also Office of the Director) T. Harry Sonat, Head, Chief Scientist II, Ph.D., Purdue U. (Organic Chemistry) Jose Grinteony, Chief Scientist II, Ph.D., U. of London (Chemistry) José P. A. Castellón, Associate Scientist II, Ph.D., U. of Buenos Aires (Radiolabeling in Organic Chemistry) George A. Siapeon,

Associate Scientist for Ph.D. Lotre Dene U- (Chemistry) Siarien N. Tals, Associate Scientist for Ph.D.s, Wbingen U- (Organic Chemistry) Gerardo Moline, Veeny Research Associate Tiy WeSy, Netina Veet of Pennsylvania (Chemistry) Vanfred Boorhardt, Associate Scientist I, Ph.D. U. of Labingen (Chemistry) Foca Santana de Tiraloy, Research Associate 22, M8, 'The Puerto Rico (Chemistry) Radiation Chemistry Mec Grinizon, Head (See also Physical Sciences Division) George A. Simpson, Associate Scientist I, (See also Physical Sciences Division) Solid State Physics Program 'Andor 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 II, N.D., V. of Buffalo (Internal Medicine) Oscar Morales, Chief Scientist II, M.D., U. of Maryland (Endocrinology) Ato Ernesto Lanaro Chief Scientist I, M.D., U. of Buenos Aires (Nuclear Medicine and Endocrinology) Jyan Santiago, Associate Scientist I, M.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 Radioisotopes 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 I, M.D., U. of Zaragoza, Spain (Radiotherapy) Jeanne Ubiiad Villeneuve, Chief Scientist I, M.D., Universidad Nacional Autónoma de Mexico (Radiotherapy) Antonio Bosch, Chief Scientist I, M.D., Universidad Nacional Autónoma de Mexico (Radiotherapy) Guillermo González Cardenas, Associate Scientist II, M.D. Universidad Javeriana, Bogotá, Colombia (Radiotherapy) María M. Palacios de Lozano, Research Associate III, N.S.-y U. of Rochester (Radiation)

Biology) Zenaida Prias Monserrate, Research Associate II, M.P.H., U. of Michigan (Biostatistics) was before Da 160 a, ---Page Break--- Agricultural Bio-Sciences Division Robert A. Luse, Head, Chief Scientist I, Ph.D., U. of California (Biochemistry) Francis K. S. Koo, Acting Head, Chief Scientist I, Ph.D., U. of Minnesota (Radiation Genetics) José A. Ferrer Monge, Chief Scientist I, Ph.D., Louisiana State U. (Biology) David Walker, Chief Scientist I, Ph.D., Washington State U. (Entomology) Shrinivas H. Kanath, Associate Scientist II, Ph.D., U. of Bombay, India (Biochemistry) Horace D. Graham, Chief Scientist I, 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 Muñiz Oliver, Research Associate I, M.S., U. of Puerto Rico (Biology) Edith Robles de Irizarry, Research Associate I, M.S., U. of Puerto Rico (Genetics) Sugarcane Borer Project David W. Walker, Head (See also Agricultural Bio-Sciences Division) Victoriano Quintana, Research Assistant I, Radicology Division Frank G. Lowman, Director, Chief Scientist II, Ph.D., U. of Washington (Marine Biology) Stephen Walsh, Deputy Director Marine Biology Frank G. Lowman, Head, (See also Radicology Division) Donald K. Phelps, Chief Scientist I, Ph.D., U. of Rhode Island (Marine Biology) Robert Y. Ming, Associate Scientist I, Ph.D., U. of Washington (Fisheries Biology) Steven S. Barnes, Associate Scientist I, Ph.D., U. of California (Chemistry) Sohn H. Wartin, Associate Scientist I, Ph.D., U. of Rhode Island (Biological Oceanography; Zooplankton) Stephen H. Walsh, (See also Radicology Division) Henry L. Beoselievze, Associate Scientist I, B.S., U. of Puerto Rico (Physics) Allan G. Gordon, Research Associate II George A. Siegli■, Research Associate II, M.S., U. de la Habana (Geology) Paul Mein Becalera, Research Associate II, B.S., U. of Puerto Rico (Physics) Russell W. Davis, Research Associate I, B.A., Inter

American U. (Chemistry) Hosa Julia Santiago, Research Associate 1, H.S., U. of Puerto Rico,

Mayaguez (Health Physics) Terrestrial Ecology Program 1 - ‘The Rain Forest Project Jerry R. Kline, Head, Chief Scientist I, Ph.D., U. of Minnesota (Soil Science) Frank G. Loman, Head (See also Radiobiology Division) Asl F. Jordan, Associate Scientist II, Ph.D., Rutgers U. (Botany) George Drewry, Associate Scientist I, Ph.D., U. of Texas (Zoology): “Wierainated before Dec. 31 1908 *#0n leave as of July 31, 1968, 161 ---Page Break--- Administration and Services Luts B. Boothby, General Administrative Officer Rann Mufds, Jr. Administrative Officer II ‘Yuan Lopea Rodriguez, Administrative Officer I Telida Banuchi de Gones, Administrative Officer T Pedro Velez Mendoza, Administrative Officer 7 Technical Services Héctor M. Barcelé, Head (See also Office of the Director) Sre cers tng, Davros 3 ater mn tne ee Tay yatrce Saprsor Mayenne: ‘Alfredo Carmona Trutten, Electronic Technician Supervisor Heleon Quifones, Technical Supervisor Victor Lequerigte, Scientific Glassblower Vicente C. Santiago Batis, Research Associate II Jean M. Dietsch, Reproduction Section Supervisor Gernan Gaztanbide, Reproduction Section Supervisor Medical Sciences and Radiobiology Division Jorge M. Chiriboga, Head (See also Office of the Director) Sayaond A. Brow, Chief Scientist II, Ph.D., California Institute of Technology (Physical Chemistry) Raniro Martinez Silva, Chief Scientist I, M.D., of Santiago, Spain (Bacteriology; Pathology) Silvestre Rodriguez de Oguondo, Research Associate I, M.S., U. of Puerto Rico (Biochemistry; Nutrition) Lawrence S. Ritchie, Chief Scientist I, Ph.D., Northwestern U. (Parasitology) Roger Rano’ Aliaga, Research Associate I, Licentiate, U. of San Marcos (Chemistry, Pharmacy) Caren Rivera de Canjos, Research Associate I, B.S., U. of Puerto Rico (Biology) Mirta Toro Gonzalez, Research Associate I, M.S., U. of Puerto Rico (Microbiology) Victor A. López Santiago, Med. Res. Technician II in Virology and Tissue Culture Sera

Jean de Jesús, Ned. Res. Technician II in Virology and Mouse culture Ina Hlena Torres de Vázquez, Ned. Res. Technician 12 in Virology and Mouse culture Sehistoron cansont Project Jorge Chiriboga, Head (See also Office of the Director) Laat (See also Medical Sciences and Radiobiology Division) sTnuetin de Baueay Hels Mes, Technician 2 in Virology and Mouse culture Felix Liard Bertin, Research Assistant II eae we vefore Des. 31, Ip 162 ---Page Break--- Program Jorge M. Chiriboga, Head (See also Office of Julio 1. Colén, Associate Professor in Virology, Mirta Toro Gontidler, Hegourch Azouckate 1 (con also Hutlontolocy Division) Carmen Rivera de Cuxpos, Heanarch Aenociave I (Hulloviolory division) “Genoveva M. de Unplerre, Research Associate Zy Mayucten (Biology) Reactor Division Richard Brown Campos, Head, Chief Scientist U. of Puerto Rico Poiro Cruz González, Reactor Supervisor, £.3-y 4. of Puerto Rico (Health Physics) Lorenzo Rosa Graniel, Chief Reactor Operator Miguel A. Rodriguez, Nuclear Reactor Operator 22 Hirun Ojeda, Nuclear Reactor Operator Joan Curios Alenuiy, Nuclear Reactor Operator 22 Bigfredo Torres, Nuclear Reactor Operator 22 Juan Jesús Pérez Muñiz, Nuclear Reactor Operator I os Divis: Health 8 jevoulakis, Head, Chief Scientist U. of Michigan (Health Fu Heidi Pabén Pérez, Associate in Health Physics U. of Rochester (Health Fernando Vallecillo, Associate in Health Efigenio Rivera, Associate in Health Physics! Michael Gileadi, Health Physics Assistant I wirian H. Vega Soterstros, Health Physics Ao Peter A. Par "ntons in Action" Project ‘Fausto Matloz Ribadeneira, Head, Research Associate I Us of Puerto Rico (suet Juan Silva Parra, Head, Research Associate: Wereinated before wetransferred to Nuclear Engineering on March 1, 1968 163 ---Page Break--- PAPERS PRESENTED Berrfos-Durin, L. A. ~ See Ritchie, L. S. Castellanos, J. - See Weisz, 8. Z. 4 Effects of Irradiation ~ Chiriboga, J.) Colén, J. Is, and Martinez Silva, R., Effects Chen cee the Beetntette inst’ tn Relation to Its Resistance Against Schisto- nsont, presented

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Arastrong, University of Calgary, Aqueous Sulfur Compounds, August 8, Dr. Roger Pedersen, Yale University, Specific Gene Multiplicity: The Ribos Cistrons, August 30. Dr. Raymond Brown, A System for Studying Immunological Phenomena, September 6. Dr. Julio A. Gonzalo, Critical Behavior of Ferroelectrics, September 13. Dr. Rodrigo Fierro, National Polytechnical School, Quito, Ecuador, Biology of the Andean Man, September 20. Dr. Walter Stahl, UPR School of Medicine, Leptin Chicleros, September 27. Dr. José P. A. Castrillén, Relación Entre Estructura Química y Extinción en el Centelleo en Fase Líquida (Relation Between Chemical Structure and Extinction in Liquid Phase Scintillation), October 1. Dr. Carl F. Jordan, Tritium Movement in the Tropical Ecosystem, October 11. Dr. Walter Katz, National Institute of Endemic 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. Rubén Pérez Tanayo, Ellis Fischell 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. Fermín Sagardía, UPR School of Medicine, Comparative Studies on Glycogen Phosphorylase from Crab Muscles and

Yeasts, December 13. WEEKLY SEMINARS, MAYAGÜEZ 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, February 16. Dr. George Bonski, Instituto Venezolano de Investigaciones Científicas (IVIC), Caracas, Faranegnetion.

in Hemoglobin, February 2. Dr. Robert Kleinberg, Magnetic Structure Determination of CoCl*6H2O, March 2, Dr. Allan Maccoll, University College, London, Ion Molecule Reactions, April 8. as ---Page Break--- 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 D2O 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, GeSeO2,757¢p,a5--A new Semiconductor, May 13. Mr. Mario Saca, W Value Determination of Fluorophores, May 27. Dr. Gabriel Chuchant, Instituto Venezolano de Investigaciones Científicas (IVC), Caracas, The Effects of Amine Groups in Aromatic Electrophilic Substitution, May 10. Professor D. R. Wiles, Carleton University, Ottawa, Canada, Recoil Reactions in Arene Metal Carbonyls, July 15. Dr. H. As Gersch, Oak Ridge Research Participant, Georgia Institute of Technology, 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. Glooshenko, Oak Ridge Research Participant, Thermal Pollution-- A Problem to Aquatic Life, September 11. Dr. Werner Fiatla, University of Puerto Rico, Neutron Reflection, September 16. Dr. Jack Chernick, Brookhaven National Laboratory, Reminiscences of a Brookhaven Scientist, October 21. Dr. Flavio Padovani, Louisiana State University, Isolation Characterization and Partial Purification of the Sex Ratio Factor in Estigrene acrea (Drury), November 6. 176 ---Page Break--- 961 soquerdog Texte eae « Tate i ¢ esto "8'Oo TOL eon oe of OR zB 6 ssazisio *S'rexolt 001 “ ° . z SET z T 3 = ‘ions t z 8 : orrandeg qusy povTen i g : a S S : : E : : es : é 3 : g i : 5 i & z S : 8 2 ug 8 : Doro 2 log i ne: i 8 oe

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