PRNC121

PRNC-121

GENERAL, MISCELLANEOUS; AND

PROGRESS REPORTS. (TID-#500)

PUERTO RICO NUCLEAR CENTER

ANNUAL REPORT 1967

OPERATED BY UNIVERSITY OF PUERTO RICO UNDER CONTRACT

NO. AT (40-1)-1833 FOR U. 5. ATOMIC ENERGY COMMISSION

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erations Office, who

the contract

blished PRNC, to

under contract

niversity of Puerto

oday Dr. Bonilla is

the Chemical Engi-

ing Department at New

York's Columbia University:

Or. Bugher is on the USAEC'S

General Advisory Committee.

Dr. Gomberg receives a plaque commemorating PRNC'S

VOth anniversary from Mr. Sapirie.

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INTRODUCTION

Though an annual report's key purpose is to describe activ-

ities during the previous year, the fact that 1967 marked the

tenth anniversary of the Puerto Rico iuclear Center merits a brief

review of the past decade.

Looking backward ten years offers a valuable perspective of how PRNC has grown, both in size and scope. With its origin in President Dwight D. Eisenhower's "Atoms for Peace" proposal, has matured since its founding in 1957 as a training center operated by the University of Puerto Rico under contract with the US ABC to what is now a full-fledged teaching and research institution. PRNC's small staff nucleus in 1957 bas since grown to over 300 scientists, technicians, and supporting personnel.

Much has been written about Puerto Rico's value as a ?cul~ tural bridge? between the North and South Anerican continents. PRNC offers a suall, but affirmative example of how this "bridge" can work. It is a bilingual institution, where scientists and students from the Spanish- and English-speaking nations of the hemisphere can work together without language barriers.

?The scientific staff has a distinctly international flavor, with a strong contingent of [atin Americans. About one-third of its scientists are native-born Puerto Ricans. Another third are fron South and Central America and other nations of the world,

and the other third are North Americans.

PRNC has not neglected growth in the educational field, which

is where it had its beginning. Fifty-nine students were trained during the first year of activity, nine of then non-U. 8. citizens, with a major share of the U. 8. citizens being native-born Puerto Ricans. In 1966, the student enrollment had grow to 173 (includ ing 32 non-U, S. citizens), and in 1967 enrollment reached a record level with 2% students (including 37 non-U. 8. citizens). In all, PRNC has trained 1,74 students, 251 of then fron abroad, representing 18 different atin American republics and other nations such as Japan, Germany, Spain, South Africa, India, the Philippines, Formosa, and Great Britain.

Perhaps the most dramatic change over the past decade, however, has been PRNC's expansion in scope; its research activities in the peaceful applications of nuclear energy are now as important as its efforts in education and training.

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?Today, biological and medical research programs include vork in marine biology, terrestrial ecology, radiation chenistry, parasitology (investigation of Schistosoma mansoni, a tropical parasitic organisn which causes Bilharzia) and entomology (tropical Insect sterilization studies of the sugarcane borer). Physical research is being carried out in neutron diffraction, solid state physics and hot-aton chemistry. A preliminary study is in progress

on the effects of mining with nuclear explosives and, in the field of isotopes development, PRNC researchers are examining the effects of radiation preservation of various tropical foodstuffs which are vital to the economies of Latin American nations.

The growth of research activity at PRNC is reflected in its publication output. Its staff produced 52 scientific publications last year, more than half the anount produced in the entire six-year period from 1957 through 1953.

?A major expansion of facilities at the Puerto Rico Medical Center in Rfo Piedras is another manifestation of PRC's growth. Construction of an entire new wing, costing over $1 million, is to begin in 1958, with completion scheduled for mid-1970.

?The tenth year marked an important milestone for PRNC. It brought with it several gratifying instances of recognition. PRNC was selected to carry out the marine ecology studies in pre-paration for a proposed new sea-level Isthms of Panama Canal. It decane more active in helping the development of peaceful muclear techniques in Iatin Anerica through its ?sister laboratory" progran with Colombia's Instituto de Asunto Mucleares, and by expanding its sponsorship of research in the US ABC atin Anerica Exhibits Program. Also,PRNC was designated by US ABC Chairman Seaborg as a regional "center of excellence" under the Punta del Este program of scientific cooperation with Iatin Anerica.

And finally, the 10th Anniversary Synposiun in October 1967 drought together distinguished scientists and goverment officials from all sectors of the henisphere. It vas a stimating event, fa source of inspiration for even greater achievenent in PRIC's second decade of life.

wee

We are pleased to announce that during 1967 the eninent chenist Dr. W. 0. Baker, Vice President for Research, Bell ?Telephone Iaboratories, accepted PRIC's invitation to join its Advisory Committee. This now completes the eight-nan conmittee (see Appendix for the full roster).

---Page Break---

Dr. Jesse D. Perkinson, Chief of OAS Division of Science Development, speaks. At left Ben S. phansky, Deputy U. S. Representative to the

: US AEC Commissioner

and IAEC Director

Eklund. Above

Professor George

University of

Right: PRNC

stant Director for

entific Programs,

Jorge Chiriboga,

of Peru.

---Page Break---

Teodoro Moscoso, Board Chairman of Commonwealth Oi1

Refining Company (and former Director of the U. S.

Alliance for Progress), speaks on "The Development

uerto Rico.?

Dr. Juan J. Touya,

nical director of

College

Montevideo, Urugu

Dr. Antonio Bacigalupo,

head of the Department

of Zootechnics and Ani-

mal Nutrition, Agrarian 1

University, Lima, Peru. vice in Mexico C!

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Educational and Training Divisions

Nuclear Engineering ....sssssess 2

Physical Sciences .... eeeeeneenal ca)

Clinical Radioisotopes Applications .+++++e.e++ 3h

Radiotherapy and Cancer . aa

Agricultural Bio-Sciences s..sssssseeeeeeeees

Medical Sciences and Radiobiology ....

Reactor .

Health Physics

Office of the Director

PRNC participation in the US AEC "Atoms in Action" exhibit

in latin America .....+++

Biological and Medical Research .

Marine Biology .....+

Terrestrial Ecology Program I: The Rain Forest

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EDUCATIONAL AND TRAINING DIVISIONS

The educational and training divi-

sions (also known as the 11 Program) of-
fer training and research opportunities
in the nuclear field for students at the
graduate and postgraduate levels. The
divisions either carry out individual
phases of the training and research, or
provide guidance and support. This area
of PRNC activities, which represents
about two-thirds of the overall program,
is sponsored by the United States Atomic
Energy Commission (US AEC) Division of

Nuclear Education and Training.

---Page Break---

Graduate students of Physics and Chemistry doing ex-
perimental work in ferroelectrics for their masters
thesis, with Or. J. A. Gonzalo. Below: Discussion
of low temperature equipment us =ray sources

in radiation effects studies. Let ae
P. Paraskevoudakis, B. Cruz, H. G
Vazquez.

---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 Muclear Engineering and Electrical Engineering as well as for pre- and post-doctoral students of other universities interested in working at PRNC,

A _US AEC grant for research in "Hot-Atom Chemistry" and National Institute of Health grants for research in "Radiolysis of Peptides" and "gmthesis of ?Thiasteroids" have contributed to expand the chemistry program. Equipment has been acquired for gas shock-tube experiments, for work in mass spectrometry of volatile compounds, and for the study of electroreflectance in semiconductors. A special facility for handling radioactive iodine was built.

EDUCATIONAL ACTIVITIES

Graduate Courses

During 1967 the following five graduate courses were taught

by FRNC personnel, with academic credit given by the UPR:

Course Professor Enrollment

Chemical Kinetics Dr. Oven H. Wheeler 3

Solid State Seminar Dr. Julio Gonzalo 2

Radiochemistry Dr. Rupert A. Lee 3

Sle tmctronies Drs Florencio Wess

Advanced Electricity \

and Magnetism Dr, Baltazar Cruz

---Page Break---

Thesis Research

Sixteen graduate students from Puerto Rico, Colonbia, and

El Salvador are doing thesis research under Nuclear Science Di-

vision staff supervision:

Thesis Title

?A physico chemical stuly

of the Chapman rearrange-

Bffect of gamma irradia-

tion on essential of;

Synthesis of thiosteroids.

Radiolysis of peptides.

Recoil labeling of aromatic compounds with halogen atoms.

Reactivity of cyclic ketones.

Neutron activation of aromatic iodine compounds.

Ferroelectric properties of the alkaline selenites,

Radiation damage in KDP and ADP single crystals.

High frequency behavior of antiferroelectric ADP.

In-pile radiolysis of hydrogen chloride gas.

Leaching of copper ores,

The effect of radiation

on fluoroform.

Student:

Fernanda Ronin

Elba Diaz

Wilfredo

Rodriguez

Dolores Julién

Hilda Lépez

Rosita Béez

de Felit

Carmen Lecunberry

Inis Carlo Nifio

Ivan Nazario

Mario Beauchamp

Iais Rivera

oycla

Samel Rodriguez

José Mario Saca

Dr.

Dr.

Mrs

O.H. Wheeler

Wheeler

OH, Wheeler

0.H. Wheeler

Wheeler

0.H, Wheeler

J.A. Gonzalo

J.A. Gonzalo

J.A, Gonzalo

RA, Lee

Fausto Muiioz

RA, Lee

---Page Break---

Thesis Title Student Advisor

Color center energies of José Casts Dr. I. Cantare?

8 Castro + Te Cant

alkali halides. (inst. of Modern Sciences) ?

The effect of incident Fernando Diaz Dr. B. Cruz

photon energy on RbBr and

KCl crystals.

Electroreflectance on Ge, Julio Marrero Dr. Fs aa

Si, MepSi, NecGe semi- ms

conductor crystals.

Oak Ridge Research Participation Program

Dr, Herbert 9. Verter, Head of the Chenietry Department at Inter-Anerican University, San Gein, Puerto Rico, spent. the sumer in the Division as an Oak Ridge Research Participant doing work on the synthesis of radiopharmaceuticals labeled with iodine~ 132. Dr. LA. Fel of the UPR Chemistry Department in

Mayaguez was given an ad honoren appointment to ccllaborate in this investigation.

Doctoral Research

?wo staff members successfully presented their doctoral dissertations. Dr. Baltazar A. Cruz received his Ph.D. in Physics from Harvard University (May 1967). His thesis research vas on "F Center Formation at 78°K in KBr During Exposure to Monochromatic X-ray Energies Around the Bromine K Eage." Dr. Rupert A. Tee obtained his Ph.D. in Chemistry at London University

(June 1967). His thesis research was on "Radiolysis of Gaseous Hydrogen Halides."

Plowshare Training

Mr. Jaine Ronin, M.S,, Assistant Professor in Analytical Chemistry, University of Rierto Rico at Mayaguez, and Mr. Carlos Ortiz, graduate student, spent the sumer developing methods for the analysis of copper in minerals to initiate the Plowshare study of mining with nuclear explosives.

RESEARCH COMPLETED

F-Centers Formation in KBr using Monochromatic X-rays =
B. Cruz (Ph.D. Physics, Nay 1967). In KBr irradiated at 78°K the rate of formation of F centers per unit energy retained in

---Page Break---

the crystal was found to be the same whether 13.4 keV or 2.2 key was the incident photon energy (the K edge of bromine is at 13,5 kev). At either ineident photon gnerey the energy expenditure per F center formed was 1.21 x 109 eV 24.4%, This result indicates that K shell ionization in bromine does not affect the mechanism of formation of F centers in KBr. However, a large

?dackground of multiple ionized atoms is expected whether the incident photon energy is 13.4 keV or 1H.1 keV. Each of these atoms becomes miltiply ionized after losing an electron in the

L shell. Thus, in a bromide the equality of the rate of formtion of F centers above and below the K edge is not sufficient evidence to conclude that a Varley mechanism of F center formation is not operative. Each of the monochromatic beams was at the fluorescent output of RbCl filtered with a thin layer of NaBr or of Sr(N03)o filtered with RbCl. ?The output of a Machlett X-Ray ?Tube operated at 45 kv was used to excite the fluorescence, The current in the tube was regulated to achieve the same energy flux on the sample regardless of the incident photon energy. An air ionization chamber was calibrated with a calorimeter and was used to measure the flux. The half-width of each monochromatic beam was 330 eV. Measurements of the energy expenditure required to form one F center vere: for KCL at, 76°K, 6.9 x 102 ev * 4.2%; for KBr Srradigted at 300°K, 4.8 x 103 ev 2 5.7%; for RbBr at 78K, 1.2 x 109 eV #174; and for RoBr at 300°K, 1,3 x 103 eV

* 30%.

Radiolysis of Gaseous Hydrogen Halides - R.A. Lee (Ph.D. chentstryy Sane TST on ai yea aE ad aod 4.7 have been measured for the radiolysis of pure gageous hydrogen chloride and hydrogen bromide, respectively, using 60¢o ganas. These yields,

together with the W values for HC1 (24.8 eV) and HBr (24.4 eV) obtained, lead to calculated G-values of 8,3 and 9.6, respectively. ?he effect of the scavengers bromine and sulphur hexafluoride on the radiolysis of the two gases revealed that there are at least two hyfrogen forming species present. One of these is a "thermal" hydrogen atom which may or may not have the elec tron as its precursor; the other is a "hot" hydrogen atom which cannot be scavenged. the results with chlorine as scavenger on the HCL radiolysis brought out the. importance of back reactions ?taking place as the concentration of chlorine builds up during the irradiation of pure gaseous hydrogen chloride. A study of the effect of an applied electric field during the radiolysis of the tyo gases shoved that reactions involving the reccnbi~ nation of ions were unimportant as a means of produe: open This study has shovn that dissociative exeitational Reseased

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fare as important as tontzation precesses in the aecompost hese two hydrogen Dalides. The Tr neleculos apres to unores ive excitational proc: i. ° etsanetats Procesees nore readily than the ic)

Radiation damage af 1 <te in 10S and Roche: -

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Raver RAs Tad paniamrta Ne teicT ce eee oe oe ee aed

tion on triglycine sulfate and Rochelle salt was carried out.
The investigation was extended up to relatively high doses, in
order to ascertain whether the reported drastic decreases and
disappearance of the hysteresis loops and the well-known blurring
of the peak in the dielectric constant ves tenperature were Te-
lated to the destruction of ferroelectricity itself in the
crystal, or, rather, to the progressive masking of ferroelectric
Churacteristioe by the presence of @ large accumulation of radla-
tion-induced defects in an essentially ferroelectric environment.
Present experiments included measurements of the temperature
dependence of hysteresis loops and dielectric constant at in-
See nte eee the irzacuation doce, unter wero and variable
d.c. fields. It was found thet the ferroelectric characteristics
Aas Poets a we ate dooes as high ax 10 Krad, for trigiyeine
sulphate, Similar results were obtained for Rochelle salt. In
this case, however, the ferroelectric characteristics of the
crystal disappeared at about 2 Mrad. as a consequence of the
collapse of both Curie points. ?The changes in domain structure
Se Reuhelle galt were also investigated by using the polarizing

microscope, and interpretation was given, which is consistent
with the results of the dielectric observations.

canna Irradiation of Liquid Alde = Ovll. Wheeler and

E. Dfaz de Osborne Thesis, February 1968; on leave of.

?absence from the Food laboratory, University of Puerto Rico).

speemcena radiolysis of decanal, citral, oitronellal, end

ie Girehyde was studied in the Liquid phase, In the absence 0

cera e Gy values were very 1ov (?v0.2 for benzaldehyde and

al) ot forthe other aldehydes). the only reaction detected was

fotjmerzation and the gaseous profucts were formed with

ae ryan O.ON acetic acid, citral and citronelial were

Gestroyed with a G value of 01, and peroxide formation was

noted.

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Radiation Protection of Glycine and Glycyiglycine -

Coil, Wheeler, M. Santos Sinchez, ReA. Ribot, and M. Ramos (NEL

Project). ?the reduction in the Gy values for glycine and

Elycylglyeine in aqueous sclution was determined by measuring

the unchanged substrate in the form of carbon-1i labeled com.

Pounts, the order of effectiveness for radiation protection for

glycine was: cysteine > thiourea> penicillamine >dinethylulforide >

methionine >phenylalanine. For glycylglycine the onder was:

thiourea> cysteine >penicillamine > tyrosine> methionine> dimethyl-
sulfoxide > phenylalani:

esis of Thiosteroids - 0.H. Wheeler, E.E. Rodriguez and
WR z (M.S. thesis, March 1968) (NIH project). A steroid
analog was synthesized from thiophene as ring A and successively
adding on ring B in the a, 8 -positions of thiophene and then ring
C with ring Das a six-menbered ring, Attempts were made to link
?the thiophene rings in the 8, SLpositions by first protecting the
a, al - positions with iodide, carbonethoxy, methyl, or t-butyl
groups. However, these groups ¢ither reduced the reactivity of
?the thiophene ring in Friedel-Craft reactions, or hindered the
subsequent cylization reaction

RESEARCH IN PROGRESS

Piegoslectric Characteristics of Lili,(%0,), - J.M, Rivera
and J.A, Gonzalo. A pre: study, of the Bigzcelectric and

elastic properties of Lilig(Se0,) at 93°C (close to the melting
point) has been undertake. Agcurate measurements of the din
electric constant as a function of frequency shoved resonance
peaks in the 109 -107 c/s region which gave reasonable estimates
of the piezoelectric coefficient and Young's modulus along the

ferroelectric axis, which is perpendicular to the (001) planes

pictestrte sperttee of AUsLise chloties = 1 Rif and

\A, Gonzalo. Single erystals of 820,)> (with

3°2'0195, 0.50, 0.60) have been growl iA'2S) tverat3eg, ?unt

measurenents of dielectric constant and hysteresis loops are

being unlertaken with the object of determining the dielectric

phase diagram of the solid solution, sone single crystals of

?the analogous systems Nay 14(_4)H3 (803)2 and Nex, C8(1_~)H3

(8e03)2 have been grown, and it is intended to complete both

series for further dielectric characterization. The Curie ten-

perature is expected to change gradually with composition.

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Scope and car

ment in fert

jout the disappearance of hyst

the dielectric constant, Dielectric et

a function of temperature in the

producible, unless a strong

for a few mimtes.

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Electroreflectance from semiconductor

A study was me on the tani properties of magnesium otiicide, ie and stannide. The technique used was introduced two years ago and is known as electroreflectance technique. An electric field was applied to the reflecting surface by intro~ducing the sample in an electrolyte. Fron the reflectance data, information was obtained on the energy dependence of the di-electric constants and absorption coefficient. Finally, the

transitions were studied in view of the available energy band calculations.

tals - P. Vazquez

Monochromatic X-ray Effects on the Formation of Color Centers in Alkali Tstides > Be hus ant Fe Diaz; A study of the effect of a halide K shell ionization in the coloration of KCl crystals is in progress, Similar work is being done on RbEr and on impurities in KI and KCl. Necessary equipment for variable temperature work, and for luminescence studies, is being acquired.

Free Energy Expansion Coefficients from Double Hysteresis Loops ~ JA. Gonzalo. A direct method has been developed to

Loop ote emerature depeydence of, the coefficients of the see tnorey expansion (A-1/2¥P* 1/h EP + 1/60 Beez) of a Suystal spontanecusly polarized in a temperature region where crystal, seme ente lospe are observable (This inplics that, tO). doubegatures of the (P) vss (B= 6A/6P) relationship are fully sepiayed in the double hysteresis loop, thus alloving the ?tomltaneous determination of x, Gand . The coefficient x can ?be measured directly from the slope (6P/ 6) of the straight line be menuvter of the double Loop. We can define Pe, ani Fy. as fhe polarizations before "switching" for decreasing and intreas- the POsid; respectively. his characterizes one of the single 16 Serine @)vs(@) diagram, and one can easily compute © and ¢ 100pe thod has been applied to BaTiO, oseillograns of the duble hysteresis loops above Ty = 111.5°¢ were collected and Geer temperature depenience of y° Cant? ¢ determined.

Mechanisn of Thermal Aromatic Re ments - O.H, Wheeler, 0, Rossioy ant F. Ronan (V5, June 1968; on leave of absence

from the Industrial Development Laboratory, Commonwealth of Puerto Rico). ?he mechanism of the Chapman rearrangenent of phenyl ?enzimino ethers to benzoyldiphenylamines is being studied by using carbon-1} labeled phenyl ethers. ?he allied rearrangenent

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a

of allyl benzimino ethers is also bei 24

of sltya bent ere 1s also being investigated by using &

Radiolysis of Peptides - 0H, Wheeler and D, Julién (M5.

March 19%8)(ILi project). Tabeled glycylglycine, phi yl

S » phenylalanyl~

glycine, and glycylphenylalanine have been synthesized from

carbon-ih Iabeled anino acids, ?their radiolysis {n aquecus

ution is being studied u: hr 2

Solution ie being studied using paper chrenatogrenhy to separate

STAFF

Dr. Juan F, Facetti, a former monber of our staff, who is

now in charge of the Fhysics Department at the National

University of Asuncién, Paraguay, spent two weeks at PRNC during

the 10th Anniversary celebration, and plans were arranged for

cooperative research efforts in the future between his group and

our staff.

Mr. Inis Rivera Oyola, research assistant and graduste student in mclear engineering, was avarded an AEC traineeship in nuclear engineering in August.

Miss Milagros Santos, M.S., research associate on an NIH financed project concerning the "Radiolysis of Peptides," re-signed in January to accept an appointment as chief chemist in @ pharmaceutical laboratory.

Miss Carmen Lecumberry joined the staff of the Chemistry Department, University of Puerto Rico at Mayaguez in July.

Miss Dolores Julidn, who was with the "Radiolysis of Pep-tides" project, joined the Chemistry Department, Inter Anerican University in September. Both are completing their thesis studies in the Division.

Mrs. Myriam Ramos, also with the "Radiolysis of Peptides" project, joined the Department of Biology, Regional College of the University of Puerto Rico at Arecibo, in August.

Mr. Grafton Olivera, a former senior student who partici-pated in research training, left PRIC to join the Research

Iaboratory of the ITT in San Juan, Puerto Rico.

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Nuclear Engineering student:

Division's Suberitical Asseml

Antonio Rivera Cordero, Lut

Raphael L. Ufret.

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NUCLEAR ENGINEERING

The prinary function of the Miclear Engineering Division 1s
to teach graduate courses for the students of miclear engineering
at the University of Puerto Rico at Mayagiie: and to direct their
Feoearch, and the thesis research of stufents fron other univer=
sities ih the United Sates and Latin America, this division
iso offers occasional short courses for scientists, engineers,
fand technicians, and for start nenbers engaged in individual ne-
searche

?EDUCATIONAL ACTIVITIES

Master of Sclence Degree Progran

__ UFR at Mayagiiez, in close cooperation with PRNC' s Nuclear Engineering Division, offers the Master of Science degree in Muclear Engineering.? The closeness of this relationship is i1-lustrated by the fact that the faculty of the UFR Department of Nuclear Engineering is composed largely of staff menbers of the FRIC Nuclear Engineering Division, and the director of the UR department is also the head of the PRNC division. In addition, ?the PRIC Nuclear Engineering Division provides the elassroone, offices, laboratories, equipment, and edninistrative personnel necessary for the eiucation and training of the UFR nuclear engi-neering students. ?he requirenents are 30 hours of gratuate Work, including the satisfactory completion of a thesis. Appli-cants for adniscion to this program mist have a bachelor's degree

in engineering or physics.

The basic pedagogical method is the presentation of lectures, strongly reinforced by laboratory work with various types of ra~ @iation counting equipment, the subcritical reactor, the 1-77 low power reactor, and the PRNC one-megawatt reactor. Each stuient is also required to use both an analog and a digital computer and to present seminar on his research to the PRNC staff. ?The stu-dents are encouraged 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 muclear engineering curriculun follows.

+ Muclear Reactor Technology Tiree lectures and one three-hour laboratory demonstration period per week. Steady-state and transient thermal conduction in fuel elements; thermal convention in heat-exchanger design; liquid metal systems; circulating fuel ?systems; tine behavior of reactor systems; breeding and conversion;

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?an introduction to the economics of reactor operation; reactor engineering design problems.

+ Muclear Measurements and Instrumentation One lecture and two three-hour laboratories per week. Characteristics of opera~tion and a thorough familiarization with the application of specialized techniques such as: coincidence and anticoineidence counting, pulse analysis, neutron spectrometry, gamma ray spectro-metry, and so on.

+ Elements of Nuclear Engineering Four lectures per week include characteristics of the atomic nucleus, radioactive decay, interaction of radiation and matter, and basic neutronics.

+ Graduate Seminar qyo hours per week include reports and discussions on special topics in nuclear science and engineering.

+ Reactor Theory Three lectures per week, Consists of neutron balance equation, diffusion theory, and slowing dom ?theory, bare homogeneous reactor, reflected reactor, heterogeneous reactor, time dependent reactor, perturbation theory and transport theory.

+ Advanced Reactor Theory ?Three lectures per week. Advanced transport theory, reactor kinetics, and heterogeneous reactor theory.

+ Reactor Laboratory One lecture and one three-hour design period per week, laboratory problems involving the mclear re-actor.

+ Nuclear Engineering Application of Wavenechanies Io lecture discussions per week, Thysical behavior and properties of moderator nuclei, Fission properties of fuel nuclei. Colli-sion theory. Quantum mechanics discussion of the Doppler Effect.

+ Nuclear Engineering Application of Wavemechanics IT wo

lecture discussions per week. A contimuation of the same topics ?eovered 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 se-

nester related to the investigation of special problems in I~
clear Engineering. (Note: During the second senester of this

---Page Break---

school year, Dr. Knud Pedersen conducted a three credit hour
special problems course in Plowshare).

+ 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 milear 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 ModernSeience IT Three lectures per week.
Partial differential equations, Bessel functions and Legendre
polynomials, and complex variables.

Supplementary Courses

+ Nuclear Reactor Metallurgy vo lectures and one three-hour Jab session each week. An introduction to elementary physical netallurgy of the principal reactor materials such as alunimm, zirconium, uranium, and high temperature alloys; mechanical properties; fabrication of muclear fuels; radiation damage to reactor components.

+ Introduction to Muclear Engineering For advanced undergraduate and non-miclear engineering graduate studente; three lectures each week in fission and chain reactions, elements of reactor design, utilization of mclear energy for power, and radiation problens.

Non-Degree Program

In addition to the Master of Science degree program, the Division offered ar participated in two special programs:

1) An intensive six-week seminar on Plowshare (peaceful uses of mclear energy) was offered during the sumer of 197. ?The seminar was conducted by Dr. James A. Cheney of the Department of Civil Engineering and Dr. Wilson K, Talley of the Department of Applied Sciences of the University of California

at Davis, and drew ite participants from the staff of the FRIC

and the faculty of the University of Puerto Rico.

---Page Break---

Above: Control rods are ad

before transfer

function measurement on th eactor. Below:

Transfer function meas ?periment on the

L-77 reactor.

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wW

2) Dr. Donald S Sasscer taught the physi:

e physics part of an

Office of Civil Defense, Nuclear Fallout shelter Sunmer Institute.

This institute was attended by professors representing 28 dif-

ferent universities from 20 different states.

STAFF

Dr. Knud B. Pedersen joined the division in June. For the past three years he has been teaching in the Departments of Iuclear Engineering and Engineering Science at Iowa State University. Before that Dr. Pedersen was a member of the staff of the Ames Laboratory of the ABC. He has been active in research in the areas of metal fatigue, muclear cratering similitude, and reactor kinetics.

Dr. Donald msscer attended the International Conference on the Utilization of Research Reactors and Reactor Mathenaties Con putation in Mexico City, Mexico, May 2-4. During the second week of May, Dr. Sasscer participated in the Atoms in Action program in Panama by giving a series of lectures to the students of the University of Panama, and by consulting with them concerning research problems related to Muclear Engineering.

Dr. Aviva E, Gileadi participated in the 13th Annual Conference of the American Nuclear Society held in San Diego, California, during July. Following this, Dr. Gileadi visited the Brookhaven National Laboratory for consultation concerning computer calculation related to neutron cross sections.

Dr. Knud Pedersen presented a paper entitled, "Measurenent of Shutdown Margin," to the llth Anmual IEEE Nuclear Science symposium held in Los Angeles, California, October 31 to November 5.

During August, Dr. Sasscer visited the Associated Midwestern Universities-Argonne National Laboratories, Sumer Engineering Practice School at the Argonne National Laboratory for an evaluation of the research activities of Mr. Antonio Rivera Cordero, a graduate student in Nuclear Engineering at the UPR, who was at~ tending the school. At the end of August, Dr. Sasscer attended the Nuclear Science and Engineering Fellovship Advisors meeting

at Gatlinburg, Tennessee.

---Page Break---

STUDENTS

During 1967, an Ecuadorian, a Mexican, a Cuban, a student from nationalist China, and seven students from Puerto Rico par- ?ticipated in the Masters Degree program. ?Three of the students were US AEC trainees and one an International Atomic Energy Agency fellow.

Three students presented papers to the Fifth Anmual Student Conference of the American Nuclear Society held in Gatlinburg, ?Tennessee, in April:

1, Antonio Rivera - ?Investigation of Puerto Rico Nuclear Center Beam Tube Explosion."

2, José E. Aguiar - "Design Criteria to Increase the Sensitivity of the Total Absorption Calorimeter for Soft X-Rays".

Francisco Jiménez - "G-Value Determination of the Fricke Dosimeter for Monochromatic X-Rays from 5 to 10 Kev".

Mr. Antonio Rivera attended the three-month Associated Mid~western Universities-Argonne National Laboratories, Summer Engineering Practice School held at Argonne National Laboratory during June, July and August.

Four students obtained the Master of Science degree in Iuclear Engineering from the Mayaguez Campus of the University of Puerto Rico under the research direction of the scientific staff of the PRNC (See Table 1).

The progress of the students active in the Nuclear Engincering program during 1967 is shown in Table 2,

Students enrolled in the Nuclear Engineering Master of Science

degree program are given in Table 3.

---Page Break---

?TABLE 1.

19

Master of Science Degrees in Nuclear Engineering 1967

student

Aguiar Aranburu,

José

Jiménez Rosado,

Francisco

Mufioz Ribadeneira,

Fausto

Reoyo Sinchez,

carlos

Thesis

"Design Criteria to Increase the

Sensitivity of a Total Absorp-

?tion Calorimeter for Soft X-Rays"

Value Determination of a Frick

Dosimeter for Monochromatic X-

Rays from 0 to 15 Kev"

?Estudios de la Relacién de Lixi-

viación de un Mineral de Uranio

Tipo Carnotita con Acido sulfi-

rico Bupleando Métodos Comnes y

Enerela Ultrasénica?

1e1 Element Maximum Temperature

as a Result of a Loss of Coolant

as a Function of Operating Power

Before shutdown"

TABLE 2

Research Director

Dr, Peter

Paraskevoudakis

Dr. Peter

Paraskevoudakis

Dr, Rafael Mufioz

Candelario

?Prof, Kenneth

Soderstrom

Progress of Nuclear Engineering Students in 1967

a

Students who received the M.S. degree

in Nuclear Engineering

Students who have completed all course

work for degree (presently working on theses)

?students engaged in course work for

M.S, degree

4

---Page Break---

TABLE 3

Students Enrolled in Master of Science Degree Progran

ss

Name Sponsor

Antonio Castro Rosario, Puerto Rico UPR

Cho-fu Lee, China IAEA

Fernando Lépez Carrasco, Mexico CNEN

Gilberto Ramos Cuesta, Cuba self

Fernando Pérez Bracetti, Puerto Rico UFR

Antonio Rivera Cordero, Puerto Rico ABC

Inis Rivera Oyole, Puerto Rico ABC

Francisco Rodriguez Perazza, Puerto Rico UPR

Rafael L. Ufret Acevedo, Puerto Rico apc

Gilberto Vélez Delgado, Puerto Rico ?PRARA

(Puerto Rico Water

?Resources Authority)

---Page Break---

aL

RESEARCH PROJECTS

Design Criteria to Increase the Sensitivity of a Total Ab-

sorption Calorimeter for Soft X-Rays - Dr. Peter Paraskevoudakis

?and José E. Aguiar.

G-Value Determination of a Frick Dosimeter for Monochromatic

X-Rays from 0 to 15 Kev - Dr, Peter Paraskevoudakis and Francisco

?Timénez.

Fuel Element Maximum Temperature as Result of a Loss of Cool-

ant as a Function of Operating Power Before Shutdown - Prof.

Kenneth Soderstrom and Carlos B, Reoyo.

Estudios de 1a Relación de Lixiviación de un Mineral de Ure

nio Tipo Carnotita con Acido sulfurico ando Métodos Comunes

Energia UltrasOnica - Dr. Rafael Mufioz Candelario and Fausto J.

Mufioz-Ribadeneira.

Measurement of the Transfer Function of the I-77 Reactor -

Dr. Aviva E. Gileadi and Fernando Lopez.

Burn Up Calculations in Uranium Fueled, Water Moderated Re-
actor - Dr. Aviva B, Gileadi and Cho-fu Lee.

Griticality Calculations - Dr. Aviva E. Gileadi and Manuel
Rodriguez Perazza.

Investigation of Puerto Rico Nuclear Center Beam Tube Bx-
plosion - Dr. Donald 5. Sasscer and Antonio Rivera.

Calculation of the Time and Space Dependent Neutron Densities

Calculation of the Time and Space Dependent Neutron Densities
Following an Underground Nuclear Explosion in Various Rocks -
?Plowshare Oriented Calculation) - Dr, Aviva . Gileadi.
Stress Corrosion Cracking of Metal Alloys - Dr. Phillip

Osborne and Erick Méndez.

---Page Break---
Dr. Jose P.A. Castri]1on Of AEGER
us for the chromatographic of
tifoxanthene.

---Page Break---

PHYSICAL SCIENCES *

the long range objective of the Physical Sciences Division (formerly called the Radioisotope Applications Division) is to Gffer advanced training opportunities for Puerto Rican and Lat-$n Anerican trainees prinarily through participation in research projects involving the use of high energy radiation and radio-Teotopes. Since this progran is geared to regional needs, it Includes an introductory training course in the use of isotopes, land requires a heavy participation of the scientific personnel in the academic activities of the natural sciences departments of the University of Puerto Rico, Rio Pledras campus, ?The lat~fer cooperative effort is encouraged through joint appointments.

EDUCATIONAL ACTIVITIES

Activities range fron a four-week non-credit training course in the techniques of radioisotope applications to research training in the laboratories of the Center.

Radioisotopes Techniques Course

Offered four times during 1967. The distribution of the seventgen trainees (Table 1) by geographical origin shove

seven participants from Puerto Rico, three from the Dominican Republic, to from Colombia, and one each from Uruguay, Peri, Chile, Boliva, and Venezuela.

University Level Courses

+ Radiochemistry one-senester graduate course, taught by Dr. Jos? PLA. Castrillén, Associate Scientist, with the participation of four students, and utilizing the FRIC Isboratory facilities.

* As a reflection of the development in the division of research training opportunities in more general areas related to a aetna field, the AEC approved the change in the name of

¢ division from "Radioisotope Application: to " Sciences? on July 6, 1967. ee Niiysical

---Page Break---

ak

ee

?TABLE 1

PARTICIPANTS IN BASIC COURSE IN RADIOISOTOPE TECHNIQUES, 1967

1. Silvio

Avistizabal, M.D.

+ Francisco

Touya, M.D.

Emperatriz

Chavarro

4. MJ, Melo

Batista, M.D,

5. Alba L. Rico

de Puente

6. Abel

Rossy

+ Tvia

Minn

8, Lydia Ne

de Reyes, M.D.

9. Roger Ramos

Aliaga

10, Helen Rodr{guez

de Curet, M.D.

1. sergio

Silva,

Resident III in Radiotherapy (Had additional

training in Clinical Applications, PRIC).

Menber of the Faculty of Medicine-Nuclear Ned~

icine Center, Montevideo, Uruguay. (Had special

?training in Clinical Applications and in Medi-

cal Sciences and Radiobiology, PRNC).

Radioisotope Technologist, National Institute

of Cancerology, Colonbia (Had additional train

ing in Clinical Applications, PRIC).

Doctor in Medicine, Radioisotope Dept., Hospi-

tal Dr. S.B, Gautier, Sto. Domingo (Had addi~

tional training in Clinical Applications, PRIC).

Medical Technologist-Experinental surgery, UR,

School. of Medicine (Had additional training in

Clinical Applications).

Research Technician, Terrestrial Ecology
Program, PRNC.

Yedical Technologist-Pulnonary Function studies,
UPR School of Medicine (Had additional training
in Clinical Applications).

Radiologist, University District Hospital,
Medical Center, Rio Pledras,

Biochemist, Faculty of Medicine, Cajamarca, Peri.
(Had additional training in Clinical Applications,
and is having special training in Medical sciences
and Radiobiology).

Clinical Research Center, UPR, School of Medicines

Graduate student in Biochemistry, UPR Schocl of
Medicine.

---Page Break---

Or. Manfred Eberhardt
Preparing equated

Samples for gamma-

radiolysis studies.

12. Claudio

Zafiga

+ Manuel

Tallo

1s, Mercedes Titigues

de Mufio, M.D.

15. Jorge

Mariaca, M.D.

16. Zobeida

Malpas

17. Américo

Rivera, Ph.D.

---Page Break---

+ Theory of Organic Chemistry A two-senester graduate course, taught? by Dr, H. Harry Samant, Chief Scientist, with the partici.? pation of twelve students.

+ Advanced Physical Chemistry A one-somester graduate course,

taught by Dr. Alec Grinison, Chief scientist, with the participa. tion of telve students.

+ Chemical Kinetics A one-semester graduate course, taught during the sumer session by Dr. George A. Simpson, Associate Scientist, with the participation of eight students.

+ Instrumental Analysis and Advanced Inorganic Chemistry

Mo one-senester graduate courses, taught by Dr. Mariel Muir, Associate Scientist, with the participation of fifteen students in each course.

Graduate Research

The graduate students supervised by PRNC personnel, and their geographical origin, are shown in Table II.

During 1967 Miss Gladys Rodriguez completed her thesis work for the M.S, degree, and has joined the teaching staff of the Chenistry Department, Catholic University of Ponce, P.R.

Non-Credit Graduate Research Training

+ During the sumer of 1967 Dr. Martin Feldman, Assistant Professor at Howard University, Washington, D.C., worked on the ganma-radiolysis of dinethyl sulfoxide in freon and methyltetra-hydrofuran matrices in collaboration with Drs. Simpson, Grimison, and Semant. Dr, Feldnan's visit was under the auspices of the Oak Ridge Research Participation Program.

+ Mr. Sergio Quadri, Assistant Professor, University of Con-cepeién, Chile, received nine months' training which included work with Drs. G. Simpson and A, Grimison on gana irradiation of heterocyclic molecules.

Undergraduate Research Traini

The folloving senior science students tock advantage of the research training opportunities of FRNC during 1967: * sonia Cruz Vega, Sandra Piflero Acosta, Marfa de los Angeles Carrera, ihmberto Reyes, and Angel Canales with Dr. N, Muir; Alex Bonilla, Carnon Meléndez, Donald Dexter and Félix Martinez with Drs, A. Grimison

---Page Break---

a

?TABLE TT

?NESTS RESEARCH SUPERVISED BY PRC PERSONNEL DURING 1967

eee

Student Country of Origin Supervisor

1. Birke, Arnoldo chile HH, Smant

2. Cancio, Baith Puerto Rico HH. Semant

3. Castellanos, Jaine Colombia Ae Cotas

2, Weisz

Conén, Jaine Puerto Rico Hu, Semant

S.PsAy Castrilion

5. Costa, Agnes Ruerto Rico HAH, Snant

6. Feméndez, cigs Cuba My Mate

7. Gémez, Elsa Venezuela HH, Semant

8 Mata, Alfonso Costa Rica EH, Senant

9. Rechani, Pio Puerto Rico Me Mair

10, Riquelme, Ta Cuba, HH, Semant

Li. Rodriguez, Gladys Puerto Rico A. Grimison

12, Trujillo, wrtha cuba. ?A. Grimison

13. Werr, Fayez Lebanon HH, Semant

2k. Zea Ponce, Ima Guatemala HH, Smant

M. ?Boerharat

15. Sprangle, Fuibp Ue8Ae A, Grimison

Several of the graduate students are expected to complete their M.S, thesis requirenents during 1968, and some plan to continue work tovard the Ph.D. degree in Chemistry since this program is soon to be officially approved,

---Page Break---

land G. Sinpsons Aida Dfaz, Francisco Rivera, Olga Rotrlguez, Janice Petrovich, Gregoria tarreo and /Sonia Vazquez with Drev Wa, fmant ani J. Castrillén; José Marrero with Drs. A. Cobae and

Z. Weise.

"Atoms in Action" Exhibit in Quito, Bouador

In Novenber, 1967, Dr. He Harry Smant participated in the ARC "Atoms in Action" Behibit in Quito, Ecuador. Small research

projects were initiated with two instructors of the Central University. Some results of previous participation by Dr. Ssmant and Dr. Castrillén at the Costa Rica Exhibit presented at scientific meetings in Kingston, Jamaica, and Chicago, Illinois, are reported later.

SDR

Dr. Manfred Eberhardt Joined FRC as Associate Scientist in Septenber 1967. Dr. Eberhardt worked previously at the Radiochemistry Institute, Technical University of Munich. He will. work on the gamms-radiolysis of dimethyl sulfoxide, and on steric effects in radiation chemistry.

During 1967 the following graduate students resigned their part-time PRIC research assistantships:

Mr. Jaime Colén, who continues his studies under an assistantship of the Department of Chemistry; Mr. Eagar Rodrfguez and Mr. Thagdish Jhaveri, who discontinued graduate studies for personal reasons. lew appointments were extended to Mrs. Agnes Costa, Mii Elsa Gémez, and Miss Myrtha Trujillo.

Participation in Scientific Meetings and Courses outside Puerto

Rico,

Dr. H. Harry Semant participated in the meeting of the Council of the American Chemical Society in Miami Beach, Florida, April 9-13, 1967. He formed part of the Organizing Comittee for an "International sulfur Chemistry Conference? to be held in Puerto Rico. On June 15, Dr, Semant presented "Research in the Chemistry of Sulfoxides? as part of a cycle of lectures on "Contemporary Research in Organic Sulfur Chemistry" at Wayne State University, Detroit, Michigan.

In June and July 1967 at the Institute of Physical Chemistry,

---Page Break---

Professor A. G. Maddock, Ci
(right), viewing the rea
PRNC staff.

University of Bologna, Ttaly, Dry
research on the theoretical spec
collaboration with Professor Carl
tute.

On June 16, 1967 Dr. Semants
chanisn of the Wolff-Kishner
Detroit, Michigan,

On June 24-26, 1967 Dre
received training in special
chemistry by Dr. Alfred Wolf at
haven National Laboratory.

On september 6-11, 1967 in
Illinois, Dr. George A. Simpson 3
Electron Spin Resonance Spet

On September 11-15 at the

Chicago, Illinois, Dr. Semant

of the Organic Division,and was

Institute of Chemists.

---Page Break---

30

_, 0m Novenber 21-28, 1967 in the ?Atoms in Action" Exhibit,

Quito, Ecuador, Dr, Semant delivered lectures on ?Application

©f Isotopes in the Study of Reaction Mechanisms," and on "

ergy and Chemical Changes."

On October 13, 1967 at the "Science in Research? sessions

of the Southeastern Regional Conference of the National Science

Teachers Association, San Juan, Dr. A. Cobas spoke on ?Iuclear

Experimentation in Puerto Rico," and Dr. HH, Semant on "Chen-

deal Research at the University of Puerto Rico.?

RESSARCH

The research prograns of the division 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 effects of high-energy deposition in chemical systems. In sone of the projects the emphasis is on the initial, or primary, products of radiation, while 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.

Ganma-Radiolysis of Dimethyl Sulfoxide (HH, Samant, Me Hherhardt)+ The previous G values of several radiolysis products have now been determined with greater precision, In a typical experiment, G values of 2.24 for dimethyl sulfide formation, 0.37 for dimethyl-sulfone formation, 0.23 for formation of the methyl ester of metharethiosulfuric acid, and 0.5 for formation of a probable DM@ 'dimer' were obtained, ?he effect of dose and ad~ Ged water on these G values is currently under study. Graduate Student trainees: Agnes Costa, Eagar Rodriguez.

Sterecehenical Bireets tn the east sot Gis a ane

2 dimethyleyclohexane (M. Eberhardt). ?he effects of stereo-

chenistry on the radiolysis of cis and trans-1-2 dinethyleyclo-

hexane ae being studied Jn rerticular the steric effects on

?ormation lrogen. ?This is a project

by Dr. Eberhardt at the Technische Hochschule, a an

which is now to be contimed at PRNC, , ,

---Page Break---

Or. Manfred Eberhardt and Mr. Alfonso Mata

student from Costa Rica, oper oh

Shudent trom ¢ ca, operating a vapor phase

Radiation-induced Addition of Thiols

t, M. Eberhardt). The stere

homolytic addition of thiols to olefinic

and the results compared with those in

actions. Graduate student trainee: Irma)

(A. Grimison, G.A. Simpson)s

rt fron the AEC Division of Biology and.

the nature of primary species formed by:

heterocyclic molecules, ?he work is de:

in this Anmual Report under Biological and

grans, Graduate student trainee: Myrtha

Radiation Danage in Organic:

Se aol =e

Division. Radiation damage in well=d

naterials is studied by conductivity

described fully eloevhere in this Anmal

Research Program, Graduate student

?Tritium Distribution in the Recoil

Lithium salts t

Ject investigates the radiation damage,

cipally, the tritium distribution in the!

ing neutron irradiation of organic 1ithium

---Page Break---

results for phenylacetic acid indicate that irradiation of the Lithium salt rather than the free acid results in a completely different tritiun distribution, with mich higher label yielie Trus 20f of the total activity is located on the a carvon atm, as against less than 2 with the standard technique. Graduate ? student trainee: Pio Rechani (part-tine participation).

Thotochemistry of Transition Metal Complexes (M. Muir). This new project studies the ultraviolet irradiation of a series of complexes of Pt(II) with ligands, such as pyridine, bipyridine, phenanthroline, and ethylenediamine. the major reaction suggested by the preliminary work is photosolvation, proceeding to 8 different extent with the various ligands.

Radioisotope studies

These projects mainly involve the use of incorporated radio-

active tracer atoms, as a diagnostic aid to the study of reaction mechanisms.

?The Chromic Acid Oxidation of 1,1-di(p~iodophenyl) _ethane-

FH. Semant). ?The mechani of the chronic acid oxidaon of 1,1-ai (p-iodophenyl) ethane-2-C-1h contimes to be studied. ?Graduate student trainee: Jaime L. Colén.

tion of CnIlinlabeled Dinethyl aulfoxides (lit. Semant,
G. Molina) C-lislabeled dimethyl sulfoxide has been prepared by
fhe reaction of dinethyloulfoxide with C-Ih labeled nethy! follde,
ani the subsequent decomposition of the orosulfonium salt with
Syridine. thie material will be used in other research projects,

Effects of Ketones and Sulfoxides in Liguid scintillation
counting (iH. Smant, J.P.A. Castrillén), ?he effect of the -
Fructures of a series of ketones and sulfoxides on the liquid
Seintillation counting of weak beta emitters is being studied.

Graduate student trainee: Elsa Gémez.

Preparation of Tritiated Benzochenone-hytrazone (HH. Sant,
G. Molina). ?this preparstion is now completed. The material
Wild be used in the study of the Mechanisn of the Wolff-ichner
reactions

Supporting Research

The projects described under this heading do not directly

involve the use of radiation of radioisotopes. However, they

---Page Break---

exist in onder to provide mipport for the previous

: jects

Producing esoontial information on the aystens ef interests

Decomposition of Benzhydryldiazine (H.H. Semant). ?this pro-

Ject studies the preparation and base-catalyzed decom

sposition of

Denzhydryldiazine. This decomposition is directly related to the

study of the Wolff-Kishner Mechanian.

Studies of the Anions of Diaryl Ketone Hydrazones (HH.

Semant), ?The Kinetics of the generation and Wolff-Kichner re-

action of the anions of diaryl ketone hydrazones are being studied.

Graduate student trainee: Arnoldo Birke.

Solvent Effect of Dimethyl sulfoxide on Wolff-Kishner Re~

action Grit Semant)s ?the efecto a ?dimethyl sulfoxide on the

Kinetics of the Wolff-Kishner reaction is being elucidated.

Graduate student trainee: Ida Riquelme de Grimany.

The Stereochemi, of the Thiol-lefin Addition (H.H. Semant, J.P.A, Castrillén) . the stereochemistry of the honolytic addition reactions of thiols to olefinic bonis is being studied, as support for the research on the radiation-induced addition. Graduate student trainees: Bdith Cancio and Janice Petrovich.

Molecular Orbital Calculations on Heterocyclic Molecules (A. Grimison, W. Adam). A series of all-valence electron calculations on heterocyclic molecules and radicals is being carried out, using the Extended Huckel Theory. ?his work aims at the elucidation of the electronic structures of these systems, and derived properties. Work during 1967 was mainly concentrated on the calculation of m-clear magnetic resonance parameters from all-valence electron wavefunctions. Treatments of aryne intermediates, and of hydrogen bonding between pyridine and water, and pyridine and methanol were also completed. Graduate student trainees: Gladys Rodriguez,

Phillip Sprangle.

---Page Break---

Above: Liver function
study in thioacetamide-
treated dog. Below:
Radiographic and radio-
isotopic localization
study of thyroid gland.

---Page Break---

CLINICAL RADIOISOTOPE APPLICATIONS

The Division of Clinical Applications of Radioisotopes is primarily oriented to Iatin American and Puerto Rican physicians Who wish to acquire special skills in the hunan applications of radioisotopes for diagnostic and therapeutic purposes. ?The main training activity, the basic Clinical Applications Course, is of= fered to physicians wishing to qualify for obtaining a license to practice mclear medicine or use radionuclides in hunans in other connections. The Division also offers extended participation to trainees in special fields of interests, such as: extenied prac-tice in a field of the trainee's choice, a special training pro-dect, or @ form course of muclear applications in a medical specialty. In addition, the Divicion offers informal teaching to the Medical Faculty, Medical Students, Nursing Staff at clin-ics, wards and courses through medical consultations, rounds and lectures. A semester course for medical residents (orientation

clinical uses of radioisotopes) has been discontinued. Long term training for students desiring at least one year's experience is also offered,

The Division is aware of the needs of preparation of personnel with more advanced skills, As the clinical uses of radioisotopes become more generalized the need for stratification is more apparent. Special clinical radioisotopes procedures are not available to the majority of radioisotopes facilities everywhere. Hence, the need for training in this area, ?he Division anticipates future efforts to meet these needs.

EDUCATIONAL ACTIVITIES

Training program in the Clinical Uses of Radlot sotopes, The courses offered are:

Basic Clinical Radioisotope Applications Course

?This formal eight week Course offers the trainee an opportunity to learn by direct personal experience the hunan uses of radioisotopes in diagnosis and therapy of diseases; provides sufficient exposure to clinical material to facilitate the correlations between laboratory and clinical findings; permits the

trainee to acquire sufficient technical proficiency in diagnostic and therapeutic radioisotope procedures to enable him to qualify for license requirements, This is accomplished by a fomal program of lectures which include diagnostic procedures that are currently in use in the following areas of medical diagnosis:

---Page Break---

?Thyroid disorders

Cardiovascular system

Renal tract

?The liver

Gastrointestinal absorption

Hematological applications

Fluid conpartments and electrolytes

?mor localization and organ visualization

Radioisotope therapy

The lectures are followed by clinical radioisotope labora
tory exercises: clinical discussions of incoming patients for
@iagnostic work upsobservation of laboratory procedure; demon
strations, and personal participation or direct performance of
work by the trainee under close guidance by clinical and labora~
tory staff.

By the end of the course trainees usually complete an aver-
age of over 100 diagnostic procedures, the minimm performance
veing 80 adequately performed procedures for the entire period
(see Table 1).

+ Clinical Applications of Radioisotopes in Pediatrics

?This course was intended to attract pediatricians to stuly
this phase of mclear medicine in their specialty. Tt was organ-
ized with help fron the Department of Pediatrics and a staff men-
ber of the Division who is a pediatrician doing radioisotope work
jointly with the Department of Pediatrics of the University Hospi-
fal, School of Medicine. Since mclear applications in Pediatrics
are moving slowly in Puerto Rico, enrollees for this course
have not yet appeared. But this Division has trained three pedia-
tricians on the University Hospital medical staff who are now
leaders in their respective subspecialties: one is engaged in

pediatrics neurology, another in pediatric hematology, and a third is doing pediatric endocrinology,

+ Dofcrmal Courses

These are extended periods of practical training 41

the major areas of melear medicine under the guidance of the clinical and Ieboratory state, fhe areas of greater interest for rrainees have been radioi so 0c
tratnene havo Deen ?ope localization studies, hematology

---Page Break---

Participants in the training program during FY 1967 are listed in Table IT. A mumerical tabulation of the professional background and countries of origin of the participants in the training program 1s presented in Table IIT.

Table IV presents procedures used in the teaching progran by and for the students.

Table V illustrates the diagnostic and therapeutic procedures carried out at the Division.

Table VI shows the relation of the research program to the teaching units of the clinical radioisotope course.

TABLE

?wo Month Training Program on

Clinical Applications of Radioisotopes

EE

AVERAGE NUMBER OF

arES eA STE PROCEDURES PER TRAINEE

Myroia Function 35

Routine uptake measurenents (as)

Assay of radioactive thyroid

hormone levels in blood (as)

Molified tests of thyroid

function (5)

Dynanic functions of the hepatic, 20

renal, and vascular systens

Hematologic applications of radioisotopes 5

?Tumor Localization studies 10

Gastrointestinal absorption 5

Electrolyte and fluid balance 2

tic procedures a

Therapeutic pr noms 2

---Page Break---

TABLE-2

Basic Course in Clinical Applteritions of Ruttot sotoves

Doce 19, 1966 to February 10, 1:

1. thago Ranfrez Maria nite

2) Yooasta aiverv{ Bontita Dominican Republic

February 14 to March 17, 1:

3. Marcelino Rispoli Argentine

April 3_ to May 2%, 1:

4. Buperatriz Chavarro Rojas Coloabia

5+ Eduardo Tonya Uruguay

6. luis FP, Barragin Bolivia

7. Silvio Aristizabal CoLenbia

June 12 to August 4, 1967

8. Alba L. Rico de Puente Puerto Rico

9. Mercedes Melo Bautista Doninican Republic

August 7 to September 29, 1

10, Tivia L. Millén Zaccheus Puerto Rico

LL, Lidia D. Mteves de Reyes Puerto Rico

12. Claudio Ziifiiga Garcia Chile

TABLE-3

Murber of Trainees

a A cc

M.D. 8

Medical Technicians 2s

z

ORIGIN, NUGER.

Puerto Rico 3

latin Anerica 9

chile (2)

Dominican Republic (2)

Colombia (2)

Argentina (Q)

Bolivia (a)

Uruguay a)

?TOTAL 12

---Page Break---

TABLE-&

Procedures completed, observed or discussed by students

Ante couse seluca_P&° Gita: Gorsions ME

Hugo Ramfrez Madrid, M.D. Clin. Applic.Rad. 71 9% 255 hee

Yocasta Subervi Bonilla " " " 9 82 279 370

Marcelino Rispoli, M.D, Nephrology - 6 : 6

?Emperatriz Chavarro Rojas Clin. AppliceRad, 883 104 256 WB

Eduardo Touyd, M.D. " " " 82 13 256 4s.

nis F. Barragin, M.D. " " " 87 10 256 453

Silvio Aristizdbal, M.D. " * . mM U5 akg, Wis

Alba L. Rico de Puente " " " 89 110 hy Aas,

Mercedes Melo Bautista, M.D. " " " 1 10h eb 439

Tivia L. Millén " " " wa 1 228 480

Lidia D, Nieves de Reyes,M.D. " " "awh 16 a8 478

Claudio Zifiiga Garcfa, M.D." sm ai 6 as 4B

?TOTALS (1025 1255 2703 4983

---Page Break---

40.

2

Thyroid studies

Liver studies

Heart studies

Kidney studies

GastroIntestinal

Studies

Blood studies

?mor Localization =.

?Training Procedures =

?TOTAL

TABLE-6&

Glinioal Applications twiy Unit

1, Tests of thyroid function

2, Kidney function

3. Liver function

4, Hematology

?Tumor Iocalization

6, ?Therapeutic procedures

Research Project

Clinical and laboratory evalua-

?tion of thyroid disorders.

Effect of radiation of ?Thyroid

?Tissue in Patients.

Renogran follomup study in can~

cer of the cervix uteri.

Combined clinical, renographic

studies in kidney diseases.

Renogran studies in diabetics.

T-131 rose bengal Localization

?ani dynamic stuiies: scinti-

granhy, hepatogram, Experi~

mental pathology of liver with

?TMhicacetanide,

?The absorption of B-12 in pa-

?tents with Tropical g3ue,

Clinical~pathologic correlation

of scanning studies,

Review of patients treated with

T3l.

---Page Break---

a

Student: Research

Students attempt to solve specific problens of their oun choice or which have been assigned them. Last year we informed on work done by a student on the labeling of human platelets in normal and abnormal states with 51 cr with which he studied survival of these blood corpuscles. During the present year we are reporting on the work done by three of our trainees,

+ Gonsideraciones acerea de un programa yara un curso de Aplicaclones Clinteas de Radiomeleltes, (Considerations sbost a Progran on the Clinical Applications of Radionuclides). Dr. Claudio 2ifiiga, trainee fron the University of Chile, analyzed relevant factors in the preparation of an adequate training progran as seen fron the standpoint of a Latin American practicing physician, Dr. Zifiiga notes the Tunianental needs of the Latin American physician as a whole, and then his particular needs as an individual, For the first part he offers an outline of subJects for a basic progran. For the secon part, he suggests specialized training, preferably in the form of research work, guided by the trainee's special interest. Such training, supported in part by the Center, could be best carried out. in a sociation with one of the teaching hospitals of the Medical Center, preferably the University Hospital. The points raised

vy Dr. Zifiiga are worth considering. Sone of his suggestions have been in operation for sone tino.

+ Sumary of work done by trainee during one month following the basic Clinical course. This is a sumary of activities of Dr. Iuis F. Barragin, trainee from Bolivia, who spent one additional month of training. During this month Dr, Barragin Worked on pulmonary scanning in the diagnosis of pulmonary embolian; he learned the technique of preparation of albumin 1-131 macroaggregates, the agent employed to label pulmonary vascularity to diagnose pulmonary embolism; he studied the chronatographic method usea to detect thyroid gland aminoacid with the aid of labeled thyroxine and trilodothyronine.

She trainee reviewed the pertinent bibliography on pulnonary scanning and studied the work previously done at this Division, which was largely based on clinical material referred from the University Hospital with signs and symptoms of pulmonary enbolisn. During his stay at the Divicion, he performed 6 lung scannings on 6 patients in whom the radioisotope technique demonstrated abnormal patterns of significant diagnostic value. Five patients had signs and symptoms of pulmonary enbolisn, and one of acute bronchitis.

---Page Break---

we

The preparation of albunin macroaggregates was perfomed in three steps:

1, Following the technique of Janes L. Quinn, mcronggre-gates of human albumin (nonradioactive) were prepared without any aseptic controls. ?he colloid was checked by microscopic exami. nation for size range by comparison with red blood cells. size range found varied between 20 and 150 micra,

2. Step 1 above plus aseptic precautions and bacteriologic control of samples prepared. ?hese were checked for bacterial sterility in sabouraud dextrose agar, trypticase say agar

and Thyoglycollate culture media, Preparations remained sterile for 15 days; thereafter positivity appeared in the Thyoglycol-late medium.

3, T-131 moreaggregates were then prepared following steps 2 ant & above using commercially available radioalbunin. ?this was successfully acconplished and tried in a dog in vhich an ade-quate inage of the lung was obtained. Via subsequent re-scanning the material vas seen to leave the lungs in 2 1/2 houres

Radiochromatograpy of thyroid hormones: Blood obtained fron hyperthyroid patients treated with I-131 was treated chromatographically according to the technique of Raurog: Detection of labeled thyroid hormones, and 13 was successfully accompli shed by autoradiography of the chromatographic paper strips.

+ Measurements of Effective Renal Plasna Flow and Glonerular ?~~ Filtration Rate by Isotope Techniques

This report is based on work submitted by Dr. Hugo Ramfrez Madrid. He studied 42 subjects employing clearance methods of renal function described by their authors: the effective renal Plasna flow (ERF) according to R.D. Wagoner et al and the Gloferular filtration rate (GFR) according to C.D. Farner et al,

A brief description of the ERPF, also applicable to the GFR, follows: after intravenous administration of the labeled substances orthoiodchippurate I-131 for ERP? or Diatrizcate I-131 for GFR the plasma clearance of these substances is fol. lowed up at 5 minute intervals. Plotting the activity on semidogarithmic paper gives a biexponential curve: one with rapid decay, gives a line with slope denominated al and intercept en 0 denominated § 5 the second exponential curve gi tt line with slope a2 and eases & straight
Slope a2 and intercept at O denominated A, T 1/2 of A

---Page Break---

43,

and B is determined for each function by the expression:

71/2 = 0,693

and the clearance for the labeled substance is cbtained from the

application of Sapirstein double exponential forma; thus

Clearance = I al

TYEE ETE

injected activity

slopes lines B+ A

intercept of B line at 0

intercept of A line at 0

1 1/2 halftime of lines A and B, respectively

PweH

uno

Clearance of diatrizoate I-131 represents glomerular filtra-

tion rate (GFR) and should be compared with that of imilin, the

standard test of GFR; while clearance of hippurate 1-131 represents effective renal plasna flow (EFPF: clearance cf para-anino-hippuric acid, PAH). ?he following observations will be presented under 3 items: a) technical difficulties, b) results, c) conclusions.

1. There were 3 major technical difficulties:

a, Vein clotting precluded the obtaining of samples cccasionally at the pre-scheduled time, Difficulty best handled by appropriate use of heparin as an anticoagulant,

b. Criticality of injected dose. Loss of a tiny amount of volume of injection adversely affected the estimated activity injected (I) by giving it a higher value; giving thus a higher value for clearence.

c. No correlation of counted activity 8-10 mimutes after injection and injected dose. According to authors, activity to be expected at 8-10 minutes was to be mich greater than hat was observed. A lower cpm of samples lowers values for A and B and hence increases the values for clearance.

2, Results: Healthy subjects. A group of 10 healthy subjects composed of 7 males and 3 females with average age of 35

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My

(range 15-58) were studied, ?The GFR determined averaged 132, ¢ 5.8 mi/min., which is sonevhat higher to the standard imlin test, 2 #15 m/min,

The ERPF was determined in 7 healthy subjects. ?he remults

averaged 641.1 + 29,3 mi/min. ?This reailt compares favorably

with the standard test of PAH clearance for ERPF which is 612 2 68 m/min,

Patients: Eleven patients with renal disease and hypertension were examined, Results of the GFR correlated with the clinical picture yielded values of impaired function and in two instances in which renal function did not seem to be impaired (normal blood chemistry), the GFR detected a minor degree of impaired function.

?The ERPF was investigated in 14 patients with renal disease and hypertension. Again the results of impaired renal function correlated well with the clinical picture, ?This test seems to reflect better the state of normal renal function than the GR.

3. Conclusion: ?he methods employed for determination of ERPF and GFR appear to be reliable means to determine renal function in healthy individuals and patients with renal diseases. Its application to the study of patients with renal disease complicated with henodynanic and extracellular fluid space changes may prove equally helpful, provided the physical assumptions upon Which the test is based would hold under these conditions.

The participants in the courses offered during 1967 are listed in Table 2. A mumerical tabulation of the professional backgrounds and countries of origin of the participante in the training program is presented in Table 3. A large portion of the laboratory activity 1s mde available to student participation. A

tabulation of the mmber of completed procedures by each trainee is given in Table 4,

Me ongoing @iagnostic radioisotopes services 4

sdeguite variety of elinieal material for the training progtn,

Table 5 presents a mmerical analysis of the diagnostic ag

therapeutic services rendered during 1967. the elinieal wy

progran generates ney ideas vhich are inccrporated in the ween

mm, aiding stimili and a fresh outlook to the teaching effrits

ing are shown in Table 6,

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COMPLETED

% total of 120 patienve with hyperthyrolaia
have been treated over the past 7 years at PRI. Ana-
lysis of dose and therapeutic effects observed indicate that

fonse rate to full therapeutic dose was of the order of 90%
of the treated patients. This includes response to one or more
doses (as necessary) of the I-131; the average dose needed to
achieve this result was of the order of 6.0 mCi (6.6mCi), not
very far from responders to a single dose which averaged 4,5 mCi

ation dose in rads estination at tisaue level was
5500 rad. While the dose evel employed in this

5 is generally lover than in other places, the

post treatment sequelae of hypothyroidien is within the Hnits
served everywhere (10-30%). The incidence of hypothyroidism

observed in this group was 19.4%.

Study of the field of vision

---Page Break---

+ Use of Todine-131 Rose Bengal excretion test in the dtttere
tal Gingnosis of obstructive Jaundice in infants, Billery cpsce
truction in infants in the firet few months of life is a perplex.
ing problem because conventional liver function tests are unable
to differentiate intrahepatic jaundice (usually hepatitis) tron
extrahepatic jaundice (usually biliary atresia). ?he first isa
medical condition in which delay in diagnosis is not of parancunt
importance; in the second type, the best chances of adequate treat.
ment and cure are insured only by a correct and early diagnosis,

Rose Bengal I-131 is a dye taken up by liver cells and ex-
creted via the biliary systen into the intestine. Patients with
dlocked biliary tree and undamaged liver tissue may show good up-
?take but poor release of the dye into the intestine, whereas
those with injury of hepatic cells may fail to show a good liver
uptake, and yet be able to excrete whatever is taken up ino
short time, because the biliary tree does not suffer a complete

or permanent degree of blockade.

?This work was performed in 10 infants from the University Hospital who were suffering from neonatal jaundice. ?There were 8 male babies and 2 fenales, with age range of 3 weeks to 3 1/2 months, and body weights varying fron 3 1/2 to 11 pounds. Jaun-ice lasted 1 week to 3 months. Liver function tests showed marked alteration of hepatoceliular function. Final diagnosis was: 8 patients had hepatitis and 2 biliary atresia. Six of the 8 patients with hepatitis were unequivocally identified by en-trance of tracer material into the intestine. Four patients who failed to show entrance of tracer into the intestine turned out to be: 2 with hepatitis and 2 with biliary atresia.

The diagnostic significance of the I-131 Rose Bengal excre-tion test is that it could correctly detect the patients with biliary atresia, and was able to clearly identify 3/4 of patiente not having this condition, It reduces the differentiation to 1/4 of the population of infants with hepatitis in which this test cannot differentiate one way or another.

Perfil Funcional Hepético durante la Experimentacién con la cctanlda (Liver Profile during the Biperinental: hinint etre etamide to Dogs). The administration of thicace-tamide to dogs induces hepatic toxicity of such degree that it may result in two types of liver cirrhosis, depending on dosage

and exposure, Acute hepatic necrosis with profound alteration

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a7

of iiver biochemistry and inability of the liver to image on

scan record after administration of 1-131 Rose Bengal occurs within a period of 3-4 weeks. Animals surviving 3 to 6 nonthe develop a hypertrophic cirrhosis with fine gramlarity, while those surviving longer (over 6 months) develop atrophi¢ Laennec like nodular cirrhosis, All these changes are acconpanied by biochemical alterations, characterized chiefly ty low levels of albuminemia, and high levels of Globulinenia. Foor uptake of I-13) Rose Bengal indicates persistent hepatic injury but recovery of at jeast part of the reticuloendothelial system is apparent by in-Proved liver uptake of colloidal gold-198, which in the initial phase of acute hepatic necrosis had been somewhat affected.

Plasma B-12 Co 57 Levels at 6 and 12 hours as indices of B12 abadeptilons B12 Ub cerSt oe ETS as ges oe Be were examined in 20 patients and 6 nonpatients (controls), Since the values of 8 and 12 hours did not differ markedly, only values of 8 hours were considered, Fifteen patients with malabsorption

syndrone (sprue or perniciuous anemia) showed a level of 0.37% dose per liter of plama with a range of 0.07 to O.dl% per liters Five patients with no absorption difficulties gave a value of 1.?1$ dose per Liter of plasma with range 0.19 to 3.734/L. A control group of persons gave a similar value with 1.234/L and range 0.52 to 2.164/L.

The variebility of the instrument, the low level of counting, and the marked degree of overlapping because of the group of individuals analyzed (patients with absorption defects, patients with no absorption defects, and nonpatients) made us consider that the test was of no clinical benefit for the Gisgnosis of intes-?tinal malabsorption of vitamin B-12.

RESSARCH IN PROGRESS

+ The use of radioiodine studies to assess response of hyper-?oid patients to antithyroid medication, Radiciodine is used

to predict pharmacologic response of the thyroid gland of hyper thyroid patients to antithyroid treatment with drugs currently used in clinical managenent: Tapazcle and Propylthiouracil. These drugs inhibit binding of free iodide trapped by the thyroid gland and thus inhibit synthesis of thyroid hormones. ?There are two basic ways in which this pharmacologic effect may come under observation with the use of radioiodine studies:

1, Thyroid uptake at an early time, say 3 hours vs, 24 hours,

---Page Break---

48

2. ?Thyroid uptake at 3 hours followed by observation of tease of trapped free iodide upon the administration of a thin?

cyanate salt.

In both instances one wishes to measure how mich iodide got trapped and then released, without actually having entered the usual metabolic cycle of hormone formation. In the first instance, iodide levels obtained at 3 hours may or may not be present at 24 hours; in the second instance iodide trapped at 3 hours nay or not be released by the gland. We measure the amount released by the amount retained in the gland, which is compared to a baseline or pre-medication value.

When the gland is pre-medicated with tapazcle or propylthiouracil, a certain degree of blockade of thyroid hormone occurs in all instances. In the patients studied, a retention of more than 25% of the baseline value at 2l: hours indicates a substantial

anount of iodide going through the blockade to thyroid hormone formation. ?Thus, we arbitrarily set a 25% residual thyroid uptake at 24 hours or 11/2 hours after administration of thiocyanate salt as indicative of a nonresponse level.

Four groups of patients have been studied:

18 patients with Tapazole

18 patients with Propylthiouracil

70 patients with Tepazole, iodide
@ischarge with KCNS

11 patients with Propylthiouraci1,
iodide discharge with KCNS

Of 18 patients with tapazole, 14 responded and aid nots in the group of propylthiouracil, 2 responded well and 16 did not. Again this sharp difference between responses to tapazcle and propylthiouracil is observed in the following two group:

1) In 70 patients with tapazole and iodide discharged from the thyroid gland measured after the administration of KCNS, 56

responded well and 1h did not.

2) ?The same procedure in 11 patients treated with propyl-

thiouracil showed 2 good responders, and 9 poor responders.

Since antithyroid drug therapy is a long t 5

the patient and a treatment witha clgnifiesnt anceeon tieesrcr

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4g

which drug allergies, invensitivity, and bone marr

» Ansensktivity, and bone marror texte!

the nore troublesone, it 18 inportant to knov in eavance er to"

predict the probable response of the patient since it may take @

year before that juiguent can be mde by elinical means.

. id I~: uptake in Puerto Rican Children, 24-Hour Thy-

yo i ae Re a, Os Be

low Through Project of the Head Start Program to which we are

offering collaboration, The group consisted of 60 boys and 55

girls with ages ranging from 6 to 10 years,

?The mean thyroid uptake was 17.4 + 4.3% with range 7.3 to

32.84. At the 956 confidence level. 4 subjects were excluded:

one below with value of 7.3%, and three above with values 2.2,

30.9 and 32.6%. It appears in this group that while average thyroid uptake is close to that of adult values obtained at this Division, the upper range of normal, and even the highest value obtained in all the group, is much iover than in adults, which usually varies fron 8 to {5% and in sone instances nay extend well above li5{ in clinically euthyroid individuals.

?Myroid uptake was also determined in a heterogeneous group of 22} six were said to be "normal" and the renaining 16 were suffering from nonthyroid diseases. Sone of these patients vere on medication, which at the tine of examination was presuned to exert no influence on thyroid function, ?he group consisted of Qh fenaies and 8 males with age range fron 2 weeks to 11 years.

?he mean uptake was 18.3 and the range was 3.4 to 35.2f. Io patients shoved lov uptakes (3.4 ant 6.2%).

?This group is small and shows wide scattering of values, Wnile no conclusions can be drawn, the scattering suggests sone effect of dissimilarity of the composition of the group as con-pared to the one above, and perhaps some influence of the non-?thyroid disease process or its treatment on thyroid function.

+ Radiation of the Neck Region and Its Bffect on a Function. Twenty-seven patients with head and neck cancer were Trradiated to the neck; the thyroid region underwent irradiation

concurrent with the treatment. Radioiodine studies consisting of 2h hour uptake, Protein Bound Conversion Ratios of 1-131, Pro-fein Bound Plasma Ievels of I-13 and scintiscanning of the thy-roid gland were performed immediately before, during and inne-diately after the conclusion of the radiotherapy. Observations

---Page Break---

Of the functional tests perfomed denonstrated « marked 4

stra kod det

fo Hureld uptake during the radiotherapy period, Mitr asettg to recovery one month after completion of radiation. (se Table

T and Graph 1).

nu gpite of heavy radiation to the thyroid tissue estinatea fe the neighborhood of 7000 r in 7 weeks, and the apparcnt ace Ferd eg nye tyTOla uptake of 1-231, the scintiscanning stuiies failed to reveal any areas of sharp localization of defestin: iodine 1-131 distribution, It may be that radiation affects the tissue in a general and diffuse manner, so that a depression pf function was not detectable by mapping tecause there might net have been any areas of isolated major tissue injury.

Tle I

Radiciodine Studies of Thyroid Gland and Radiation

??

Radiotherapy (RT)

RAI Test py (RT)

Before ?After One Nonth After

??_??_____Efore After the Month After

9.6% 3.8%

2k Hour I-131 Uptake 18.5%

Protein Bound Conversion 9.4% 6.2% 6.36

Ratio I-131

Protein Bound Plasma 0,048

caeeigreaad 0.042% 0.040% St

Hyperthyr ith I-131. A total of 120 pa-

?Treatment of Hyperthyroidism wit "

idism treated with 1-131 were evaluated in

fellosup port therasy., three nev cscs of post treatment hypo-

follow-up post therapy. res

A ?oup of 53 patients within o

tnyroidian were detected in a grou Pa autane cbeorved

year of previous evaluation. Average thyroid uptake cbenrred |

saat ree ape. Contrary to expectations fron reported experience

ae "incidence of post treatment hypothyroidism in this

Sanltaes not follow a regular pattern, nor is there a tendency

ees during the period of observation (7 years).

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+ Tung Scanning in Pulmonary Enbolisn. This project is carried

out in collaboration with the Pulmonary Laboratory of the UFR

School of Medicine under the direction of Dr. Adelaida Elfas. It

is proposed to correlate data of clinical value with other labo-

ratory diagnostie procedures including pulmonary function tests, enzyme studies, electrocardiograns, angiograms and pulmonary scanning.

The diagnosis of pulmonary embolism and its differentiation from other acute or chronic pulmonary or cardiovascular problems is of utmost importance, particularly when massive enboli obstruct major pulmonary arteries, in which case prompt surgical intervention to relieve the obstruction is a life saving procedure. qual~ly important is the detection of other degrees of embolization since adequate management of the patient depends on this.

During the present year, 55 lung scans have been performed on M6 patients, the majority of which were referred to this Division to rule out the diagnosis of pulmonary enbolien. A group of 10 patients in which the final diagnosis of pulmonary enbolisn was unequivocally established by clinical laboratory tests (which included WBC, EKG, enzyme studies, and chest x-rays), angiography, and post mortem examination had abnormal lung perfusion patterns; (poor circulation) by scanning. ?The lung scan was also abnormal in 10 disease categories involving the lungs, besides embolic phenomena, ?These included a heterogeneous group of diseases such ?as lung tumors (primary or metastatic), acute exacerbation in chron-4c Bronchitis;chronic Bronchial Asthna, Pneumonia, Pleural Effusion, cardiac disease, Bronchiectasis, etc. In another group of patients with strong suspicion of pulmonary enbolisa there was a

marked discrepancy in the findings detected by pulmonary scan and by angiography of the pulmonary arteries, The angiogram was positive in only one instance, while the scan was definitely abnormal in all of then.

Lung scanning is very useful in the detection of pulmonary enboli of all kinds: large, medium, or small. It is also sensitive to other pathologic or vascular abnormalities of the lung parenchyma. Its capability to detect emboli when no other diagnostic procedures can is probably its greatest merit. Further experience with the method and its correlation with other diagnostic procedures and clinical information is being sought to ?increase the chances of accurate diagnosis and appropriate management.

---Page Break---
SDF

Dr. J.0. Morales, Specialist in Internal Medicine, was appointed jointly between the Muclear Center and the school of Medicine for one year to work part time at the Department of

Medicine and Radioisotope Laboratory of the University Hospital.

Miss Myrna Rivera resigned her position as Research Technician to accept a position as a chemist at the laboratory of Toxicology of the Medical Center.

Mies Norma Gindara resigned her position as Research Technician to accept a position as chemist at the Public Health Laboratory of the Department of Health.

During the past year
and Argentina to attend
present two works (listed

At these meetings
people interested in o
contacts at teaching
interest in prospective

Measurement of a flu

---Page Break---

Mrs. M. M. Palacios de Lozano, Res
and Mr. Michael Gileadi, Research

on the Li F dosimetry project,

of the use of lithium fluoride mic

solution of radiotherapeutic probl

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RADIOTHERAPY AND CANCER

?The Radiotherapy and Cancer Division program is designed to provide education, research and service in the application of radiation therapy to the treatment of cancer.

The Division functions as the Radiotherapy Department of the Dr. I, Gonzdlez Martinez Oncologic Hospital, which is adjacent to the PRNC Bio-Medical Building in the Rierto Rico Medical Center. The Hospital provides sone of the paranedical personnel, beds, operating rooms, clinical laboratories, outpatient faciiities, equipment, space, and other medical services essential for the care of cancer patients.

Me Oncologic Hospital renders service to over two-thirds of the indigent cancer patients in Puerto Rico. Tt has also provided all the radiotherapy services offered to patients in the Puerto Rico Medical Center since May 1966.

At the academic level, the Division operates as the Radi
therapy Section of the UPR School of Medicine. It also works in
close collaboration with the Cancer Control Program of the Puerto

Rico Department of Health,

Partial support for the Division program is received through
?a National Cancer Institute Training Grant to the UPR School of
Medicine.

EDUCATION

Description of Courses

A brief description of the principal formal educational ac-
tivities follows.

Radiotherapy Residency Program. This program is designed to

prepare qualified radiation therapists and meets the requirements
of the American Board of Radiology. ?he 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)
defore admission to the specialty examinations. Diagnosis of can-

cer, determination of the extent and radiosensitivity of tunors, selection of appropriate treatment, and the planning and conducting of radiological therapy are included in the curriculum. Background in clinical oncology is imparted to residents through su-

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Pervised work with new, follow-up, and hospitalized cance: tents, Radiation therapy experiénce is acquired by working with roentgentherapy machines of various voltages, cobalt asd cesium teletherapy units, and the internal application of radio. active material guch as radium, strontium, cobalt, iridium, ant cesium in solid (needles, tubes, wire) sources.

Special Short-Term Radiotherapy Course. ?This course is pre-

pared according to the needs of the individual requesting the training; the person mst have had previous radiotherapy experience, Participants may engage in research and may participate in all training activities of the Division; however, they are not extended the privilege of patient responsibility. A minimm of one month of training is required.

In-Service Cancer Course for Medical Students, ?This course is designed for future physicians with clinical problems and current research in cancer and radiation therapy. the minimm length for this course is one month.

In-Service Training for Radiological Physics Personnel.

?This course is offered periodically as requested.

In-Service Training for Radiotherapy Technicians. ?This

course is offered as requested.

Radiotherapy of Cancer Lecture Course. ?his course for third year medical students is offered yearly as part of the UPR school of Medicine curriculum. ?Wwelve lecture hours are offered, high-Lighting: epidemiology of cancer, radiological physics, radio-biology, clinical radiotherapy, and radioisotopes in therapy.

Educational Activities

?The educational activities offered to physicians included lec tures, seminars, demonstrations, and patient care under supervi-sion with rotation through the various sections of the Division: FRNC treatment area, Oncologic Hospital treatment area, Curie~ therapy and Hospital inpatient area, follow-up, and radiclogical physics. the Residents rotated through the Pathology Departnent of the Oncologic Hospital and also took the PRNC Radioisotore ?Training courses. (?Table 1 presents a swmary of the regular ac~ tivities of the Radiotherapy Division; Tuble 2 provides informa-

tion on the trainees in the Division courses; ?Table 3 presents

---Page Break---

Wednesday

?Thurstay

Priday

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?TABLE 2.

REGUIAR ACTIVITIES OF THE RADIOTHERAPY DIVISTON

8:00 = Curietherapy patients evaluation and plan-

ning clinic

8:00 ~ Head and neck cases followup clinic

12:00 = Oncedegic Hospital new patients conference

2:00 = Examination of new patients end

consultation

7:30 = Journal Club

8:00 = Application of radioactive material

Pelvic cases fellov-up clinic

12:00 = Oncedogie Hospital new patients conference

1:00 = University Hospital tunor conference

1:30 = Municipal Hospital tuncr conference

1:00 = Examination of nev patients and

consultation

8:00 - 10:00 asm, Radictherazy Grand Rounis

10:00 = 12:00 asm. Radiotherapy Staff and consultation

conference

12:00 = 1:00 pem. Onccllogic Hospital new patients

conference

1:00 = 5:00 pom. Examination of new patients and

consultation

5:00 pam. Curietherapy cases evaluation

8:00 = 10:00 asm. Esophagus cases follov-up clinic

11:30 = 12:00 asm. Oncologic Hospital morbidity conference

2:00 - 1:00 pm. Oncologic Hospital new patients

conference

1:00 = 5:00 pem. Examination of new patients and

consultation

8:00 - 12:00 asm. General follow-up clinic

12:00 - 1:30 pem. PRNC Seminar

2:30 - 3:30 pam. Radiotherapy Weekly Conference

?eletherapy applications are scheduled for the PRNC and

Oncologic treatment areas from 8:00 to 12:00 asm. and

1:00 t0 5:00 Dette

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puns 2

BADIOMERAPY AND CANCER DIVISION TRAINEES, 1:

BADIONERAPY RESIDENCY PROGRAY

1. Silvio Aristizdbal, M.D. - Colombia - August 2, 1965 to present,

Tow in his third year of residency in the Radiotherapy Diviston,

Félix Rodriguez Cabrera, M.D. - Venezuela - Jamary 1, 1967 to

February 10, 1967, Had to interrupt his training because of

health reasons.

2

SPECIAL SHORT TERM RADIOTHERAPY TRAINING

1. Dr. Herman Nussbaum - U.S.A, Experienced radiologist receiving ?a year of advanced training at the San Francisco Tumor Institute; spent the month of March 1967 training at the Radiotherapy Division, His training was supported by the U.S, Public Health Service.

Dre Jacobo Ramos - New York - Novenber 1967. Dr. H. Treitel = New York = December 1967. One month training for residents in Radiology at the Veterans Administration Hospital in Bronx, New York, by special arrangenent with Dr. B, Roswit, Chief of Radia~ tion Therapy Service at that Institution,

CANCER COURSE FOR MEDICAL STUDENTS

2

One month training for third and fourth year medical students at the U.P.R, School of Medicine under the auspices of the Cancer Control Division of the P.R. Department of Health and the National Cancer Institute Radiation ?therapy Training Grant.

1987 eA. - ith Year 1967

Jamary José A. Lozeta October Carlos M Rivas

Frank Kolodziej £

a pk Decenber Carlos M, Ramirez

Jorge A, Blanco

May Robert M, Friedman

June Juan A, Torres

Iuz M. Lopez x

July ?Nitza A. Vanga 2281

Iuis A, Vazquez gune

August =? Manuel Nater Antonio R, Villanil

Iuis A, Oliver duly Juan Me Rosa

José V, Figueroa

---Page Break---

mame 3

?CLINICAL RADIATION THERAPY ACTIVITIES

A, Distribution of New Cases Treated in the Radiotherapy and

?cancer Division

BY SITE

ORAL CAVITY 6

?Antertor 2/3 tongue 19

Floor of mouth ES

Other aL

?oROPAARIO. 105

Base of tongue

Other

as

HYPORARTI ue

TASOPEARII 9

[RESPIRATORY SYSTM 6

?Paranasal sinuses

BBE

DIGESTIVE SYSTIM 95

Esophagus

Other

re

BREAST 103

Bs Telgtherapy Applications

(e060, X-ray, and Cesium

Cy curgetherary

(co, Radium, Iridiun)

Dz Follow-up

By Consultations

FINALE GENTTAL ORGANS 9

Cervix Uteri ar

Endonetrius Ea

Ovary uy

Other uy

MALE GENTIAL ORGANS 10

?URINARY ORGS Ey

Bladder a9

Kidney 6

sc 6

[BRAT AND TERVOUS SYSTOM ae

BONE AND CONNECTIVE TISSUE 5

?LMGHATIC AND HENATOPOTETIC syed 3

Hodgkins disease 2

Other 32

ona ag

rom. om

6,169

259

5,393

315

---Page Break---

TABLE 4

AINEES NOW

University of Miami

National Cancer Institute, Mexico city

National University, Caracas

- Juan Reusche Radiology Institute Cayetano

Heredia, Lima

Alva Roffo Cancer Institute, Buenos Aires

. Ernesto Amadey Universidad Nac: del Nordeste,

Dr. Lucas Di Rienzo

. Arturo Valencia

lapoleén Matos

Dr.

Miss C. Ramirez examin=

ing mould work used in

radiotherapy.

---Page Break---

information on the distribution of cases treated in the Radio-

?therapy and Cancer Division; and Table 4 provides information on

former trainees.)

The training progran was eshanced during 1957 by the partici

pation of the following consultants and presinent spectalhats fren

other institutions: Dr. Alfred Gellhorn, Chief, Inetitute of Ca

cer Research, Columbia University and Head, Department of Medseine,

Francis Delafield Hospital, llew York City; Dre Jerome Yaeth, Dic

rector and Chief of Radiotherapy, San Francisco ?mor Institute,

Sin Francisco; Dr. carl Hansen, Director, Radiation Research Pro=

gran, National Cancer Institute, Bethesta; Dr. Bernard Rosrit,

Chie? Radiation Therapy Service, Veterans Adninistration Hospital,

Brom New York City; Dr. Herman Siit, Associate Radictherapist,

Radiotherapy Department, M.D. Anderson Hospital and ?hmor Insti-

tute, Houston; Dr, Willian Caldwell, Associate Professor of Ra~

Giolégy and Chief, Radiotherapy Division, Shool of Medicine,

Vanderbilt University, Tashville; ani Dr. AW, lias, Principal

Research Officer, Patterson laboratories, Christie Hospital and

Folt Radiun Institute, Wanchester, England.

The Division staff also participated in the teaching of other FRNC training courses, the weekly Tumor Conference of the UPR School of Medicine, the weekly ?humor Conference of the San Juan City Hospital, and the daily New Patients Conference of the Onco-logic Hospital. Dr. Antonio Bosch continued supervising the Ra-@iotherapy Technicians Course for the Oncologic Hospital and other nenbers of the Division staff participated in the teaching program until the course terminated in May.

REGUARCH IN PROGRESS

The following research projects were active at the end of the year:

Dose-time relationships in the external irradiation of carci-noma of the uterine cervix: comparison of 4,500 R vs. 5,000 R.

Fractionation in radiation therapy of carcinoma of the uter-ine cervix: 3 vs. 5 fractions per weeks

Fractionation in radiation therapy of inoperable breast can-

cer: lvs. 5 fractions per week.

---Page Break---

In the photos, clockwise:

Or. Ghelman loading radio-

active sources for curie=

therapy; Mrs. Lozano engaged

in dosimetry work with the

Telecesium unit; Dr. Arenas

and technician plan radiation

therapy of oral cancer in a

patient.

---Page Break---

Fractionation in radiation therapy of head and neck eancer:

3 vs. 5 fractions per week. oe cancers

Split-course technique in radiation therapy of cancer.

Study of results of trestuent techniques in adenoe

of the endometrium, " Sreinone

Surgical adjuvant breast project (participating in a Nation-

al study),

Carcinoma of the cervix in sterilized women,

Study of prophylactic irradiation of adjoining anatomic 1ym-
Batic regions in Hodgkin's Disease (participation in a National
project).

Radiotherapy for carcinoma of the prostate - Stage C (partici-
pation in a National study).

Study of the incidence of leukemia in patients with cervical
cancer treated with radiation (participation ina National study).

EESEARCH COMPLETED

Study of the optimal tumor dose in radiation therapy of can-
cor of Ee etophanus: 5000 Nin Pour weeks ve, 6000 Rin 6 weeks.
This project was ended when a total of 200 cases were accumlated.
The data will be published when a mininal two-year follow-up is
achieved for all cases. It appears that the results to date con-
firm the preliminary impressions reported in the PRNC 1966 Annual
Report, page 61,

The significance of persistent tumor cells in the vaginal
suear after radiation therapy of carcincna of the uterine cervix:
stic significance. This project was ended and its results
presented at the anmual meeting of the American Radiun Society in

Toronto in Nay 1967. The paper has been accepted for publication in the American Journal of Roentgenology, Radium Therary and tu-clear Nedicine.

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ou

Prelims sis of the study: Fractionation in radia.
tori therapy of careinona of the uterine cervix: Two joa ee
Of prospective study of 3 ve. 5 fractions per week, to hea?
cases were analyzed. the prelininary results of this stuay et
gest @ more favorable situation regarding completeness of vrs.
nent and survival, when the stated weekly dose is delivered te
three fractions versus the conventional fractionation; this £2
more notable in the advanced cases.

Study of modified "split-course" technique in the treatment of cancer of the esophagus (see PRNC 1966 Annual Rey Page 66),
A total of IK cases were included in the study. Tt was found that this technique is well tolerated by patients. Due to time linita-

tions caused by contimal use of the therapy machines, the project
Was discontimed, to be resumed at a later date,

A pilot study of a ?oplit-course" technique in the treatment of advanced cancer of the urinary bladder and of the uterine cor-

Vix, Details of this study appear on page 66 of the FRNC 1966 Tin nual Report. It has been found that two courses of 2500 R adminis tered in 10 daily fractions of 250 R each in a two week pericd, separated by a rest period of 2-3 weeks prior to curietherapy, is well tolerated by patients with advanced cancer of the uterine cervix. Advanced bladder cancer cases tolerated well two and at times, three courses of irradiation with daily fractions of 250 R for 10 fractions, separated by rest periods of two to three weeks.

The influence of the intracavitary curietherapy applicator in the prognosis of cases with carcinoma of the uterine cervix. This project was reported in the PRNC 1 ?Annual Report on page 66. The study has been completed and is being prepared for publica- tion,

Evaluation of treatment results in carcinoma of the bladder. From 1950 to 1965, a total of 179 cases with bladder cancer were seen at the Oncologic Hospital. Surgery was the preferred treat- ment, with radiation therapy used for inoperable cases or post- surgical recurrence. The overall five-year survival achieved was 28%. A complete course of radiation therapy for surgical recur~ rence or persistence produced a five-year survival ¢ 30%.

---Page Break---

total of 51 cases were submitted to radiation thera,

ip because of
inoperability or post-surgical persistence; the five-year surviv-
2 AgMeved in the group with non-pituitary lesions (49 cases)vas

STAFF

Dr. Guillermo Gémez Cérdenas, Radictherapist at the Instituto Nacional de Cancerologia in Bogota, Colombia, joined the Division staff on May 15, 1967, to serve as a Visiting Radiotherapist. While Dr. Gémez is carrying out educational and clinical recearch activities, he is receiving advanced training in radiation thera-
PY

At the end of 1967 the Division staff included 4 radiothera~ pists, 1 visiting radiotherapist, 1 physicist, 1 assistant physicist, and 1 biostatistician. Additional paramedical services were provided by 1 research medical records librarian, 3 graduate murses, 3 office employees, and a photographer-electronic technician. ?the Division staff is still not large enough to handle the present needs, especially at the radiotherapist level. ?he present load should be handled by 6 radiotherapists.

SCIENTIFIC MEETINGS

During 1967 various staff members presented scientific papers at professional meetings and these are listed in the Appendix. In addition, Dr. Victor A. Marcial attended the First Gray Memorial Conference at the Mount Vernon Hospital in London, England on September 20-22, 1967. Dr. Jeannie Ubifias and Mrs, Marfa Palacios de Lozano attended a meeting on Computer Dosimetry sponsored by Washington University in St. Louis, Missouri on Novenber 11-12, 1967. Dr. José M. Tomé attended the Annual Meeting of the Radio-Logical Society of North America in Chicago during the period of Novenber 25 - December 1, 1967.

---Page Break---

Or. Ferrer Monge studies the cytogenetic effect of ionizing radiation, using irradiated root tips of Vicia faba. Be-low: Drs. Koo and Kamath at the control console of the x-ray spectro-meter used to produce monoenergetic x-rays,

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AGRICULTURAL BIO-SCIENCES

The purpose of the Agricultural Bio- Sciences Division remains a two-fold one: first, the training of students in agricultural research in its broadest sense, emphasizing nuclear techniques; and second, the contimuation of basic research prograns which are concerned with problems in tropical agriculture that can uniquely be studied by mclear techniques.

EDUCATIONAL ACTIVITIES

In 1967, the Division continued to further the application of nuclear technology in the agricultural and biological sciences. ?This was done in part by training students in agricultural and biological research, with emphasis upon nuclear techniques. Training was frequently related with the Division's basic research activities, which are outlined in 9 later section.

During 1967, the emphasis upon training contimed to be airected tovard the graduate and post-graduate level, since graduate programs in science at both the Rfo Piedras and Mayaguez cam puses of the University of Puerto Rico are nov well established. ?As honorary menbers of the various science departments of the Uni~ versity, Division staff offered the following courses during the year:

Instrumental Techniques in Biological Research - Dr. S.H. Kanath, This course was offered through the UPR School of Medicine and was attended by six graduate students, two of whom were faculty members. It was the first time a course in instrunental analysis with biological orientation was offered at the University.

Radiobiology - Dr. ReA, Iuse, Dr, JeA. Ferrer-Monge, Mr. J. Cuevas. Five graduate students at the University in Mayaguez attended this new course, which made extensive use of the PRNC gamma facility for laboratory experiments--an uncormon feature in

such courses.

ties - Dr. J. Ferrer-Monge. ?his course serves as

core for one of the three areas of specialization chosen for

emphasis in the graduate program by the Biology Department in

Mayaguez.

Biology: Research and Thesis. - Dr. F.K.S, Koo. ?This course

was taken by students doing ?thesis work in biology.

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conomy: Research and Thesis - Dr. luse. Thi,

was taken by sbudents doing M.S. theses in agriculture ® CO

Eee ae

sity's course in radiochemist: 7 ~

sity's 6 renistry, and the PRIC course in tise

Graduate Research

The munber of graduate students engaged in research for m5 degrees in biology or agriculture contimes at the 1956 level,? which was double that previously. ?Their research topics reflect ?the broad interests of the Division:

, Effects of tonizing radiation on enzyme kinetics - Adriana Baez (Puerto Rico). ?This project is designed to determine quantitatively the relative radiosensitivities of the two enzymatic activities of a bifunctional system. ?he peptidase and esterase activities of carboxypeptidase A were chosen for study. This

work was discontined due to lack of funds.

Effect of temperature on the mitotic cycle of Vicia faba - Carmen E. CintrOn (Puerto Rico). the effect of tenperature (in the range 0 - 40°C) on the mitotic frequency, synthesis of DMA, and frequency of chromosone aberrations in the broad bean is being studied. Completion is expected late in 1958,

Radiation inactivation of the enzyme polyphenol oxidase - Aiaa Garefa de Fournier (Puerto Meo}~ Estimation Of the molecular weight of this enzyme, vhich may be a mononer or tetraner, has been made fron the radiation sensitive volume and found to agree well with the tetraneric weight. This thesis will be com

pleted by March, 1968,

Effect of ionizing radiation on levels of plant nucleic acids - Tsu Hui Lin (Taiwan). New chromatographic methods using NAK columns effect separation of several fractions of plant mucleic acids and permit their quantitative analysis following various irradiation treatments, ?This work was discontimed after seven months when student transferred to Texas A&M University.

Fixation of phosphates in tropical soils - José Narvaez (Nicaragua). ?The fixation of Phogghorus by four Puerto Rican soils was determined by addition of 3*P-labeled phosphate salts to soil columns, their elution with water or acid, and subsequent measurement of eluted ("non-fixed") phosphorus by radioactivity and chemical techniques, ?Thesis was completed in August and student has returned to Nicaragua to conduct soils research.

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Rodiation-indueed delay in ripening of bananas - Joagufn oy ver {hstte Hico)e the entent of delay in Tipeniay of Johnson ay

Montecristo variety bananas given lov doses of gama irra
has been determined. ?The interaction of radiation delay with oct
sequent artificial ripening by chemicals also has been studiea
This thesis will be completed in the spring of 1968, *

Host plant preference of Diatraea saccharalis (Fab.) - Vieto
piano Quintana (fuerte Rico). Seaccnal-curveys? of ?the infects.
tion by the sugar cane borer in 120 species of grasses have bees
nade, using the University's world grass collection. ?the eight
grass species with greatest borer infestivity are now under
to determine the oviposition rate, survival rate, and development
time of the borer in each host. ?Thesis should be completed by

October, 1968,

Combined effects of chemicals and gamma rays on the production
of chromosomal aberrations in Tradescantia paludosa - Edith Robles
de Irizarry (Puerto Rico). ?Three chemicals (Gcthogeatfoine, 5
aminouracil, kinetin) and gamma radiation have been used separate-
ly and in combination to produce chromosome aberrations in Trades-
cantia paludosa root-tips. When the chemical and radiation were
applied in combination, synergistic effect was observed in the
production of chromosome breakages and interchanges at different
recovery times, ?he latter result is of special interest because
it indicates an interaction between chromosome breakages produced
by two agents. Thesis will be completed by May, 1968,

Influence of ionizing radiation on methionine utilization b;

E. coli - Frederick Rushford (Puerto Rico). Rapidly miltiplying

populations of E. coli exposed to various doses of gamma irradia~

tion are being studied as to their ability to incorporate 39S-la-

beled methionine into cell constituents, ?thesis is expected to

?be completed in early 1969.

Degradation b radiation of pectinic acid and related

polymers - Gregory Telek (Puerto Rico). Ionically-bonded gels

of citrus pectinic acid were studied after their ganma irmelie-

tion to determine the extent of depolymerization produced by

---Page Break---

Right: Atomic absorption

Spectrophotometry permits

measurements of trace met-

als in plant material at

the parts per million

level or less Here, Tech-

nician A. Colon runs plant

digests. Below right

Dr. Kamath collects frac-
tions following a chroma-
tographic run to separate
components of irradiated
biochemicals on the basis
of molecular weight. ? Be=
low: Technician M. Pagan
Prepares a sample of Eu
coli cells for irradiatio
with monoenergetic x=m

in a special micro-chai

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Grtogenetic effects of chronic game re SS
ronetaeie in Palicourea riparia - Ropert Venator (Puerto Rico
sogenesis In Pips wer stuied cytologically folloving a short
form chronic gama-irradiation in the rainforest at E1 Verde. In
General, the results show that the meiotic abnormalities in ni-
Grosporegenesis increased with dose and these aberrations ap-
peared to decay with tine. Pollen abortion was found to be re~

Tatively lov, presunably due to the small chronosones and poly-
ploidy nature of this species. Also uncovered in this species
were several inherent cytological anomalies such as cytomixis,
binucleate sporocyte formation, and polyspoy. This thesis will
be completed in the sumer of 1968,

Advanced Training

At a more advanced level of training, the Division provided
fa nine-nonth period of training to an TABA Fellov, Sergio Quadri
C., Assistant Professor at the University of Concepeién, Chile.
This wae a further example of the individualized training which
has been offered by the staff to four other trainees (sponsored

by ORINS, IAEA, the Peace Corps, and CAS) since 1965. Mr. Guadri's
research consisted of the exanination--by optical absorption,
photobleaching behavior, electron spin resonance, and thin layer
chronatography--of the radiation danage produced in thymidine,
ascorbic acid, and vitamin Byp. Working in cooperation with
nembera of the iysical solenees Division, Mr. Quadri was able to
Grradiate these compounds as solids in an organic glass hatrix at
TPK to stabilize reactive intermediates. Upon completion of

?these studies in December, 1967, Mr. Quadri returned to Chile where
he has becone a menber of a group studying radiation preservation
of Chilean food products.

"Atoms in Action!" Exhibit

?The Division staff continued to serve as Scientific Advisors

at the USABC "Atomos en Accién? Exhibit in latin America. In

1967 their activities were as follows:

site ane Sibjects covered

Panand City, RA, Iuse Food Preservation by Radiation

anand

Quito, Eouador D.W, Walker ?Insects Control by Radiation

sterilization

Quito, Ecuador J. Cuevi

Food Preservation by Radiation

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scientific research in latin Anerica has attained positive re-
?sults; research groups in El Salvador and Guatemala have requested
and obtained US\ID or local national government support for their
research in the past two years. Projects for insect control by
radiation sterilization are in active progress in Guatemala, El
Salvador, and Ecuador, Munerous theses have been supervised, so
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fiion of molear Sechuiques in Contra ant South Amerdoan agri-
culture.

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offers a solution to the declining yields returned by sugarcane,
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Gxperinente to detemine the radiosensitivity of seeds and buds to
{ee nixed gamma-neutron radiation produced in the FRNC megawatt
reactor were completed in 196, Subsequently, thousands of seeds
ani vegetative buds have been irradiated, germinated and planted
(nthe field. Second and third generation material, likely to con~
{ain a higher frequency of mitants, has been mass screened during
the past year using automated analytical techniques. Small tismie
Samples are taken fron each stalk; those individuals showing high
Sugar content are vegetatively propagated and grovn for later eva~
Justion in the Sugarcane Inprovenent. Progran of the University
Agricultural station, ?This year over 5,000 assays were run in the
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Gndieate that other favorable characteristics may be induced.

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tic effects of chronic irradiation on micor
rogenbeie te tateonee in Policoures riparia - Ropert Venator (Puerto Rico)s~

Falicourea riparia was studied cytologically following a short term chronic gamma-irradiation in the rainforest at E1 Verde. In general, the results show that the meiotic abnormalities in microsporogenesis increased with dose and these aberrations appeared to decay with time, Pollen abortion was found to be reatively lov, presumably due to the small chromosomes and polyploidy nature of this species, Also uncovered in this species were several inherent cytological anomalies such as cytomixis, binucleate sporocyte formation, and polyspory, This thesis will be completed in the sumer of 1968,

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experinents to determine the radiosensitivity of seeds and buds to he mixed ganma-neutron radiation produced in the FRIC megawatt reactor were completed in 1964. Subsequently, thousands of seeds and vegetative buds have been irradiated, geminated and planted in the field, Second and third generation material, likely to con~ tain a higher frequency cf mutants, has been mass screened during the past year using autenated analytical techniques, Small tissie samples are taken fron each stalk; those individuals showing high sugar content are vegetatively propagated and grown for later eva- Justion in the Sugarcane Inprovenent Program of the University Agricultural Station. This year over 5,000 assays were run in the chenical screening progran, with about 40 superior mtants found and propagated, Visible mitations such as wider, stiffer leaves Gndicate that other favorable characteristics may be induced.

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Another project directed toward improved sugarcane yields vas that of the radiation induction of resistance to the mosaic virus Gisease. Seven strains of sugarcane showing desirable breeding

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?

characteristics but susceptible to the virus were irradiated with mixed ganma-neutron radiation from the megawatt reactor. Over 2,000 seed pieces were irradiated at 2-3 kilorad doses and grow in the field. At present, some 1500 cuttings fron the first gen-eration plants (grown from the irradiated seed) have been grown to the second generation crop and tested for their virus resist-ance through a sandblast infection technique, Seedlings showing resistance will be incorporated into the University's breeding program.

2, Radiation Sterilization of the Sugarcane Borer,

Division activity in this research area is carried out by
Dr. D.W, Walker, with primary financial support provided by the
USAEC Division of Biology and Medicine, and is reported elsewhere
in this Anmual Report.

3. Radiation Preservation of Tropical Fruits.

Within the Division, considerable effort is now being
directed to the underlying processes associated with radiation
preservation of tropical fruits such as mango and banana, ?This
research supplements the feasibility studies which are supported
by the USAEC Division of Isotope Development.

To study the relationship between degradation of structural
polysaccharides in the fruit tissue and fruit softening, pectic
constituents were extracted from irradiated and non~irradiated
mangos, Here fruits of the Mayaguezano and Sandaresha varieties
Were irradiated to doses of 500 to 1,500 Krad and their pectic
constituents from the alcohol-insoluble residue were fractionated
on the basis of solubility and extent of methylation by successive
extraction with cold water, 0.5% EDTA solution, and 0,05N hydro-
chloric acid. Each fraction has been characterized by determina
tion of total uronide content, degree of methylation, and mole-

cular weight (both weight and mumber average). It was found that there was a nearly linear decrease in mumber and weight average molecular weights over the dose range studied, Water soluble pectinic acid exhibited considerable change in nunber average weight at doses above 1000 Krad and may be considered more radia-?tion sensitive than the other pectin fractions. the rather srall changes in extent of pectin depolymerization (5-15 percent for 500 Krad doses) result in appreciable loss of fimness in the irraii-ated mango, Nethoxyl content of the fractions decreased to ap-

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B

proximately two-thirds of control values when fruits were irradia-ed to 1000-1500 Krads. ?There was no appreciable change in the total uronide content of the various pectin fractions with increas-ing radiation dose.

Preliminary studies were carried out on the volatile components so important for flavor in the mango. Macerated fruit was swept with nitrogen and the volatiles trapped at liquid nitrogen temper-ature. Gas chromatographic analysis indicated a predominance of carbonyl compounds. New chromatography equipment is now being calibrated and a new low temperature extraction system is being ?built to permit quantitative studies of flavor in both irradiated and non-irradiated fruit.

Other Research

In addition to the Agricultural Bio- Sciences Division's basic research in agriculture, two projects of fundanental radicbiclogical importance are incorporated within the Division. These may be summarized as follows:

1, Resonance in Radiation Effects.

Tt has been shown that there exists a resonance in radiation effect in onion root tips containing BUDR, i.e., there occurs ?a maximum of chromosome damage for a given dose of monochromatic yerays at a photon energy at or near the K-absorption edge of bromine. ?These studies have been extended to Tradescantia paludosa root tip cells treated with BUDR and monochromatic x-radiation. Chromosome aberration frequency passed through a maximum at 13.5 Kev as x-ray photon energies were varied from 12.5 to 15.5 Kev, with 68 breaks per 100 cells found at 13.5 Kev (Br K-edge) compared with approximately 23 at 12.5 and 15.5 Kev. No such peak was observed in similarly x-irradiated cells containing no BUDR. These results seem to provide further support for the existence of the resonance in radiation phenomenon,

To test if this resonance effect is also expressed in mtation induction, experiments have been carried out using Escherichia coli

and Corynebacterium equi, In the present studies the same target atom, bromine, was incorporated into the bacterial DNA by treating the culture at log phase for five hours with 100 ug/ml concentration of BUDR. The samples were exposed for 18-20 hours to monochromatic X-rays of various energies. ?he irradiated as well as

---Page Break---

controls were plated on agar media for mutation and survival assay. Presented in the following Table are the results for all the series treated with both BUDR and X-rays (these results are not corrected for the slight changes in beam intensities and mass absorption coefficients at various photon energies).

oten Reversion rate Color_mutation

or iB goll rate tn' Gy equ

teers} 365) eat

12.5 0.21 0.36

13.5 1,02 0.85

el 0.39 -

15.5 o1 0.40

Apparently in both organtaus the mitation rates at the K-edge energy (13.48 Kev) vere significantly higher than those belov and above the K-edge energy. he reversion rates (from tyrosine-de~

pendent to independent) for B, coli obtained vith X-ray treatment Alone at these sane energy levels were very lov, ranging from a low as the spontaneous reversion rate up to 0.007 x 10, ?the average reversion rate for BUDR treatnent alone was about 0.15 x 10-6,? For color mutations (from the original orange color to red, yellow, white, etc.) in C. equi the mitation ratesfor X-ray treatment alone were again very low at all energies studied, ranging from the spontaneous rate to 0.05 x 10-3, The average mitation rate for BUDR treatment alone was about 0,09 x 10-3, ?hese results once again unequivocally confirm that the resonance phenomenon can be produced in genetic systens by low energy nonochromatic X-rays.

Previous work with metalloenzymes likewise has indicated that ?there is an energy dependence of damage (inactivation) related to the constituent metal. Catalase shows a ten-fold increase in inactivation at 7.1 Kev, the K-edge of iron, compared with danage a few Kev above or below this energy (constant dose). To determine nore precisely the nature of the danage produced by x-irradiation at the iron K-edge, irradiated catalase was studied by sone of the latest techniques of protein chemistry (molecular gel sieving, electrophoresis, fluorescent tagging), to determine the structural changes in the enzyme induced by such radiation. No cleavage of ?the protein portion of the molecule was indicated at totally in-

activating doses. Study of the release of iron fron the encyne's porphyrin structure is now in progress using very highly sensitive methods (fluorescence spectrophotometry, atomic absorption spectro-photometry, electron spin resonance spectranetry).

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2, Radicbiological effects of neutrons in plant systens.

In onder to further a world-wide progran being establich-ea ty the International Atnic Energy Agency, the Division has started experiments on the effects of fast and thermal neutrons in plant aystens. ?he firct of these, most directly related to ?the Agency's progran, is to utilize barley seeds as a biological dosimeter of neutron irradiators (such as reactors). By measure-nent of seedling grovth following germination of irradiated seeds, a useful index of the neutron flux and relative energy dictribu-?tion may be deduced without reliance on elaborate physical charac-terization, A second series of experinents now unterway by Dr. Ferrer involves the effect of tenperature on frequency and type of chronosone aberration in neutron irradiated plant tiesue (seeds, root tips). A third series of experinents initiated to determine biochemically the changes in plant micleic acid follow ing sub-lethal neutron doses was abrogated due to loss of person-nel.

Dr. Luse served in 1957 as President of the Sociedad Americana de Ciencias Agricolas ("American Society of Agricultural Sciences), and Mr. Cuevas as Secretary-Treasurer. Dr. Koo, in conjunction with menbers of the University of Fuerto Rico faculty, organized a seminar group called the "Geneticscope Club" to pronote exchange of new findings and ideas in the field of genetics and its allied @isciplines.

Dr. Luse was an invited participant in the FAO/IAEA study Group Conference on "Coordination of Research on the Use of Neutrons in Sed Irradiation" held in Vienna, Decenber 11-18,

The year 1957 saw the Division in new quarters in Nayaguez. The new Plant Sciences Building adjacent to the Greenhouse provides space for the tvo walk-in plant grovth chanbers, as well as ?two laboratories and a low temperature room. A new cytogenetics laboratory and a new biochenistry laboratory were constructed in space in the Reactor Building made available by moving the shops. ?The Division contimes to carry out field work in many sites on the island: a new plot south of Mayaguez (Cornelia Hil1), the ?two acre banana plantation near Mayaguez, and sugarcane plantings in Rio Pledras ani Gurabo.

---Page Break---

Right: Dr. Ramiro Martinez Silva using lamina flow hood in tissue culture. Below: Mr. Roger Ramos Aliaga with

Dr. Jorge Chiriboga viewing the special auto-

matic spectrophotometer.

Mr. Ramos Aliaga, from
the School of Pharmacy
and Bio-Chemistry, Uni-
versity of San Marcos,
Lima, Peru, is here
studying enzymatic kine=
tics for his doctoral
thesis.

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MEDICAL SCIENCE AND RADIOBIOLOGY

?the Medical Sciences and Radiobiology Division offers train-
ing and research opportunities in fundamental aspects of radia-
tion biology, biochemistry, parasitology, virology, and medicine.
Research is directed in large part toward biological problems en-
countered 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.

EDUCATIONAL ACTIVITIES

?The following courses were offered during 1967:

1, Tissue Culture and Radioisotope Techniques at Cellular and Subcellular levels. This course was offered in November, ?1967 under the direction of Dr. Martinez Silva, in collaboration with the UPR School of Medicine's Departnent of Microbiology. Participants were:

WE counmRY TEOTURES LABORATORY

Antonio Rodriguez, M.D. Cotonbia x

Humberto Rendon, "M.D. Ferd x

Berta Morales Lira, M.D. Fert x x

?Antonio Pedraza Ruiz Spain x x

Ivonne Lastra, Ph. De Puerto Rico =X x

Carmen Romaguerra, M.S. Puerto Rico =X x

Iylia Esther Parts Puerto Rico = -X

?Angel H. Torres Rivera Puerto Rico =X

Carmen Me Walsh de Rivera Puerto Rico -X

Aida Mercedes Diaz Puerto Rico =X x

Carmen Minerva Nieves Puerto Rico =X

2. Graduate Course in Virology. Sponsored by the UPR school of Medicine's Department of Microbiclogy, this course is offered at PRNC under the direction of Dr. Julio I, Colén, Associate ?Scientist (ad honorem). Participants, all from Puerto Rico, were: Dr. Ricardo Rosa, Wilda Alicia Méndez Neves, Guadalberto 1, Borrero Aldahondo, and Muri R. Rodriguez del Valle.

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3. Sueotal Training, he folloving persons vere given training in the topics listed: G

Tair Cleon	Medical Radicbiological tech	
Boje de Towa	Uruguay	student niques applied to Parae sitology.
Rosaura Puerto	Medical tech-	Chromatographic separa~
Rivera Rico	nician, Munici-	tion of aminoacids,
	pal Hospital	
Wilda B, Puerto	Public Health	Labeling of snail and
Knight Rico	Service	cercariae of Shistosom mansoni.
George V. Puerto	Veterans Ai-	Radiol sotopie techniques
Hyllier Rico	ministration	in immunology.
Bauardo	Uruguay 7 months	Iabeling of antibodies

?Touya, M.D. for the @iagnosis of

tuners.

Berta Morales Peri «2 months Chromosomal. techniques.

Tira, M. De

Inis Chromatographic techni

Barragin, M.D, Bolivia 1 month ques for separation of

Jabeling compounds.

Chromatographic purifi-

Chile 1. month cation of labeled com

pounds.

4, Ra@icbiology and Isotope Techniques, A special 3-day course at PRNC was offered to the following students as a contribution to a graduate course in Bubryology at UPR, Rio Piedras:

Melania Rodriguez, Dominican Republic; Zaidi Bagar, Pakistan, ?and Carmelo Camacho, Olga Vazquez, Maria Bobonis, Rafael Goytia, Miguel Bisbal and Ivonne Iastra, Th. D., all from Puerto Rico,

5. Orientation on PRNC Program in Tropical Nuclear Biclogy and Medicine. A special orientation was given on July 2, 1907 Zo the following postgraduate fellows attending a Tropical Medicine Course at Louisiana State University: Allan James Cooper, M.l

Hugo

Ranirez, M.

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4 MDes ary We ,

Ingersell, Woe cneasencs MERZ MIMI, Mss Rtn

6. thesis Rese 4 :

thesty reese Research. The folloving students initiated thetr

Source of Spon-

Kane Country Degree serehtp mitre

camen PR. Mastery NIH

Re er, Effect of irradiati

Rivera Mierobiology in interferen levels

Marto Master, NII_?_Bffect| of irradtation

josa, M.D. Microbiology of the antigenicity of

Eeho viruses

Roger Ronos Peri Mh.D, in PAD. Labeli s

De ing of cocaine

?linge Biochemistry and metabelie studies

orlando Ph.Ds in School Effect of irradiation

Rendén Prysislogy "of on chronosone function

(Preliminary Medicine on human diploid cells

work started)

COOPERATIVE RESEARCH AND TRAINING

Cooperative research and training programs are maintained with the following institutions and agencies:

A, School of Medicine, UPR

1. Department of Microbiclogy - Dr. Julio I. Colén, virologist, has been assigned to work at PRIC as an "ad honoren nember of the staff.

2. Department of Parasitology - ?The interchange of information and biological material with this departnent has been continued.

3. Department of Biochemistry and Nutrition - Dr. By

Toro Goyco, Associate Professor of Biochenistry and Nutrition,

has begun a study of the biochemistry of Schistosoma mansoni eggs

he is receiving help from the Division.

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ee

4, Dr. Jorge Chiriboga, Professor of Biochemistry (ad

honorem) at the UPR School of Medicine, has lectured at the De-

partment of Biochemistry.

B, U.S. Public Health Service

Cooperation on Schistosomiasis research with the group

headed by Dr. Frederick Ferguson has continued. Bionphalaria

dabrata snails are labeled with 89 gr and Schistosama cercarise

with se to study the biological characteristics. It is hoped

that these studies will eventually contribute to the control of

this disease. Mrs. Wilda B, Knight of the USPHS is assigned to

PRNC on a part-time basi:

C. Veterans Administration Hospital

A project on the resistance of mice to Schistosoma man-

soni introduced into the peritoneal cavity in Millipore diffusion Chanbers is being conducted by Dr. Menéndez Corrada and Mr.George Hyllier of the Veterans Adninistration Hospital in collaboration with PRNC, A note with the results is ready to be sent for publication.

Dr. P, Crosby of the VeA, Hospital is conducting research on xanthene-cxidase levels in mice infected with normal and irradiated cercariae provided by PRIC.

D, Schistosomiasis Laboratory

Dr. José Pellegrino, Director of the Universidad Federal

of Minas Gerais, Belo Horizonte, Brazil, spent one month at PRNC with the Schistosomiasis group.

Dr. Celio Murilo de Carvalho Valle spent three months at FRNC working on the rhythm of shedding of the Schistosoma cercarine by Blomhalaria glabrata snails, studing the effects of radiation on host-parasite relationships of snails infected with Schistosoma mansoni, and learning radicbiological and isotopic techniques in

parasitology.

E. Walter Reed Army Institute of Research

Dr. Lawrence S, Ritchie of the Walter Reed Army Institute of Research in Washington, D.C., has been temporarily assigned to

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RNC to collaborate with the Schistosomiasis group as an ad honoren staff member.

RESEARCH ACTIVITIES

Research is associated with radicbiclogical training activities offered at animal, cell and subcellular levels. Special emphasis has been given to the study of tumors and the effects of radiation on the host-parasite relationship in various biological systems using tissue culture, arthropods, snails, and other animals. schistosomiasis research is described separately in this Report. An account of current research, organized by sec~ tions, follows:

?A. Mammalian Metabolism Section

1 Seandiun-li6 to Test its Utility in

ation Dynamics Research. The study of the biological behavior of ?Se in the vectors of various diseases was continued, When in jgoted Anto the mouse either intraperitoneslly of intravenously,

?is permanently retained. When injected in the stomach st is eliminated within the first 24 hours. If ?se comes in contact with the skin it is not absorbed.

When the isotope was injected intravenously, @ blood clearance of i.6 hours was found. Lizards, frogs, and different

foaile such as Yariea cormarietti and Biombelaria glabrata were successfully labeled with ®S.

gq. me iver 1s the organ that picks up most of the activity when ?go is injected intravenously. After cell fractionation of the Liver, the mclei and cell debris have the largest activity.

Following intraperitoneal injection, most of the activity was present in the intestine.

Results thus far indicate that ?6sc is satisfactory for population dynamics studies.

The feasability of adding two or more radioactive labels

?that could be detected by whole body counting with gamma spectro-

metry to the predator of the snail, Bi ia glabrata, was

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ah

explored. This snail is one of the hosts of Schistosomiasis, a

parasite which affects man.

2, Nedemethylation of Cocaine and Nutritional Status -

Ten million natives of South Anerica's Andean regions chew coca

leaves, which contain cocaine. This addiction is associated with

the low nutritional levels prevalent among the population. In

rats it was denonstrated that cocaine reduces to normal levels the

high lipid content in the liver of the animals being fed ¢, low

protein diet. One of the goals is to label cocaine with ?4c in

?the methyl group of tertiary amine in order to learn about the

mechanism of methyl donation. ?The enzymatic N-demethylation of

cocaine has been studied as a possible important pathway in the

uetabolism of rats and mice. The Km. of the enzymatic reaction

for cocaine is 1.09 x 10-6 m (See Figure 1).

?The enzymatic reaction is catalyzed by a microsomal sys-

tem of the liver. ?The enzymatic system uses NADPH and Nett ag

cofactors, The system needs a contimous generator to produce a

reduced coenzyme, ?the animal's nutritional state changes the rate of the reaction. Animals with low protein diet have a 70% reduc-

?tion compared with the controls.

Chromatographic methods and chemical synthesis of the metabolites has been accomplished.

3. Correlation between body burden and Schistosoma pig-

Correlation between body burden and Schistosoma pigment in the liver of mice experimentally infected with Schistosoma

mansoni. *

4, ?the study of the effectiveness of Schistosomidal drugs with the aid of D9Fe. *

B, Mammalian Radiobiology Section

1. Radiation effect (69¢o) on the host-parasite relation:

ship in mice infected with Schistosoma mansoni.*

2. Susceptibility of mice to Trypanosoma cruzi.

a. Effect of irradiation. Because of mumerous

* See Schistosoma report elsewhere in this Annual Report.

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dizect or indirect physiological effects of radiation on animals (anemia, leucopenia, plama, electrolyte and protein disturbance, ulceration of the gastrointestinal tract, etc.), it is expected Yat the host parasite relationship in zice infected with Beypanosoma cruzi will be affected by radiation, In one experinent a group of newborn mice was irradiated with 400 Rads and another Group vas kept as contrel. Both groups vere inoculated ?by the Intracerebral route with 1025 ml of a five-day culture of Trypanosoma cruzi; thirteen days later the ariaals were bled froa the tail and tested for parasites. When the mice died, the tissues vere examined in search of pefasites, he results are sumarized in the Polloving table:

Non-Irradiated Control Irradiated (400 Rads)

No. of, Now No, of Nos

Bissue	Positives Examined	Positives Examined
Brain	T 7	8 8
Blood	2 7	8 8
Heart	° 6	5 8
liver	° 6	5 8
Spleen	° 6	6 8

As can be observed, irradiated mice showed 100% parasitemia when the controls showed only 14% ?The other organs shoved a still more striking difference.

(1) As can be seen in Figure 2, a radiation dose of 400 Rads induces death of the infected aninals at an earlier stage than in non-irradiated animals. Under these circumstances, the LDsq occurs in the irradiated group on the 17th day after inoculation: in the non-irradiated group, the same effect takes place 26 days after inoculation.

bd, Dime of radiation relative to infection, It has been reported that the monent selected for radiation during the course of an infection is of great importance. An experiment was designed in which mice were exposed to 400 Rads and infected at different tine intervals. the infective doses of Trypanosoma cruzi

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were administered ty the intracerebral route 7, 2, and 1

al route 7, 8) an 3 days

Yefore irradiation, mediately after irradiation, and 1) 2) and

Tiays after irradiations, the sesuita, swmarised in me?

dnowed an increased effect on noreality by Fadiavion, wore evi-

dant aten given one day after infection.

c+ Resistance in mice to Mypenosona crust infections

snquoed vy? ax SSE Sultana ta one mH Tresiated

SOT CeaeT Cent multiply in the mouse host without PPO

Hep disease ut inducing resistance, one experinent vas Ae~

Signed in which the strain Corpus Christi was subjected to aif

fetent radiation doses: A nonrirradiated group vas used a8

Sontrol, the six ice groupe treated aid not show parasitenia

within the first 2h days. Five of these groups were challenged

Whee he fulamsen etrein and the remuits are sumarized in Table 2,

3. Radiation activation of latent viruses in wild arthropods

and vertebrates.

a. Effect of Gama irradiation on the infection of mice

?and rats with Coxsackie virus, Adult white mice and adult wild

Fats Umttus Fattas), normally resistant to coxsackie infection,

were exposed to whole body radiation with gamma rays from a co-

Balt source of 1510 curies. Inmediately afterward, they vere

Jnoculated with coxsackie virus type ALO. Nonirradiated controls

sree inoculated with the virus at the sane tine. Nonirradiated

Neinoculated controls were also included in the experiment. These

(groups of aninals were bled daily and the virus content of the

Plood was determined in suckling mice.

me mortality rates in irradiated mice inoculated vith cox-

sackie virus type ALO are shown in Table 3. Virus inoculations

se frvadiated mice and in the group of mice irradiated with

in untyan hod Rada caused no deaths over a period of 21 days. ?The

jess ehthown in Table 1, that appeared in the groups of mice irra-

aeetea with 00 or more Rads and inoculated with virus, were

daereiees due to the irradiation and not to the virus. The pat

coupe deaths vas very irregular vhen the inoculated and un?

jer fated aud groups were compared, but the death rate increases

ino e average day of death decreases with the increase of radia-

Mont regardless of the presence of virus (Table 4). These rex

sults indicated that there was not a synergistic effect of virus

Shi?ganna radiation vhen only death of the aninal vas taken as

?the criterion. However, when infectivity was taken as the

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criterion, a consistently higher concentration of virus was denonstrated in the blood and tissues of the irradiated ones (Table 5). The viremia lasted for several days, depending on the radiation doses. Groups of mice irradiated with 100, 200, 300, and 400 Rads had a viremia that lasted up to 3 days. In the groups of mice receiving 500, 600, 700, and 800 Rads, the viremia lasted from 4 to 8 days, depending on the radiation dose. At present, we do not know if the virus is indeed replicating in the aice tissues or if it is just the inoculum that persists longer in the irradiated aninals. However, the high titer of virus recovered does indicate that sone multiplication is taking place in some of the irradiated groups.

The resulte obtained with the rats are very similar to those obtained previously with adult mice. Anong the rats irradiated with 400 Rads and inoculated with virus a significantly high concentration of virus was found in the blood from the first to the ?7th day after irradiation and inoculation with the virus. The rats irradiated with 600 Rads and inoculated with virus showed viremia on the 1st day which lasted for more than 7 days (Table 6). Although not at a very high titer, virus seems to persist longer

in animals irradiated with 800 Rade. Rats that were not irradia.
ted and inoculated with virus showed a very low titer virenia for
only one day.

b. Activation of coxsackie virus by radiation in adult

?After an observation 22 days follov-

ing the Original treatment, surviving mice were again tested for
the presence of virus in the blood, feces and fron sone selected
organs of animals that vere sacrificed. No viral activity was
found in the blood of any of these aninals nor in the organs of
those sacrificed. A second dose of irradiation (400 Fads) was

then given to these mice. After 48 hours they were bled, sacri-
ficed, and the following organs were selected and harvested
individually: brain, lungs, heart, Liver, pancreas, and spleen,
Pools of sinilar organs fron animals of the sane group were wade
and tested for the presence of virus in suckling nice, Viral
getivity vas found in the spleen, brain, heart, liver, and pancreas
(table 7). Only the original virus, coxsackie Al0, was found in
these organs. he important point here is that after the secont
irradiation treatment virus was isolated fron groups of mice that
just previously had shown no virus in the blood, nor in any of

the organs tested. Either the active virus had?been present dn
very low concentration, and was not detectable by our methods or

the virus was ina latent state and was activated by radiation:

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?the wild rats that survived 25 days after the original treat-
ment showed no viral activity from the 16th day after treatment.
These aninals were further irradiated with 600 Rads. Fifteen days
later they were bled, sacrificed and the following organs tested
for viral activity: ?lungs, heart, liver, pancreas, and spleen.
Coxsackie A10 was again isolated from the pancreas of rats that
were previously irradiated and inoculated with coxsackie virus.
?As shown earlier in the mice, here we also have an indication of
activation of a latent infection by radiation.

4, An attempt to induce immunity in mice to Schistosoma
mansoni using milipore diffusion technique.*

Cc. Invertebrate Metabolism Section

. Inbeling of Biouphalaria glabrata with Radioseleniun*

2. labeling of Marissa cormarietis with Radioseleniun
and Strontium 69."

3. Periodicity of cercarial energency.*

4. Iabeling of cereariae of Schistosoma mansoni with
radioisotopes.* ee

5. The antigens of Biouphalaria glabrata haenolymph.
characterisation and identification of bands by Imminoelectro-
phoresis.#

6. Tabeling the .osoma cruzi with 75se. josoma,
cruzi in the Tepe he aR phat yas given JOC ¢ Growth phase was given Joc of T9Se. After
Fraays the culture contained 1.72 x 107 trypanosomes and 60,400 cpm.
After centrifugation at 5,000 rpm and resuspension in a new seleniun-
free medium, 3 groups of mice were inoculated by the muscular, peri-
toneal, cerebral, and venous routes. In order to determine the
fate of the inoculated parasites, mice were sacrificed at different
intervals and total body counts, as well as of organs were made.
Results are summarized in Table 8.

D. Invertebrate Radiobiology Section

1. Effect of irradiation on the reproductive potential,
of Biomphalaria glabrata.*

% See Schistosoma report elsevhere in this Annual Report.

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2. Bftect of srradiation (60Goba1t) on the hostaparastte relationships In snsits infected vith Sehtstesien mannose

B, Cellular Radiobiology Section

1, Cellular lines derived from a murine chondrosarcona.

It was reported previously that at PRNC three cellular lines had ?been isolated and serially propagated in vitro from a mirine chondrosarcoma. Work is being carried out in order to determine characteristics related to the chromosomal complenent and inm-nology of the cells.

?The methods used to obtain the cellular lines as well as the chromosome study were reported in the 1966 Annual Report, page 85.

It was reported in the PRNC 1966 Annual Report that the DC Il-2 cells showed a bimodal distribution of chromosomes with peaks of 74 and 128, After cloning the cells it was possible to obtain a clone with a distribution of 69, while one of the clones showed 14% of the cells with 75 chromosomes and 86% of the cells with 136. ?The studies with DC-II-4 have showed a clone with a modal distribution of 70 chronosones.

2, Bffect of irradiation on Trypanosoma cruzi. Further studies have been conducted in order to determine the mechanism of action by radiation on Trypanosoma cruzi.

Besides the Corpus Christi and Bartoldo strains reported on in PRNC 1966 Annual Report, the Tulahuen strain of Trypanosoma (kindly provided ty Dr. ?Irving Kagan, fron, the National Communicable Disease Center, Atlanta, Ga.) was used,

Results concerned with modifications by the different doses of radiation under Morphology of Trypanosoma cruzi have been reported previously.

Reproduction: After exposure to doses ranging fron 100 to 100,000 Rads the lag phase is increased in relation to the dose. With 1,000,000 Rads, viability is entirely abolished,

In order to detemine the ability of irradiation exposed trypanosoma to incorporate thymadine into DNA, one experiment vas designed and the counts per minute pt H3 labeled thymidine determined per 3 days every 24 hours. ?The results, swmarized in Figure 3 show a close relationship with the growth in vitro.

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tivity in cells (Figure 4).

3, Bffect of Irradiation in muman diploid cells. - Himan lung fibroblasts of fetal origin (Wi-33) com be ultivated, in vitro for about 50 passages. When the cells have reached this state they are no longer able to divide and gradually die. ?This Process has been compared with aging in the superior animals and might be used as a tool for studing the effect of radiation on the aging process at cellular level.

During the 20th passage, WI-38 cells seeded in Leighton tubes (100,000 celis per m1) incubated for ' hours at 37°C. While attached to the glass they vere subjected to the following doses from a 6o source: 25, 50, 100, 200, and 400 Rads. After radiation the medium (Eagle's plus 10f calf serun) vas changed and the cells incubated again at 37°C. The cells were observed daily. When they reached a confluent sheet in the tubes that had received the higher doses of radiation, they were trypsinized, counted and split 1 to 2 in new Leigiton tubes. After 24 hours of incubation, one tube in each series vas renoved and the chrono-somes were counted. ?The other tube vas further incubated and

observed daily until sheets vere present. They vere trypsinized, Split 1 to 2 and the same process repeated. ?The mmber of splits of the control was considered the reference and compared with the irradiated cells.

Six days after irradiation the cells that received 25 and 50 Rads reached approximately the same population as the controls. However, the cells treated with 100 Rads reached only 50% of the control population, and those exposed to 400 Rads shoved a greater delay in division, reaching only 20f of the control group after

6 days. Byen though the cells exposed to 400 Rads were the most damaged, and alvays shoved a smaller population, this effect 1s not observed in the total mmber of cell divisions. They reach the same level of mltiplication and the cumlative munber of cells is not significantly smaller.

Chromosome alterations: When designing this experiment it was hypothesized that chromosome aberrations induced by radiation might lead to heteroploidy and, therefore, to the appearance of & nev cell line. In the experiments conducted so far, it has not been possible to obtain a new line of cells even with the highest

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93

radiation dose (400 Rads). Howevey i

However, qualitative atterati

?the chronosones were obtained fron split 1 to split s2 when the

cells had reached the Linit of their reproductive capacity,

Nev experinents are being planned in order to study

er he meta

olism of DIA and RU that could serve as a clue to understand

the observed alterations. © to unders ine

4, Effect of irradiation on the host-parasite relationship

of Trypanosoma cruzi at cellular level. As previously reported,

cell monolayers irradiated with doses fron 100 to 50,000 Rads

were able to support the cellular miltiplication of Trypanosona

emuzi. It was observed that the munber of parasites per cell

Was greater with increasing radiation doses. In order to study the radiation effect on cells infected with Trypanosona cruzi, one group of cell monolayers in Leighton tutes was irradieted with 6,400 Rads. The medium was replaced and the cells inoculated with 1,000,000 culture forms of Trypanosoma cruzi. Tue control group was treated ina sinilar way, dut Tt was not irradiated, Every 24 hours one tube of each series was renoved, fixed, and stained.

?The results (Table 9) showed a greater munber of parasites in the irradiated cells at an earlier stage. ?The mechanisn accounting for this phenomenon could be an alteration of the cellular membrane by radiation that would permit the earlier entrance of the trypanosomes. Once inside the cells, the parasites mltiply by binary fission with a generation tine of approxinately 12 hours, When the miltiplication of the Leistman-Donovan vodies reach a certain number inside the cells, the parasites undergo morphological changes. These are characterized by the acquisi-

?tion of protoplasm, appearance of a flagellum, and separation of

the mucleus-kinetoplast complex. At this stage, the parasite

becomes motile, enabling the cell to move. The maturation process continues until the elasticity of the cellular menbrane is overrun and the cell is disrupted, liberating the intracellular trypanosones. The liberated parasites swin in the mitrient media until they penetrate the new cells, to repeat the cycle. ?The whole process of intracellular infection fron the penetration of a single parasite

Into the cell, until the cell is disrupted and the parasite becones free,lasts about four to five days.

?An experiment was designed to determine whether the parasites reproduced in cultured mediun irradiated or non-irradiated, kept their

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ou

infectivity for mice and cells. Monolayers of DC-II Cells were irradiated, and one non-irradiated monolayer group was used sea control. Both groups were inoculated with 1 ml of cultured taysae Rosones and were left undisturbed during 4 days.? the medion a? changed and the cellular sheets washed three ?times with Hanks solution. The last washing was titrated in order to detemive the infective activity, both in mice and in cells. From the fourth day, the medium vas changed every 24 hours, the trypanosomes counted and infectivity tests in mice and cells were carried gut. The infectivity of trypanosomes was not affected for st

least a period of 32 days. (Figure 5).

Mouve iecity

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TABLE 1

lethality of 1, emuzi Infection on Mice Exposed to

400 Rads at Different Stages of Infection

Day of Infection Uso at 35 Days

1 860

-2 834

a 700

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4 87

+2 620

7 390

No Radiation 1,000

TABLE 2

Cross Strain Protection

Corpus Christi Death Rate

Group 1.5107 in mice i. p. Parasitemia (7-21 Days)

1 untreatea Sg ag/a0e 0-208*

2 60% x1 Hour Ey 23/23 23/23

3 105 Rade gif unk ui/ah

4 5 x 109 Reds Ga 8 17/17 L317

5 10 Rads dB p 25/25 25/25

6 Medium Only 8° @ 26/26 26/2

er

* Minimal and delayed (appearance in some up to 99 days).

#* 2/20 at 35 days; 7/20 at 9 days.

---Page Break---

?TABLE 3

Nortality Rates in Irradiated* Mice Inoculated and

Won-Inoculated With Coxsackie Virus

Mortality**

Radiation Not Inoculated Inoculated

Groups ads Ratio Per Cent Ratio Per Cent

I oO 0/16" ° 0/14 °

Ir 100 0/14 ° 0/12 °

IIL 200 Of15, ° ofa °

wv 300 0/16 ° 0/16 °

v hoof we Wak ag

vI 500 /y 29 w/t 29

vit. 600?«10/14 70 6/uy 43

VIII 700 14/14 100 14/1k 100

x 800 14/14 100 16/16 100

Mitice (28-30 weeks old) were inoculated with 105-7 suckling

mice coxsackie virus type Al0 imuediately after irradia

tion with gamma ray from a cobalt60 source of 1,510 curies

**Animals were observed for 21 days.

?eelumerator is the mumber of mice dying; denominator is the

mumber of mice exposed to risk.

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TABLE 7

Viral Activity in Organs of Mice Irradiated* With Gamma

Rays and Inoculated With Coxsackie Virus

??

Number Organs Testea**

Treatment of © ???__

Groups Fads Mice Spleen Brain Heart liver Pancreas

?e_s _Mice Spleen Brain Heart __Idver__Pancreas

I ° 7 - o ° = ©

Ir 100 T = - = = -

ur 200 6 - - = _ a

v 400 5 = + = + +

v 500 5 = - - Z

VI 600 5 - - -

?lice (28-30 weeks old) were inoculated with 105-71D, suckling mice Coxsackie Virus Al0 immediately after the first @rradiation. A second dose of radiation 400 Rads was given 22 days after the first irradiation dose vas given.

?Similar organs of the animals of a group were pooled and tested for viral activity in suckling mice.

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Above: Silvio Aristizabal, M. D., a radiotherapy trainee from Colombia, is taking @ radiobiology course in the Medical Sciences and Radiobiology Division. Below: Medical School student Gualberto Borrero propagates sindbis virus into chicken embryo by inoculation. Observing are Dr. Julio I. Colom and Research Associate Mrs. Mirta Toro de Rodriguez

Sawer

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Right: Control rod drives and operating Platform for one kilo-watt reactor. Below: Reactor control room.

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REACTOR

The Reactor Division offers support and services to other divisions of PRNC which require neutron and/or gamma irradiation. It operates and maintains: (1) a one-megawatt, pool-type research reactor, (2) a ten watt, aquecus-homogeneous L-77 reactor, (3) a cobalt sixty gamma irradiation pool, and (4) high level hot cells.

Jhe Reactor Division also operates and maintains all the auxildary equipment associated with the reactor such as bean tubes, rebbit system, fuel elenent irradiator ani gama room, transfer port, etc., and all pool water cooling and purification equipment.

During the year, the one-megawatt reactor has been operating routinely two shifts per day, five days a week accumlating a total of 2939.76 megavatt-hours. During thie sane period, a total of 968 side-cf-core irradiations were performed. In the gamma pool a total of 747 irradiations were carried out.

?The L-77 reactor has been used intermittently for training and student experimentation. During the month of August, a pile oscillator was introduced in the I-77 reactor core, This oscillator is being used to carry out the experimental portion of the work of a graduate student.

Preparatory work to determine the worth and characteristics of the oscillator poison material and calibration of the associated electronic equipment vas perfomed during the remainder of the year.

Installation of the one-kilovatt reactor facility in the north end of the one-megawatt reactor pool has been completed. Fuel grid plate, control rol drives and nuclear instrumentation have been mounted and tested. Installation of the ionization chambers is the only work remaining to be done,

A draft of the "Final Safety Analysis Report for the PRIC One-Kilowatt Reactor" has been prepared and submitted for ABC review and approval. Other documentation for which AEC approval is required prior to reactor startup is being prepared.

During the year, an experimental run with the one-megawatt reactor was carried out. This run was made at two megawatts and was of approximately three days duration. From the information gathered from this experiment, it was determined that the power

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level of the present reactor can be increased to two megawatts with minor modifications to the present reactor operating limits.

?A recommendation to that effect has been submitted,

EDUCATIONAL ACTIVITIES

Mr. Fernando Lépez-Carrasco, from México, finished his reactor supervisor course in June. He is now finishing the thesis work necessary for the completion of the requirement tovard the M.S. degree.

During this year, the Reactor Division initiated a Reactor Operator Refresher Course. ?his course is designed to review all the material covered in the original reactor operator course and to bring up-to-date the operational aspects of the operator's duties which have changed during the past years. Course duration is expected to be two years. One operator trainee will become a qualified operator after successfully completing the course.

SMAFF

Mr. Richard Brown-Campos, who served for several years as Reactor Supervisor, has been named Head of the Reactor Division. Mr. Pedro Cruz-Gonzélez, formerly with the Health Physics Divi-

sion, is now working with the Reactor Division as Associate Reac-

tor Supervisor. Also, Mr. Fernando Lépez-Carrasco is now working

Part time with the division as Associate Reactor Supervisor. Mr.

Ermatto Guerre, Associate Reactor Supervisor, left the division in

june, 1967.

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1967

1965

REACTOR OPERATION PER MONTH

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Personnel monitoring. The developing of the
films has just finished.

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HEALTH PHYSICS

Mayaguex vith two main functions: C1) it ereennen ae as a
needed for safe operation of the Puerto Rico Nuclear Center; (2)
At contributes to the educational and research programs of PRNC.
the responsibiiiticn of Fine Motto ey ane of FRE

The services (see Table I) include consultation and super-
vision, as needed, in all matters concerning safety and especial-
ly in radiation safety. The Health Physics publications, PRIC-1,
PRNC-2, PRNC-3, PRNC-1, PRNC-5, PRNC-6, and PRIIC-89, establish
the rules, regulations, and procedures to be followed by all
PRNC personnel for safe operation, and by the Division in fulfil-
ling their responsibilities.

In order to implement and enforce the safety regulations,
the Division instituted monthly safety inspections and establish

ed safety committees with menbers within each Division. ? Indoc-
trination on safety is offered to all PRNC personnel either
through special courses or through the safety coordinating com-
mittee.

?The education and research program includes: (1) courses in
basic Radiation Protection at the graduate level for students not
specializing in the field, (2) a progran leading tovards the M.S.
degree in Health Physics, (3) advice and supervision of student
research theses, (4) special training in applied Health Physics,
and (5) basic research.

rogram leading tovards the M.S. degree in Health Fhys-
es tobe béfered through the Department of Preventive Nedicine
265 Ranie'tealtn of the UR, San Juan campus, 1s being consid
ered. ?he program is expected to start in August 1968 pending
creas al of the Council of Higher Biueution of Puerto Rico, and
GRE ?U.s. Atonie Energy Comission.

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Table I

?The following services are offered by the Division to any
other project at PRNC:

&. Personnel monitoring* J. General laboratory safety

D. Area monitoring k. Industrial safety

¢. Calibration of radia~ 1. Fire safety

tion monitoring equipment © m, Consultation on matters

4, Radioactive materials concerning all safety, es-

handling pecially on radiation ani

Environmental surveillance radioactive materials.

Dosimetry* n, Indoctrination of staff men-

Muclear accident dosinetry* bers in Health Physics, In-

Decontamination dustrial liygiene, Industrial

Waste disposal Safety and Fire Prevention,

¥* This service is also offered to BONS.

SERVICES

A11 service functions have been improved with emphasis on prompt service. Procedures have been revised and updated. ?the PRNC 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 progran, now in de~ velopment, becomes effective. Personnel monitoring films are nov

deing supplied to the T. Gonzélez Martinez Oncologic Hospital, University Hospital, the UFR School of Medicine, and the BONS power plant, as well as to PRC personnel (see Table II).

?The enviromental surveillance of soil, water, and vegeta ?tion in the vicinity of Mayaguez was discontimed. Only one sample of each is collected in addition to a water sample fron the well of the India brewery, and these samples are processed monthly. ?The laboratory, however, is maintaining complete capa- bility of performing a surveillance in case of an emergency.

?The construction of the calibration facility was discontimued. New constructions in Mayaguez permitted the Division to hold the old calibration facility for lover range calibrations. The 20 Ci Cesium 137 source will be placed in one of the hot cells which will be modified into a calibration room for higher range cali-

brations.

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?The installations at Cornelia Hill will not be used at the present time. The film badge service and the Muclear Accident Dosimetry (NAD) program will remain at the same place. A com-

plete revision and updating of the NAD program is planned for the next year.

The radiation safety program at the Oncologic Hospital has greatly improved. Our aim is to adequately train hospital personnel so that they can implement the progran under our supervision. The program, except for the film badge service, 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 of the nurses in charge of the patients carrying radioactive sources, and indoctrination in Health Physics to new hospital personnel.

All necessary Health Physics assistance was given to the oncologic Hospital during the transfer of a Cobalt-60 ?Teletherapy unit from the San Juan City Hospital to the Oncologic Hospital.

?A rough draft of an emergency plan relating PRNC problems and competencies to the surrounding comunity was prepared.

New procedures for the production and use of radioactive materials are now in effect.

?Two committees were organized to deal with all safety problems. ?The committees have branches both in Mayaguez and in

Rio Piedras. ?he first consists of all division heads and one nenber from the Director's office. Through this committee, general safety policy and rules will be approved. ?The second consists of one member from each division who has supervisory or technical background. Through this committee, follow up of recommendations will be implemented, Ihdoctrination of personnel is offered in two ways: first, through safety institutes both in Mayaguez and in Rio Pledras in conjunction with the Labor Depart~ment of the Commonwealth of Puerto Rico; and second, through lectures, personal contact and information pamphlets and posters supplied by the National Safety Council.

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SES

Health Physics Services 1967

Film Service to PRNC and BONUS ?~

Bota Gama Neutron totals

PRNC 5,41 853

BOWS 1337 L110

?Total 6,748. 1,963 8,71.

Radiation survey neters calibrated:

gamma, 149

neutron ?23

total fe ae

Area monitoring samples analyzed:

snears 896

water 7

air 2

Total 933 933

Environmental surveillance samples analyzed:

water ee

air 59

soil, 5

vegetation 45;

?Total 33 331

Review of questionnaires for reactor

experiments: 202 202

Review of requests for use of irradiation

facilities other than reactor: 4 4

Medical Dispensary - Number of cases seen:

minor accidents 83

physical exams 74

wr 1st

See

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13

EDUCATION AND TRAINING

?Te education progran in Health Fhyatcs has to
tives. ?The first. in to provide a grafuate progres Seen es,
the M.S. degree and advanced training in Appliet Health: Fresies
for siuients who are planing a career in Health Bysiess "tke
second is to provide indoctrination in radiation safety and
(generat a a8 well) for PRNC personnel and for students who
working with radiation source . °
wilt be workdng vith radiation souoes, but vo do ne fntend ©

Taree students were accepted during the year in the Health
Mhysics master's progran: Amalia Vélez Paradis; iuis Martinez
Bayréns "Efigenio Rivera,

One student was accepted in the Applied Health Physics Pro-
gram: Ignacio Maldonado-Rico,

Three courses, one at the College of Arts and Sciences, Na~

yaguez, and the others at the School of Public Health, San Juan, have been given for non-specialists. Bach course covered such topics as: basic mclear physics, radioactivity, interaction of radiation with matter, the biological effects of radiation, Instrunentation and methods of measurenent, and the principles of handling of radiation in all its forms. Public health aspects of radiation were emphasized in the San Juan course since the students were either physicians or sanitary engineers. In addition, lectures related to radiation protection were given as part of the regular PRNC "Radioisotope Techniques" course offered four times this year (see Table 3).

OLE IIT

List of Stutents

A. Biol. 601 (Health Physics): Aida Roca de Mari; Jorge Pérez Rivera; Efigenio Rivera; Michael Gileadi.

b. Rf Pi 232 (Radiation Hygiene): Tuts D. Dernier Rivera; pranises Fernandez Irizarry; Francioco Folch Castafiers Juan, Prangi fe lage} Rafuel Orta Allende; Radanés Rotriguez Guonins Tegret Sincher Valentin; Angel Santiago Garcia,

c. Radiological Physics Course for Residence in Radiology:

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Personnel monitori

on special film by n

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Jos$ A, Berlingery; Priseiiia Dfaz de carauj Bernanto J. Marquéss

José A. Nassar; Lidia D. Neves de Reyes; César H. Soto} santiago

Vidat,

?Thesis research status under the supervision of

Dr. Paraskevoudakis is as follows:

Determination of G-values of the Fricke Dosimeter for Mono-

chromatic X-Rays in the Range of 5 to 15 Kev. Francisco Jiménez.

?This work was completed and included a calibration of the calori-

meter, measurenents of dose rates of fluorescent monochromatic

X-ray beams. The student received his M.S, degree in August 1967.

Sensitivity Improvements of the X-Ray Calorineter. José Aguiar.

This work was completed and included the construction of two new

absorbers with reduced mass, use of new type thermistors, cons truction of a new Wheatstone bridge, noise reduction, calibration, and X-ray measurements, The student received his M.S, degree in August 1967.

Ganma-Ray Spectra Around the PRNC Reactor. Heriberto Cucbas. This work is Incomplete. ?he purpose of this study is to determine the spectral distribution of gama radiation around the reactor, ?The results so far indicate that the predominant ganmas have an average energy of about 0.1 Mev. ?The student is not working at the present time.

Study of Exposure Received by Patients During Chest X-Ray Examinations, Amalia Vélez. The purpose of this study is to determine the dose delivered to the patients during routine chest X-ray exposure in Puerto Rico. ?The age and the size of the pa-?tients, and the particular X-ray unit used, kVp, mA settings and the filtration used are considered, The entrance, the exit, and ?the gonadal dose are to be determined utilizing thermoluninescent dosimetry techniques.

BASIC RESCARCH

The calorimeter project. Sibstantial progress was made last year in the improvenent of the sensitivity of the calorineter. The purpose of this work is to measure the weak monochromatic

X-ray beams produced by crystal diffraction, The work so far has denonstrated that this is feasible. Povers lover than 0.05 wil can be measured. A new design of a miltiple bridge is completed

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and it 1s expected to reduce the noise level sufficiently to Pactan ROMGTS of the order of 0.02 ul. the power content or ai. fracted X-ray beams is considered to be within this . ~
Feo Reutron dosimetry project. This vork 4s also in progress senate dade complcted only if requested ty another project, pending decision on the new reactor. ?The data collected ve fer at the beam tube suggested the redesign of the plug systes with & new shutter and a new collinator 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 4s the purchase of a solid state neutron spectroneter, This aysten is the best available today for measuring neutron spectra. Tus it will be possible to develop fairly accurate neutron dosinetry for chemical and biological studies using the neutron beam and ?the pool as well.

?The enzyme inactivation project, ?This work has been reacti-vated recently. The purpose was to study the heat inactivation pattern or Horseradish Feroxide (HRP) in solution before and

after irradiation, and to determine the radiation danage intuced.
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. he new development includes reconfimation of HRP
results and use of other enzymes to check the sane effect.

of the tritiated water project. This work

du rnin of eae ee ate et
the tain Forests The transpiration of tritiate water fran the
wi aTtorest sols was studied in cooperation with the Terrestrial
Beology Project. the Terrestrial Ecology Project is studying the
Rovenont of tritiated water in soils, ani tle sealth Piysies Di-
eens eee ees ee aaa ie Leal enpatoe at
Phere. A cold trap technique using 1iquia nitrogen was utilised
fo coitect tritiun sanples fron 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. ?The results thus
far indicate that the transpiratin of water in the rain forest te
a very slow process. Following an initial rive of a fev howty
the activity persisted for several weeks at low ates. the rota
tive humidity was 80 percent. The experiment will be repated at
a higher relative humidity level in the near future.

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The phantom dosimetry program. This is a joint project with the Radiotherapy Division. Measurements are taken using the microrod teflon version of LiF thermoluminescent dosimeter in a plexiglass phantom. ?the advantage over the past technique is ?that one is able to place the dosimeters 0.5 cm apart. Dose distribution and depth dose measurements are being carried out.

x oe *

Finally, it is worth mentioning a new effort in measuring the gonadal? dose to patients undertaking abdominal X-ray exposures. It is felt that this kind of exposure may be more hazardous to the public in Puerto Rico than any other exposures The work will consist of compiling data throughout the island and will include statistical variations. This work has just been initiated and there are no reportable results as yet.

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10th anniversary symposium:

U.S. Ambassador to the OAS

Sol M. Linowitz reviews the

day's activities with PRNC

Director Henry J. Gomberg

prior to Mr. Linowitz's
symposium luncheon address
on October 31. Below: Par-
ticipants at one of the sym:
posium's technical sessions
many of them using simul ta=
neous translation "wands."

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OFFICE OF THE DIRECTOR

?The Office of the Director is responsible for planning and Girecting graduate level training and research activities and programs at PRNC, all of which are concerned with peaceful applications of muclear energy.

The Office serves as the focus of internal and external com munications for FRNC. Its staff prepares documents and reports on all organizational activities, assists in planning and managing special meetings and conferences related to PRNC's program, and participates in the teaching and research of several divisions of PRNC. ?the Office also handles the dissemination of public information.

MEETINGS

During 1967 the staff of the Director's Office participated in meetings outside of Puerto Rico, and assisted in planning and preparing for others held on the island, An account of participation in meetings not listed in the "Papers Presented" section of ?this Report follows:

Dr. Howard L. Andrews, Assistant Director for Health and safety, attended a meeting of Subcommittee 23 of the National Counett on Radiation Protection in Washington, D.C, on January 23-24.

In February, Dr. Henry J. Gonberg, Director of the Puerto Rico Muclear Center, represented PRNC at a meeting convened by the Educa~tion Committee of Associated Midwest Universities at Argonne National Iaboratory. ?The need for a conference on Nuclear Energy Biuca~tion in latin America, to be sponsored by Associated Midwest Universities, was considered at this meeting. Among others invited to participate in this meeting were: Dr. Carlos ?Vélez, Instituto Po-Titéenico Nacional, Mexico; Dr. Milton Campos, University of Minas Gerais, Brazil; Professor José Enilio Amorés, Instituto Tecnológico y de Estudios Superiores, Monterrey, Mexico; and Mr. John C, Cera, Division of Nuclear Education and Training USABC.

Following the Argonne meeting, Dr. Gomberg visited the mines

of the Inspiration Consolidated Copper Company of Arizona to ob-
Serve techniques, processes and problens related to copper mining
and refining, This information is needed in connection with
development of the FRNC program in "Plowshare."

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Fron Arizona, Dr. Gonberg went to the Nevada ?Test site as
an official observer of the Cabriolet shot in the Plowshare fro
gran. ?Though the shot was delayed because of adverse weather, ne
observed other related activity at the site, including inspecsinn
of results of previous tests, the U.S, Public Health Service fare
headquarters for study of fallout effects, and the luclear Rocket
?Test Station installations.

On February 6, a joint meeting of the Puerto Rico Radiation
Control Commission and the Radiation Advisory Board was held at
the offices of the Department of Health of the Commonwealth of
Puerto Rico in Gan Juan, Dr, Amador Cobas, Deputy Director of
FRNC, is a member of the Radiation Control Commission. The fol-
owing FRNC personnel are menbers of the Radiation Advisory Board:
Dr. Howard L. Andrews, Assistant Director for Health and safety;
Dr. Victor A. Marcial, Associate Director for Medical Progransjand
Dr. Sergio Irizarry, Head of the Clinical Applications Division.
All FRNC menbers attended.

?The purpose of this meeting was to initiate revision of Legislation governing the use of ionizing radiation in Pierto Rico in accordance with Law 79 dated June 24, 1965, In this Law the Governor of Puerto Rico was given the authority to eign an agreenent with the USKEC to assime responsibility for controlling the use of radioactive materials in Puerto Rico which is now controlled by the USEC. This responsibility will be assumed jointly vy the Departmentsof Health and Labor of Puerto Rico. This was the first meeting of the Commission and Board. At this meeting Dr. Hovard L. Andrews from PRC was naned chairman of the Radiation Advisory Board.

Dr. Gonberg represented FRNC at the USEC Bio-Medical Program Directors Meeting at the AEC Health and Safety laboratory in New York City on February 13-14. ?he first day and a half of the meeting was devoted to the Health and Safety Laboratory program, Aspects of procedures on clinical research and investigation involving human subjects were discussed during the program of the USAEC Bio-Medical Division, ?he Congressional Sib-Comnittee Report on Food Irradiation was also discussed.

On February 16-17, the Advisory Comittee to the Puerto Rico Wuclear Center met in San Juan, In keeping with the recormoniations of the USKEC Oak Ridge Operations Office, the Conmittec was

expanded and broadened to cover the physical sciences and engineer

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dat

Ang, in addition to biclogy and medicine. ?vo outstanding scientists accepted invitations from University of Berto Rico President Jaime Benitez to join the Comittee: Dr, Michael Ference, Vice President for Research and Development at Ford Motor Company, and Dr. Frederick Seitz of the National Acadeny ef Sciences. Also, Dr. John C. Bugher, who served as PRIC's Director from July 1960 to November 1966, accepted an invitation to return to the Comittee, on which he had served before be-coming Director.

Dr. Gonberg presented a paper at the Seminar on Applications of Nuclear Energy in Latin Anerican Development, held at UCLA on March 27-28. During the trip, Dr. Gonberg also made arrangenents for a future PRNC teaching progran in "Plowshare" technology+

On April 24, Dr. Andrevs, who is a past President of the Health Mhysics Society, officially installed the Florida Chapter

of the Health Miysics Society, in Jacksonville. Dr, Andrews also st-

fended a special meeting of the liational Acadery of Sciences Ad-
Visory Comittee to the Federal Radiation Council in Washington,
D.C. the meeting was held to consider the problen of radiation
exposure of uraniun miners.

Dr. Gonberg attended the Conference of Presidents ani Rectors
of caribbean Universities at the Crovn Point Hotel, Tovago, on
Ruri 27-30. He served asa delegate fron Puerto Rico at this
porting! together with UFR President Benftez, and participated in
seer aes fon" on research progran planning for developing countries.

on May 1, Dr. Gonberg went to Washington, D.C. to attend the
presentation of the Atonic Energy Commission Citation to Dr. John
©. Bugher, former PRNC Director, by Dr. Glenn Sesborg, Chairman of
?the USEC, the Citation included mention of Dr. Bugher's ?out~
standing leadership and foresight in developing and directing the
training, education and research prograns of the Puerto Rico Muclear
Center.

From Washington, Dr. Gonberg traveled to Mexico City for the
International Conference on the Utilization of Research Reactors
?and Reactor Mathematics Computation, sponsored by the Reactor Group
of the Centro Muclear de Mexico and by the Mathematics and Computa-
tion Division of the American Nuclear Society. At this meeting,
Dr. Gonberg net with Dr. Graef Herndndez, Chairman of the Nexican
?Atonie Energy Commission; Dr. Albert Barajas, Chairman of the Ai-

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visory Board of the Centro Nuclear de Mexico; and with starr members of the Centro, of the Instituto Politéenico, and of the Universidad Nacional Auténona de Mexico. Preliminary plans were nade to train Mexican students and staff at PRNC.

Dr, Victor Mareial, Associate Director for Medical Prograns, attended the USEC Bio-Medical Program Directors Meeting at the lawrence Radiation laboratory in Livermore, California,

On May 3, the Puerto Rico Chapter of the Health Physics Society was inaugurated by Dr. Walter Snyder, President-elect of the Health Physics Society, during a meeting in Mayaguez. Dr. Peter Paraskevoudakis, Head of the Health Physics Division, was installed as President of the new Chapter; Mr. Carlos Jinénez,an engineer at the BONUS Pover Plant, was installed as President-elect; Miss Heidi Pabén, Research Associate in the Health Physics Division, was installed as Secretary; Miss Rosa Julia santiago, Research Associate in the Marine Biology Program, was installed as Treasurer, Approximately 50 persons attended the meeting.

?The 15th Annual Meeting of the Radiation Research society was held at the San Jeronimo Hilton, San Juan, on May 7-11, Over

800 persons registered for the meeting,establishing a new attendance record. PRNC's staff prepared an exhibit for the meeting, organized a symposium on Tropical Radiation Ecology, and presented papers at many of the sessions. Dr. Bugher served as chairman of ?the symposium. The local committee, responsible for coordinating meeting activities, was staffed entirely by PRNC scientists:

Dr. Howard L. Andrews, chairman; Dr. José A. Ferrer Monge; Dr. Francis K,8. Koo; Dr. Robert A. Luse, and Dr. Peter Paraskevoudakis, Mr. Teodoro Moscoso, Board Chairman of Commonwealth Oil Refining Company and former Coordinator for the Alliance for Progress Program of the U.S, State Department, presented the address at the

Society Banquet.

On May 3, the Technical Sub-Committee of the Puerto Rico Committee for Bilharzia, held its quarterly meeting at PRNC in San Juan, Personnel from the following institutions attended: Puerto Rico Nuclear Center, U.S. Public Health Service, Puerto Rico Department of Agriculture, Fisheries Comission, Department of Health, General Clinical Research Center, UFR School of Medicine, Walter Reed Army Research Institute, and the San Juan Veterans Administration Hospital,

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On February 25, approximate

students visited PRNC in May

with the annual Open House sj ns

versity of Puerto Rico at Maya

members prepared exhibits in

Agriculture, Physical Sciem

and International Nuclear Ene

House. A documentary film

was shown at regi

photos on this page show vai

Open House at PRNC.

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On June 11-15, Dr. Gonberg attended a meeting of the Committee on Honors and Awards during the annual meeting of the ?American Muclear society in San Diego, California. On June 16, Dr. Gonberg visited the U.S, Department of Agriculture and the USIBC Headquarters in Washington, D.C. to confer with officials on insect control and other FRNC prograns.

On September 28-29, the PRIC Advisory Comittee met at FRIC,

Mayaguez.

On October 16-20, Dr. Wheeler attended the study Group Meeting on Research Reactor Utilization organized by the International Atomic Energy Agency at the Japan Atomic Energy Esta-Dlismment, Tokai, Japan.

Tenth Anniversary Symposium

?The UPR and the USAEC organized a "Symposium on Nuclear Energy and Latin American Development" to mark the tenth anniversary of the Puerto Rico Nuclear Center. ?The symposium was held at the San Jerénimo Hilton Hotel in San Juan, Puerto Rico during the period of October 29 to Novenber 1, 1967.

Among the distinguished participants in the Symposiun were: Dr. Glenn Seaborg, Chairman, USABC; Mr. James T. Ramey, Comuissioner, US\EC; Honorable Sol M. Linowitz,U.S, Anbassador to the Organization of American States; Honorable Ben S, Stephansky, Deputy U.S. Representative to the CAS; Mr. Teodoro Moscoso, former Director of the Alliance for Progress; Mr. Sam S, Sepirie, Manager, Oak Ridge Operations, USAEC; Mr. Jaime Benitez, President of the University of Puerto Rico; and Dr. Sigvard A. Exlund, Director General of the International Atomic Energy Agency. Mr. John T. Commay, Executive Secretary of the Joint Congressional Conmittee on Atomic Energy, read a "Statement" by Congressman Chet Holifield,

Vice Chairman of the JCCAE, to the participants.

Puerto Rico's Governor Roberto Ginchez Vilela and his wife attended the cocktail and dinner held on Monday, October 30, 1967, uring which Dr. Glenn Seaborg spoke on "Nuclear Energy in Latin - America." All participants in the Symposium were invited by the Governor to a cocktail in his hone, Ia Fortaleza, which was held on Tuesday evening.

Approximately 113 persons participated in the Symposium, including 25 from South and Central America, 49 from Puerto Rico,

and the remainder from continental United States and Burope.

On tlovenber 2, 1967, tours were arranged for the participants to visit PRIC facilities in either Rfo Piedras or Mayaguez.

From Novenber 6-8, 1967, Dr. Gouberg attended a mecting of the advisory group for program planning in nuclear energy activities (OAS Regional Scientific and Technological Development: Progran), as one of two representatives from the United States. the other representative was Dr. £.S, Friedman fron the Division of International Affaire of the U.S, Atomic Enerey Comission.

?The advisory group prepared a preliminary report outlining an international miclear energy progran. ?The necting was held in Oaxtepec, Mexico.

On Novenber 18, 1967, the Puerto Rico Chapter of the Health Physies Society held its quarterly meeting in the Conference Roam of the PRNC Bio-Medical Building.

?The following PRNC staff members presented brief payers at the meeting:

a. Marfa Palacios de Lozano, "Radiological Protection Problems Associated with Interstitial and Intracavitary Therapy"

b. Heidi Pabén, "Radiologic Protection in X-Ray Technology"

ce Peter Paraskevoudakis, "Health Thysics in Space

In addition, Dr. Victor Marcial, Dr, Oven H, Wheeler, and Dr. Robert A. Luse participated from PRNC. Dr. Charles Meinhola of the Brookhaven National laboratory spoke on "Health Physics ?Training in Brookhaven National Laboratory.?

pr. Gonberg departed fron Puerto Rico on Novenber 2h, 1967,

in response to an invitation to Join an IAEA Panel of Experts
on Research Reactor Utilization which met in Vienna from Novenber
27 through December 1, 1967.

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Following the meeting in Vienna, Dr. Gonberg visited the te.
cilities of the Greek Atonic Energy Comission in Athens to reviey
its program and met with the President of the Comission, Dr. F
Demopoulos and menbers of the staff. Also at the invitation of
the IAEA, Dr. Gonberg visited the IAEA Monaco Laboratory to ais-
cuss possible cooperative programs related to problens arising
fron discharge of radioactivity into the sea.

Dr. Marcial was in South America during the period of
Novenber 23 to Decenber 16, 1967, participating in the folloving
activitie

a. the Latin American Regional Conference of Cancer
Control which was organized ty the International Union
Against Cancer in Santiago, Chile during the period
of Novenber 25 to 29,

?b. the IV Latin American Cancer Congress in Buenos Aires, Argentina during the period of November 30 to Decenber 5.

ce the IX Inter-American Congress of Radiology in Punta del Este, Uruguay during the period of Decenber 6 to 12 where he served as a representative of Puerto Rico in the capacity of Counsellor. Dr. Marcial presided at the session on "Fractionation in Radiation Therapy.?

@, he National Cancer Institute in Rio de Janeiro, Brazil, on December 13 where he met with Dr. Adayr Erias de Araujo, Head of the National Cancer Service.

Mr, Héctor Bareelé, Assistant Director for Operations, attended the IAEA study Group Meeting on Research Reactor Utilization in Bogoté, Coloubia, on December 11-15, 1967. Mr. Barcel attended this meeting as a representative of the U.S. Goverment.

?The Anerican Society of Agricultural Sciences ("sociedad Americana de Ciencias Agricolas, "or S\CA) held its 27th Annual Meeting in the PRIC Conference Room, Mayaguez, on December 1.

Dr. Robert A. Luse, Head of the Agricultural Bio-Sciences Division, presided over the meeting as President of the society. ?Mr. José Cuevas, also of the Division, assisted as secretary-Treasurer. Fifteen scientific papers on Puerto Rican Agriculture were pre-

sented at the two similtaneous sessions in the morning. At this meeting Mr. Cuevas presented a paper entitled "Radiation Preservation of Tropical Fruits." This meeting marked the end of the

?term of office for Dr. Ise and Mr. Cuevas, though both continue on the Board of Directors of SACA through 1969.

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er on the first night of the symposium. Seated,

left to right: Roberto Sanchez Vilellay Governor of Puerto Rico; Dr. Glenn T. Seaborg, Chairman, US AEC; Sol M. Linowitz, U. S. Ambassador to the OAS. Standing: UPR President Jaime Benitez, PRNC Director Henry J berg.

Left: UPR President Benitez; John Conway, Secretary

Of the Joint Congressional Committee on Atomic Energy

James T. Ramey, Commissioner, US AEC. Right: During

one of the technical sessions. PRNC Deputy Director

Dr. Anador Cobass Or. Stgvard ?. Eklund, Director General

of the International Atomic Energy Agency; Dr. Shields

Warren, Cancer Research Institute, New England Deaconess

Hospital, Boston.

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?EDUCATION

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His disseration, entitled "F Center Formation at 78°K in Kir

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K Edge," was prepared in Puerto Rico under the supervision of Dr.

Gonberg. Mr. Cruz was granted a Ph.D. degree in Physics by

Harvard.

Dr. Oven H, Wheeler submitted a proposal in Nay'to the Dean of Arts and Science of the UPR at Mayaguez for the participation of FRC (Nayaguez) in a doctorate progran in Chemical Physical Sciences.

STAFF

From May 29 to June 10, Dr. Howard L. Andrews served as a ?Temporary Adviser for the Pan Anerican Health Organization, Pan American Sanitary Bureau, Regional Office of the World Health Organization in Venezuela, Trinidad, and Guyana. In August,

Dr. Andrews resigned his position as Assistant Director for Health and gifety to accept an appointment as Professor of Physics in the University of Rochester Medical school.

Miss Vivian Taylor terminated her appointment in Novenber as @ Technical Assistant to the Director.

Mr. Hector Barcelé, who has served as Head of the Reactor Division and Technical Services, was appointed Assistant Director for Technical Operations in October. His responsibilities in this new position include supervision of reactor operations, supervision of Technical Services, coordination of planning ant

conceptual design preparation for general plant projects and capital projects, development of technical training programs, provision of logistic support for the International Exhibit

gram,

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"ATOMS IN ACTION" IN LATIN AMERICA

Since 1965, the Puerto Rico Nuclear Center has assumed responsibility for the research activities conducted in conjunction with the ?Atoms in Action" exhibits

in Latin American countries.

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Above: Inauguration day at the "Atoms in Action" exhibit in Quito, Ecuador. Below: Otto Arosemena, President of Ecuador, speaking at the inaugural ceremony.

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PRNC PARTICIPATION IN THE US AEC "ATOMS IN ACTION"

EXHIBIT IN LATIN AMERICA

Since 1965 the Puerto Rico Nuclear Center has been responsible for research conducted in conjunction with the Atoms in Action Exhibits in various countries of Latin America. ?the exhibits provide 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 demonstration lecture courses and supervised participation in research involving applications of radiation to problems of regional origin and interest, with emphasis on the use of ganna and neutron sources available at the Exhibit.

In May and June, the exhibit visited Panama City, Panamd.
In November and Decenber it visited Quito, Ecuador.

?RESEARCH ACTIVITIES IN PANAMA

?A preliminary visit to Panama indicated that the research emphasis should be directed to the biclogical sciences because Of the existence of the Gorgas Memorial laboratory and the well-established Department of Biology at the National University. Projects were selected according to local needs, similarity of Gurrent research, and availability of PRNC personnel. Most of the projects were designed to be of service to graduate students working on their theses at the College of Pharmacy and Natural Seiences of the National University. The 5000-curie ?cobalt-60 gamma irradiation facility, the principal research tool, was used fn projects related to mathematical statistics, radiation chen-istry, food preservation, parasitology, bacteriology, and radia-tion effecté in biological systems. A 6-curie Pu-Be neutron source vas utilized primarily for neutron diffusion theory expe-iments. Phosphorus-32 was utilized for rice-soil fertilization Ztudies. ?The exhibit's program in Panama received special cooperation from the Ministry of Agriculture, Commerce, and Shaustry; the University of Panana (College of Engineering, Natural Science and Pharmacy, Agricultural Engineering, Special-ized Laboratories for Drug and Food Analysis) and the Gorgas

Memorial Laboratories. The National Association of Engineers and Architects cooperated in a special lecture program on Plowshare.

LECTURES IN PANAVA In conjunction with the research program, PRNC personnel gave the following lectures during the "Atoms in Action" Exhibit in Panama, which were attended by 645 persons.

Dr. Rupert Lee, PRNC Nuclear Science Division: Radiation Chemistry and Gas Evolution; Degradation of Polymers with Gamma Radiation.

Dr. Jorge Chiriboga, PRNC Assistant Director for Scientific Programs: Radiobiology in the Tropics I and II.

Dr. Robert A. Iuse, PRNC Agricultural and BioSciences Division: Actual Status of the Food Preservation Program; The PRNC Projects in Food Preservation by Radiation.

Dr. Donald Sasscer, PRNC Nuclear Engineering Division: Neutron Cross Section; Neutron Diffusion Theory I and II; Neutron Activation Analysis.

Mr. Fausto J. Mufioz-Ribadeneira, International Exhibits Program: Introduction to Radiation Chemistry; Applied Statistics in Chemical Analysis; Calculation Formulas in Nuclear Homogeneous

Reactors I and II; Chemical Dosimetry of Gamma Radiation.

A series of lectures on Plowshare using slides and films

were also offered to the Association of Engineers and Architects of Panama. Mr. Harold Curtis from the ABC's San Francisco Operations Office, and Mr. Peter Myget fron the Interoceanic Canal ?Studies Commission helped prepare the lectures and answered questions pertinent to the Panama Canal.

?The PRNC representative, Mr. Fausto J. Mufioz-R. (M.S.) was in charge of this special lecture program on Plowshare requested by the AEC Division of Peaceful Nuclear Explosives (PNE). One

hundred and forty people attended lectures on: Characteristics of the Miclear Explosives and Wiclear Explosions; tafety Consid era jses of Nuclear Ex, 3 -
clear Bxplosives in Large Scale Civil Evetieen eset

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A List of the graduate student theses already accepted >
the University is indicated below: ? v

A, PROJECTS AT THE UNIVERSITY OF PANAMA

* ?statistical Paired Comparison of Results Found in the Fricke Dosimetry System Using Neasurenents at Three Different Wave Lengths." Persons in Charge: Miss Beatriz Green and Miss Evelyn Marshall,

+ "Application of the Least Square Theory to Chemical. Analysis". Person in Charge: Mr. Rubén Rivera.

*"Statistics and Nuclear Disintegration.? Persons in Charge: Mr. Rolando Carvajal and Miss Delia Falcén.

+"G Value Determination in Fricke-Copper Solutions" I. Sulfuric Acid Concentration. Persons in Charge: Mr. Carlos Re Cérdova and Mr. Brajil Morén,

"Quantitative Determination of Fe*+ by the Prussian Blue Complex" . Persons in Charge: Miss Jacinta Him and Miss Gladys Ortiz.

+ "Dosimetry by Gas Evolution." Persons in Charge: Mrs. Nitza de Diaz and Miss Myrna Barreto.

+ "Depolymerization of a Polymer of Methyl Methacrylate

?by Gamma Radiation." Persons in Charge: Miss Angela Tellos and Mr. Francisco Flores.

+ "Binding Energy of the Deuteron" (H@). Persons in Charge: Mr. Gonzalo Molina and Mr, Francisco Flores.

+ "Determination of Diffusion Length of Neutrons in Water Using Foil Detectors." Persons in Charge: Miss Elvira Cabada and Miss Irma Rios

+ ?Determination of Thickness of Water for Moderation of Neutrons fron a Neutron Source." Persons in Charge: Mr. Plutareo Ranos and Mr. Félix Cuevas.

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+ "Pitting of a Thermal Neutron Flux in e Cylindrical Arrange-

Mr. Bolivar Vazquez and Mr. Jorge

+ "Neutron Activation Analysis." Persons in Charge: Miss Analida Ardila and Miss Teresita Jaén.

+ "Determination of the Range of Beta Particles." Persons in Charge: Mr. Silvio Candanedo and Mr. Bladimiro Castillo.

* ?orange Preservation by Gamma Radiation." Persons in Charg Miss Blasina Siavedra, Miss Aganda Monge, Miss Elizabeth Roar{-guez, and Nrs, Wercedes de Leén.

+ "Radiobiology of Rhodnius prolimus." Persons in charge: Miss Geneva Luciani and Miss Carolina Windehake.

+ "Special Project in Rhizobium §." Persons in Charge: Miss Alina Torres, Miss Mitzi Sarenga and Mr. Carlos Delgado.

"Radiation Effects on Daphnia, Sp". Persons in Charge: Miss Sabina Gonzdlez and Mr. Alberto Cruz.

+ "Radiation Effects on Frogs? Pignentation," Person in Charge: Mr. Raimundo Husband and Mr. Domingo Lépez.

+ "32p in Soil-Rice Plants Fertilization Studies." Person in Charge: Mr. José M. Chaverri.

B, PROJECTS AT OTHER INSTITUTIONS

+ At the Ministry of Agriculture, Commerce, and Industry

The research divisions of this Ministry participated in radiation preservation studies of potatoes and onions. ?The min objective is to control sprouting and extend product shelf 1ife.he projects are being satisfactorily contimed.

+ At the Gorgas Memorial Laboratories

?The Gorgas Memorial Laboratories are sponsoring the pro-Ject on the radicbiology of Rhodnius prolixus where radiation effects were carried out in eggs, fifth pupae stage, and adult insects, by two students of the university, This institution has already completed studies of radiation effects on the development of infection by Tripanosoma rangeli in Rhodnius prolixus and Rhodniug pallences. ?A third part of the project, initiated in cooperation with the PRNC Division of Medical Sciences and Radicbiclogy, consisted of studying the virulence of infection caused by Tripanosoma cruzi under the parameter of radiation.

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?EESEARCH ACTIVITIES 1H BOUADOR

The sane procedures used for the establishnent of the PRNC program in Panana were followed, although the scientific develop-nent of the universities in Ecuador and the interest of govern-ment institutions in introducing the nuclear energy parameter in their current research problens was taken into account, ?This made it possible, for the first time in the AEC International Exhibits Progran, for institutions located in Guayaquil (400 kil-ometers from Quito), Cuenca (600 kilometers from the capital), and Portoviejo (350 kiloneters fron Quito) to actively particl-pate in the progran.

The research program at the Exhibit in Ecuador had the cooperation of the Franco-Ecuadorian Institute of Agronomic In-vestigations (IFEIA, Guayaquil), the National Commission of What (CNT); the Central University of Ecuador (College of Phar-macy, College of Engineering, College of Agronomy and Veterinary Medicine); Polytechnic Institute (BPN); Ministry of Agriculture (Division of Agronomic Institute), the Catholic Institute (Ins-titute of Natural Sciences), and the University of Guayaquil (College of Agronomy).

With the coming of the "Atoms in Action" Exhibit to quito,

for the first time studies in problems related to the agricultur-
?al economy of Ecuador were initiated using nuclear techniques.
easel socinies stulies on the preservation by radiation of "na-
ranjilla" (Solamum guitensis); the radiation effects on "Picudo
negro" (Cosmopolite sordidus); and third, the first shipment of
irradiated bananas was exported to the United States. For the
first time also in South America, experiments on radiation ef-
fects on Anastrepha fraterculus Wield, were carried out. Due
to the special cooperation received from Dr. Iuis A. Romo (Ph
D. University of Wisconsin), a professor at Central University,
it is anticipated that the number of publications produced will
be the largest ever generated from an Exhibit research program,

LECTURES IN ECUADOR

In conjunction with the research program, personnel of the
Puerto Rico Nuclear Center gave the following lectures during
the "Atoms in Action" Exhibit in Ecuador, which covered the
cities of Quito, Guayaquil, and Cuenca; registering a record at-
tendance of 1731 people. Lectures offered outside of Quito are

indicated.

Dr. David Walker: Nuclear Techniques in Agricultural Research; The PRIC Research Project in the Irradiation of the Sugar Cane Borer; Nuclear Techniques in Agricultural Research (Gaayaquil).

Dr. H, Harry Semant: Mechanism of Chemical Reactions Using Radioisotope I and II; Mechanisn of Radiation Induced Reactions.

Mr. José Cuevas Ruiz: Food Preservation by Radiation; The Fat Research ?Projects in Food Preservation by Radiation (Guayaquil).

Mr. Juan Silva Parra: Muclear Pover and Desalinizations

Radiation Sources and Their Application:

Dr. Badie Ortiz: Neutron Cross Section; Neutron Diffusion Theory Tand Il,

Me. Fausto Mufioz-R: Research Programs of Atoms in Action

Exhibit in Central America; Possibilities of Research at the

Bnitit iaboratories; Principles of Radiation Chemistry (Guaya~ quil); Atoms in Action Exhibit in Ecuador (Cuenca); Theory of the Free Radical Formation in Radiation Chemistry; Chemical Dosinetry of Gamma Radiation; Research Programs of Atoms in Action Exhibit (Guayaquil); The Development of Atomic Energy and its Importance in Modern Technology.

Mr, Mufioz-R. also offered several lectures on "Plowshare" which are listed under the PRNC Peaceful Nuclear Explosive Pro- gran.

ACCOMPLISIMENTS OF IME RESEARCH PROGRAM IN PANAMA AND ECUADOR

Results are gratifying, since several scientific papers are being prepared for publication and sone graduate students fron the Universities will receive degrees through theses prepared under the PRNC research program at the Exhibits, A list of continuing and completed research projects is presented.

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FOOD PRESERVATION

studies were carried out on the radiation preservation of bananas (Ecuador's nost important export product), "naranjilla, "

a typical fruit of the Eoutdorian highlands, and potatoes.

+ Studies on Banana Preservation ~ The Franco-Beuadorian Institute of Agronomy Research (IFEIA) carried out this project. Banana fruits from the Pichilingue area were irradiated with doses from 10 to 60 kilorads; the most favorable doses in "Gross Mitchell" variety were found between 30 to 40 kilorads, and the retardation on the maturation time was 6 days when bananas were kept at 65°F. A refrigeration chanber of the National Institute of Fishery and Hunting was adapted for this experiment.

+ Radiation Bffects and Mycology Studies on Bananas - The objective of the project was to study the behavior of the fungus infection in bananas which vere irradiated for preservation studies. The fungus species which were used were Clestrotiun

musanena, Fusarium solani, Botrodiplodos thecbrone.
The procedure was as follows:

a) a series of fruits were irradiated before the inocula-
tion; b) a series of fruits were irradiated after the
inoculation,

Doses of 30 to 40 kilorads, were found to be the most favor
able in the preliminary studies.

+ Export of Irradiated Bananas to the United States - Through direct action of the Exhibits? Office in Washington (DIL), Dr. E. ©. Maxie of the College of Agriculture, University of California, at Davis, California, agreed to study the irradiated bananas (35 Kilorads) fron Ecuador, which were shipped from Puerto Bolivar (Pais de El Oro) on Novenber 27 to Long Beach, California. | The daily newspapers "El Comercio" from Quito and "EL Universo" from Guayaquil published a first page article titled "First Exportation of Irradiated Bananas to the United States.

+ Preservation of Potatoes - ?his project vas located at the college of Tharmacy, Central University, and will form a base for ?a thesis project. In addition to physical tests on the acceptaDility of the product, the following biochemical tests related to dose and time parameters are being carried out: total sugar,

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reducing sugar, and vitamin C.

* Radiation Effects on "Naranjilla" Preservation - "Naranjilla"

(Solanum guitoense) is a delicious fruit which has a wide internal market but foreign markets have not yet been found due to the fast deterioration of the fruit. This project was located at the Polytechnic Institute where a special maturation chamber with controlied temperature was built. ?The project, being carried out under the direction of Marcelo Coronel, has thus far shown that doses higher than 200 kilorads produce a physical damage in the fruit

&s well as destruction of flavor and aroma, Near ripe fruits sho ?the most favorable aspect for irradiation treatment.

+ Entomology - Studies on insects attacking valuable food stuffs and export products in Ecuador were carried out in cooperation with the Exhibit.

+ Radiation Effects on the Highlands Frutt Fly -Fruite of sweet pulp that are cultivated in the highland valleys are suffering great danage fron infestation by a fruit fly (Anastrepha frateroulus Wield). ting ae a bace the station ce dee Lie ?eyele performed ty researchers from the College of Agroncay, Central University, preliminary studies on the radiation effects on this insect were carried out by Mr. Cristébal Barba and Mr. César Wanderaberg from the Research Division, Ministry of Agriculture,tWo thousand insects in pupal stages Were irradiated vith @ifferent dosages.

+ Work on ?Picudo Negro" (Cosmopolite sordidus)-For the first tine in Latin Anerica, studies on the radiation effects of Gosmopolite sordidus were carried out, thanks to the interest of IFEIA. Using special precautions, about 1000 insects were brought from Prebilingue to Quito. ?The study showed that doses of the order of 100 kilorads killed the insects in one day. If these studies are a success, they may constitute a real contribution ?to Ecuador; although mich effort should be dedicated to studying the appropriate diet in rearing this insect, first in the laboratory and later in massive form,

+ Disinfestation of Wheat and Flour-Due to the interest of the National Comission of Wheat (CNT), a project on radiation effects in Platiedra gossipeda was initiated with the Exhibit in Eouador; this insect is causing great danage in Quito's flour mills. CET hired Miss Beatriz Hidalgo and asked Mr. Jaime Flores, employee of CNT, to work on a full tine basis for the project whose main objective was to determine the ovoposition rate and

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fertility of the eggs of Platiedra gossipiela in relation to the dose parameter. The Ministry of Agriculture also cooperated in this project and Mr. Flores will use the data when submitting his thesis to the College of Agronony, Central University.

RADIATION EFFECTS IN ORE DRESSING OPERATIONS

Studies on the radiation effects in the flotation of sulfur and copper ores (Chalcopyrite type) were initiated at the Exhibit in cooperation with the Polytechnic Institute and the College of Engineering of Central University. Preliminary flotation trials in both projects indicated the most significant parameters that should be taken into account for the success of the opera tion, Based on this information, a factorial experiment. wai designed. Analysis of variance indicated the influence of the effects of the different factors by themselves, and in their combinations, on the yield of the operation. in both projects the equation of yield is being calculated by taking into consideration the replications and factors used in the experimentation. Correlation of data done by using the reciprocal matrix concept.

?A second part of the project consisted of irradiated sulfur ore and chalcopyrite ore samples at different dose levels; ?the yield on the valuable component will be correlated to the dosage received by the examples.

?The third part consisted of selecting sulfide and sulfur crystals and submitting them to an intensive gama radiation field. Possible effects in cyrstalline structure are being

studied at the laboratories of the National Bureau of Mines and also at the PRNC, using X-ray analysis diffraction techniques. Data from X-ray analysis will be correlated with the yield of flotation due to radiation effects, if any.

two graduate students from Central Untversity (Mr. Biuardo Vega and Ue, fafacl Peonitio) and one from the Polytechnic, Mr. Trajeno Randves, participated in these projects and will use the sta unen submivting theses. The thesis is prerequisite for @ professional degrees

GEIBTICS

IFEIA and the Catholic University at Quito initiated the folloving projects at the Exhibit.

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avo

+ Banana Buds - IFEIA decided to study the radiation effects on banana buds of the "Gross Mitchell" variety, which is very susceptible to fungus infection, ?The objective was to study the possible development through radiation of a mutation resistant to the fungus infection called "Panama sickness."

+ Work in Chalceonaria crenata - Chalceonaria is a plant cultivated in the Eouadorian highlands for ornamental purposes. Brother Clenente Amas (iS. Biology, University of California at Berkeley), nov a professor at the College of Science, Catholic University in Quito, Irradiated seed samples of Chalceonaria for studies of chronosones.

Special Research Progran at the College of Pharmacy, Central University

Due to the special interest of the Dean of this College of Central University, and through the special cooperation of Dr. Inis A. Romo (Ph.D. University of Wisconsin), the folloving projects were carried out during the "Atons in Action" Exhibit in Quito:

+ Adsorption of Cobalt-60 in Silicates - Several samples of Ecuadorean clays activated by different procedures were used in this project. Mr. Claudio Carrillo cooperated with Dr. Romo and will use the data for a professional thesis at the university.

+ Radiation Effects in the Crystalline Structure of Kaolin as Measured by Phosphate (P3¢) Adsorption and X-Ray Diffraction

Studie:

+ Depolymerization of Polysacharides by Gamma Radiation -

Pectine samples were irradiated and viscosity measurements were used to evaluate the depolymerization rate.

+ Radiation Effects on the Degradation of Vitamin ¢ and Stabilizing Effects of Polysaccharides. An experiment was de-Signed to study the possible stabilizing mechanisn of polysaccha~rides in Vitamin C under ganna irradiation conditions. Thin layer chronatography techniques were used to evaluate the results.

+ Investigation of the Minimum Dosage of Gamma Radiation for preakiom of Vitasin BO am B12

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* Dimerization of Acenophtylene - ?The dimerization of Acenoph-tylene was achieved under a variety of experimental conditions and the mixture of trans and cis dimers is being separated by chromatographic means. ?This project, suggested by Dr. Harry Semant, is being contimed; all the other projects were com pleted in their experimental part.

Other Projects in Radiation Chemietry

?The Exhibit's ganma irradiation facility was also used to study the decomposition of bipyridine, and in a polymer chemistry project.

+ Radiation Effects on Bipyridine - Mr, Guillermo Romero, a graduate student from the Chemical Engineering Department, Central University, has been studying the copolymerization of vinyl acetate and crotonic acid using the concentration cf this acid and ?the radiation dose as parameter. ?The copolymerization rate and reactivity ratios have been evaluated and the molecular weight of the polymer will be determined at the PRNC laboratories. Mr. Romero will use this data for a thesis at Central University.

GRADUATE STUDENT THESES

Graduate students from the Central University and the Polytechnic Institute participated in different research projects and will use the data for submitting a thesis, prerequisite for a professional degree. ?The students and project titles are:

+ Radiation Effects on the Flotation of Chaleopyrite. Mr. Rafael Pazmifio and Mr. Eduardo Vega (U.C.)

+ Radiation Effects and Copolymerization. Mr. Guillermo

Romero (U.C.)

+ Adsorption of Cobalt-60 in Silicates, Mr. Claudio Carrillo (u.c.)

+ Radiation Effects on Flatiedra gossipiela, Mr. Jaine Flores (u.c.)

+ Radiation Effects on Bipyridine. Mr. Edwin Acosta (E.P.N.)

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ae

+ Radiation Effects and Flotation of Sulfur. Mr. Trajano Ramirez (E.P.N.)

+ Radiation and Preservation of Naranjilla. Mr. Bolivar Izurieta (E.P.N.)

+ Preservation of Potatoes Through Radiation, Miss Rosario Jacho (U.C.)

Consultant services have been rendered to several students of the College of Education, Catholic University, in relation to their thesis,

Special Program, Department of Physics, Central University

Due to the interest of this Department, a special denons~
tration program in neutron diffusion theory was presented, It
was attended by all the professors of rhysics fron the University
?and also by three professors from the College of Science, Univer~
sity of Cuenca, a city located about 600 kiloneters fran Quito.
The Director of the Department of Physics (U.C.), has written a
letter of acknovledgenent to Dr. Eddie Ortiz indicating the bene-
fit received by Central University fron this lecture and demons-
?tration program.

Acknowledgement from the College of Pharmacy
?to PRIC Personnel

?The Dean of the College of Pharmacy, Dr. Gerardo Armendariz,
and the Faculty of the same College of Central University, held

a reception for PRIC personnel who participated in the "Atoms in
Action" Exhibit in Quito. He gave Diplomas of Acknowledgment to
Dr. H, Harry Scmant, Mr, José Cuevas, and Mr. Fausto J. Mufioz.
The diplomas clearly show the impact made by the lectures and -re-
search. projects initiated with "Atoms in Action" in Quito.

Other Activities and Services

+ Irradiation Services - Irradiation services were offered to high school students for projects which were included in the First National Service Fair of Ecuador, Several seed irradiations were also performed for people in the flower business interested in observing the possible changes in color of ornanental flowers, as well as for agricultural people interested in observing the radiation effects on barley and wheat seeds. Irradia-

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Above: President Arosemena and other Ecuadorian government officials hear explanation of the uses

of the gamma radiation facility in agricultural-economy research programs initiated at the time of the ?Atoms in Action" exhibit in Ecuador. Below: President Arosemena and Education Minister Dr. Fabian Jaramillo with the "At in Action" staff in Quito, Ecuador.

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aN

?tions were performed, too, for several mall fruit and vegetable packing companies interested in observing the radiation effects

on the preservation of their products.

+ Attendance of Special Groups fron the Universities of Ecuador = Due to direct action taken by the RNC representative, professors and students from the College of Engineering, University of Manab§, cane to Guito and attended a special ceninar on Plowshare and other lectures related to the nuclear engineering field. Four of the young assistant professors have already written to the University of Puerto Rico requesting application blanks for graduate studies. ?This program took place during November 27 ~ Novenber 29, 1957.

Professors and students from the College of Pharmacy, University of Guayaquil, also visited the Exhibit during December l-5, 1967, and a lecture-demonstration in radiation chemistry and muclear instrumentation was offered to them, ?wo students fron this College attended the Exhibit courses offered by personnel of the Oak Ridge Associated Universities (ORAU).

By request of the religious onder of the Christian Brothers (HI.CC) a seminar was arranged on Novenber 26, 1967. For twelve brothers of the order, and for professors of physics and mathenaties fron the Ia alle, Carlos Marfa de la Torre and ovielado Schools in Quito, and San José, in Guayaquil.

PRNC personnel participated in the special "VIP" seminar prepared for The National Assenbly, the Junior Chanber of Commerce, the Rotary and Lions Clubs.

+ Consultant Services - PRNC personnel rendered the following consultant services

a) of Health, Dre
Jorge Chiriboga stopped in Guayaquil on his way to Peru, and iscussed with members of the NIH of Ecuador the implenentation of meclear techniques in parasitology studies, NIH sent four people to attend the Exhibit courses and is initiating radiodiology studies on several parasites using an X-ray source fron ?the Cancer League (SOICA) in Guayaquil.

>) Sugar Exporters Association end INRIA, Guynquil, Dre
David W. Walker discussed the uses of radiation on the control of insects, and advised these organizations on the steps to

---Page Break---
follow in order to correctly apply the radiation paraneters.

¢) College of Science, University of Cuenca, and Central University, Quito. Dr. Eddie Ortiz gave advice on the improvement of a curricula in Physics to professors of these univer-

sities who attended his. seminar on neutron diffusion theory.

4) Central University of Ecuador. At the request of the Vice-Chancellor, Mir, Fausto Mufioz R., scientific coordinator of ?the PRNC Program at the International Exhibits, presented a meno-randum indicating the need to establish a Nuclear Science Ins-titute at this University.

We think the success of the PRNC Program at the Interna-tional Exhibits has opened a very wide field of possible applica~ tions of atomic energy in problems related to the agricultural economy, public health and scientific development of the uni-

versities in these countries, Several publications from work initiated during 1965 and 1966 have appeared during 1967.

One, by Dr. Pedro Solé of Guatemala, titled "Gamma Radia-tion Sterilization of Canned Pineapple," has been submitted to Intern J. App. Radioisotopes. Another, by Dr. Ricardo Bressani (INCAP) and Mrs. Aurea de Monzén of Guatemala, titled "Radiation Effects in Incaparina," was also submitted to the sane journal.

?the other three papers, prepared in collaboration with PRNC personnel, will appear in the Appendix of the annual report after publication,

Four other papers are ready and will be presented at the loth Latin American Congress in Chemistry in February, 1969. An~ other paper has been accepted for publication by the magazine of the Entomological Society of America, Washington, D.C.

Several young university professors from the countries which the Exhibit visited have been or are presently enrolled in graduate studies at UPR and are doing their research work at PRNC, (Table 1). sone students received their professional degrees in 1967 through thesis work initiated with the Exhibits in their countries, This was made possible by the contimous association of FRNC scientists who had participated in the Exhibits and the local personnel who participated in the projects (Table 2).

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TABLE 1

List of Persons who Have Continued Graduate studies Through Assistance Given by the PRN Exhibits Progran

Tames Original Institution Studies agin Or Tn

Fellowship (Mos.)

1. Dr. Alicia Instituto Salvadorefio M.S. Agri- AD (1)12

Pineda de Investigaciones del Café culture

2. Dr. Armando ?Ministry of Public Health Post-graduate AID (1)28

Tustemante «El Salvader studies in Ra~

diclogy (UPR) _

Prof. Mario Dept. of Physics, cies UR

Saca Univ. of El Salvador ee:

Mr. Roger Ministry of Agriculture ?MiS. Agri- apm (1)*6

Tandaverde El Salvador culture

+. Virgilio Ministry of Agriculture M.S. Agri- Am (1)*6

be ee Ne BT salvador culture

. so Dept. of Chemistry PheD. ?UPR he

+ Prof. Alfonso Torts Gf Cowta Rica ?-?Chenistry

of. Delia Dept. of Chemistry MoS. ?UPR oh

?T. Profs Dergegn Univ. of Kicaragua Chemistry Univ. of

Prof. it. of Chemistry M ae 2h

. tuisa Depts 28 nn

S ?Benedet Biology

g. Prof, Ima Dept. of Chentstry Mes. sara R

Zea ?Univ, of San Carlos, Ghenistry

Guntenala

x six month extensions were obtained in order to pes en to 0

their graduate work. permit them to complete

(2) Returned already to their country.

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?TABLE 2

wr

List of Students Who Have Received Their Professional Degrees

?Through Thesis Work Initiated with the

Atons in Action Bynibit, Progran During 1965-1

anes Thesis Gitie Gameetion Tegies,

iar Jaine Effects of the Forme

Cdeeres _Acsa in the Fricke

Dosimetry system Nov. 1965 Chemist

Nr. Rafael ?-?Radiatiion Effects on

Granados Beans(Phaseoulus July 1966 Agronomic

?vulgaris 1) Engineer

Mrs Max She Femi Acid-Fricke

heel «System Te Ng004, Con

centration Dec. 1965 Chemist

Mrs, Puuline Radiation Chemistry

de Rodriguez of Titanium Sulfate Chem,

Solutions June 1967 Engineer

Mr. Mario Kinetic Interchange

Tépez ?Between Cyclo Alkine Chloride

& Radioactive Chlorine Ton Chen.

(See Table I) Mar. 1967 Engineer

Mr. Roberto Radiation Effects on Canned chen.

Gutiérrez Pineapple (See Table 1) June 1967 Engineer

Mrs. Aurea Radiation Effects in Inea~ Chen.

?de Monzén parina (See Table 1) Apr. 1967 Engineer

Miss Juanita Sulfur-35 Exchange Reac- Nov. 1967 Chemist

Freer tions in Triphenylphos-

phine Silfide (See Table 1)

Mr, Carlos Preservation of Bananas Nov. 1967 Chemist.

Rodriguez Cavendish variety

?through gamma radiation

Mr. Luis Muclear Energy & lav Dec. 1956 Lawyer

Guillén

Country

EL Salvador

El Salvador

Guatennle

Guatemala

Guatemala

Cuatenala

cuatenala,

Costa Rica

Costa Rica

Costa Rica

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?The PRNC International Exhibits Program was visited in

Ecuador by Dr, Henry J. Gonberg, PRNC Director, and Dr. Amador Cobas, PRNC Deputy Director, We express our gratitude for their coments, suggestions, and support of the Program, Mr. Juan Silva Parra also attended the exhibit in Ecuador. He is taking over the responsibilities of the field operation of the program, The special support in logistics from the USKEC Division of ?Technical Information is acknowledged. A resumé of the Exhibits in Panand and Ecuador is presented in Table 3.

TABLE 3

Réauné of the FRNC Program at
The Atons in Action Exhibit in Panama and Ecuador

	Panand	Bouador
FRNC Participating seientiets	5	5
Total Mumber of Research Projects	6	20
Research Projects at Government Institutions	2	7
Research Projects at Private Institutions	1	-
Student Participation	45	8
Tecturés Offered by PRIC Scientists	18	2B
Attendance at Lectures	705	2B.
Expected Publications During 1968	1	10

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BIOLOGICAL AND MEDICAL RESEARCH

PROGRAMS

The research activities in bi-

ology and medicine (also called the

06 Program) are sponsored by the US

AEC Division of Biology and Medicine,

and comprise approximately one-thir

of PRNC's total program.

1g

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Right: Preparation of

an orang

for use i

a sample of marine bot-

e-peel-grab

n collecting

tom sediment off the

west coas

Rico.

Right: TI

content of

samples i

by bomb

Trace elem

reported o1

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weight, p

carbon and

and wr

calories,

t of Puerto

he Caloric

biological

s measured

alorimetry.

ents are

nthe basis

t and dry

er gram of

nitrogen

10,000

Left: A technician sepa-

rates infaunal polychaetes

from a sample of marine bot-

tom sediment for trace ele-

ment analysis on individual

organisms.

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MARINE BIOLOGY

?The aims of the research in the Marine Biclogy Program have

not changed during the past year although the methods of approach

and points of emphasis have, in a few instances, been altered.

?The work includes field and laboratory investigations with the major emphasis directed tovard neamrenents wer naturel conditions.

The field area on the west coast of Puerto Rico includes a 20-mile stretch of coast which encompasses the watersheds and offshore marine areas of three rivers. ?the northernmost river, ?the Culebrinas, drains a watershed with large amounts of lime-stone. ?he central Aflasco River has its origin in volcanic terrain with hydrothermal deposits of copper. ?The Guanajibo River, to the south, drains an area with extensive outcroppings of serpentinite. Each river carries a unique assenblage of trace elements into the marine waters; the influences of these additives upon the productivity of the marine areas, and the trace element composition of the marine organisms are being studied.

Investigations of trace elenent distributions in the sea is of interest in the study of oceanographic chemistry and in allied areas including those concerned with biological productivity, the {influence of organisns upon the chemical and physical forms of elements in sea water, the geochemical histories of elements in-troduced into marine waters by natural processes, and the dis-tribution of man-made radionuclides deposited in the sea.

A knowledge of the biogeochemistry of trace elements is of

critical importance to man insofar as radioactive isotopes of the same elements may become incorporated into food webs from which human food is derived. ?the distribution patterns of many of the trace elements in marine waters, organisas, and sediments have not been measured, Little is known of the relative influence of physical, chemical, and biological mechanists which con~trol the transport and distribution of these elements. Thus, Little is known of the relationships between rates of photosynthesis by marine plankton and the rates of incorporation of trace elements into marine food webs, Even less is known of the relative rates of loss of trace elements with the death and

decomposition of marine organisns.

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Investigations designed to measure and def

ne the relat

and individual influences of the physical, chesioal eats

trace elements in the sane emiroment. Inthe Marine Sica Progran, analyses are being made for cadniun, ealoium, carbon, cobalt, copper, hydrogen, iron, lesd, manganese, mciyedomn, nitrogen, phosphorus, rubidiun, scankiun, sliver, strontium sulfur, and zine ind linited funber of ainerals) rocker sells,

river Waters and river sediments tren the laninse which eontedb=
utes trace clenents to the neighboring marine waters, the pelagic,
Littoral and benthic organiansy end sediment. For A11 Sioiogiceh
samples, micrograns cf trace elenents are reporte! per Era of
wet, dry ant ash weight, per gran of carbon and nitrogess per
10,000 calories, and per nlcrogran of phosphorus

In addition to the distribution studies of stable elenents,
other areas of investigation being carried out off the west coast
of Puerto Rico include basic studies in marine ecology and tax-
onomy; measurements of biological productivity; background obser-
vations in physical, chemical, and biological oceanography; ana-
lyses for rare earth distribution patterns in the watersheds and
?the neighboring marine waters, organisns, and sediments; and lab-
oratory measurements of the rates of accumlation and loss of se-
lected organians for given radionuclides,

DEVELOPMENT OF ANALYSIS METHODS

?A significant part of the work is concerned with the devel-
opment of methods for stable elenent analysis ina variety of
Sample types. Among the methods used in the Marine Biclogy Pro-
gram are destructive and non-destructive neutron activation ana~
Sysis, x-ray emission spectrography, atomic absorption and flane
?spectrophotonetry, colorimetry, fluorescence analysis, arc spec-
trogrephy, polarography, gas chronatograrhy, and autonated chen

ical analysis using, primarily, colorinetry. During the past year a non-destructive neutron-activation method has been developed for the analysis of alunimm in sediments, rocks, minerals, ?and modern biogenic carbonates. A method is under development for the analysis of the sane element in river and sea water. A rapid separation for neutron-activated scandium in rocks, miner~als, and biogenic carbonates by liquid-liquid extraction has been developed to replace a slover precipitation method. An ion

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Technicians measure
gamma radiation dose
from a rabbit with
samples irradiated
in PRNC's research
reactor. Several
elements, including
manganese, aluminum,
copper, silver, iron,
scandium, mercury,
cobalt, zinc, iodine,
strontium, lanthanum,
tungsten and chromium,
are analyzed by this
method.

?
Dr. R. Gordon Pirie removing a sed
from the orange-peel-grab.

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exchange method has been tested and used for the determination of
Cu, Fe, Zn and Sc, ani rare earths by feutron activation in
samples of marine organisns, A method for measuring zinc and

manganese in sea water samples by coprecipitation ani liguid~ Liguid extraction followed by atomic absorption spectrophotonetry has been developed. In sea water samples containing large anounts of silica from phytoplankton, the samples mst further ?be purified by an ion-exchange step using @ chelating resin.

__, During the past year a Technicon Autoanalyzer has been put into operation for the analysis of phosphate, nitrate and silicate in samples of river and sea water and marine organisns. The equipment performs 20 analyses per hour. Methods are being developed to analyze for Ca, Sr, Fe and No.

IMWESTIGATIONS

Studies have been started on the influence of age and size upon carbon-nitrogen ratios and trace element content in z00-plankton, Analyses of 150 individual specinens of the marine copepod, Pontella mimocerami, have been completed. In conjunction with these analyses, a study is in progress of the total CHN content in specimens which have been subjected to lipid extraction. ?The fatty acid distribution patterns in these lipids are being analyzed by gas chronatography of the nethylesters.

Field investigations, related to uptake studies of , Cu, Fe, sn and Zn by populations of the intertidal clan, Donax den titulatusyand the nine-amed starfish, Iuidia senegelensis, were

?completed. Natural populations of the starfish were collected from areas under the direct influence of two river outflovs. An analysis of their stable elenent content denonstrated that, of the elenents analyzed, the levels of Fe and Zn were different between the two areas, ?These clenents varied in relation to feeding activity in previous studies.

Ievels of the stable elements Zn, Sc, Fe, Sr, and Cu have been compared between inshore-offshore populations of benthic fauna in an area adjacent to the Afiasco River. Levels of Cu and ?a in the fauna are enhanced ty proximity of the landmass, while Jevels of Zn, Sc, and Fe are not. In both areas the sediment-water interface, and the feeding activities of the fauna that live above and below it, proved to be important in the partition-ing of Zn, Fe, and Cu in the organisns, Change in the taxonoic

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composition of faunal groups does not appear to influence the stable element composition of the group, but feeding types seen ?to have a major role in stable elenent distribution.

"No studies of diurnal variation in zooplankton abundance, species composition, and elemental content were completed. In the first study, marked changes in the species composition of the surface-water plankton were accompanied by fluctuations in concentration in several of the 15 elements analyzed. In the

second investigation changes were again observed at the surface and also at 100 meters depth,

?A survey was begun of the concentration of plant mtrients important in primary production off the mouths of the three rivers on the west coast. In conjunction with this study, salinity measurements are being made in order to better understand ?the magnitude and direction of flow of the rivers.

Smdies vere made on the frequency distributions of Od, Ca. Co, Cay Fe, FO, Mm, Mi, fe, S& and zn in the shells of Donak denticulatus and the queen conch, Stronbus gigas, and in the soft tissues Sf thread herring, (Ophisthonena oglimm),and millet, (jugil curena). Aithough the frequency distributions for the trace elenents approximate a log-normal shape, statistically significant differences do not cecur in the concentrations of the elenents within a population from one location,

Preliminary investigations on uptake of a wide variety of elements by the invertebrate, Artemia, show that the elenents in sea water are concentrated in patterns by chemical groups. Th general, the "B groups" of elenents are concentrated to @ higher degree than the "A groups."

Studies on the taxonomy and distribution patterns of fora~ niniferans in the marine sedinents off the west coast of Puerto

Rico have been continued. Over 160 species and subspecies have been identified to date. Seven living foraminiferal as-genblages have been found including near shore, reef, inner shelf, middle shelf, outer shelf, maddy sediments and deep water.

?the topography and bottom sediments of an off'shore-onshore transect in Afiasco Bay have been investigated. Samples were analyzed for percent sand and gravel and for mean dianeter and Standard deviation, Carbonate was determined by gasonetric ana-lysis and the amounts of organic carbon and nitrogen were meas-ured, ?the paraneters vary in a regular pattern which may be

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related to sedimentary processes and sediment types along the transect. Four sediment facies have been identified.

VISITING INVESTIGATORS

In addition to work conducted by the staff, a group of visiting investigators worked in the Marine Biology Program during the sumer of 1967.

Dr, Tudor Davies and Mr. Ian Evans of the University of

South Carolina did the field work for an investigation on the microarchitecture of living mlluscan shells, their contained trace elements, and the changes which occur in the structure and compositions of the shells after death of the organism.

Dr. R. Gordon Pirie, Mr. Robert Kattmanand Mr. John Comer of the University of Wisconsin investigated the sedimentology ?and petrology of the carbonate sands on the Cabo Rojo platform, ?a submerged reef off the west coast of Puerto Rico; the clay mineralogy of the Afiasco River sediments and the marine sediments of Afiasco Bay3 and the distribution of trace elements in ?the waters and sediments of Joyuda Lagoon.

Dr. James Zischke, an Oak Ridge fellow, from st. Olaf College in Minnesota, completed a study of calcium deposition in the shells of marine molluscs.

PANAMA-COTOMBIA STUDY

?As an extension of the work in Puerto Rico, field collections and measurements were made in Panama and Colombia as part of a feasibility study for the possible use of mclear explosives for digging an icthnian sea-level canal. ?The marine bicLogy group at PRIC conducted the estuarine and marine phase of the project. ?he research ships were in the isthmian region for seven months, returning to Puerto Rico Septenber 6, 1967.

Samples of water, sediments, phytoplankton, zooplankton, fish, crustacean, and other benthic invertebrates, including nollusts, were taken for analysis of H, C, N, P, Mn, Fe, Ca, Sr and &, In addition, a limited mmber of analyses for I, rare earths, and U are being made. ?

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The distribution patterns of the trace elements in the sediments and waters of the Gulf of Panama and the Pacific Coast conform to the patterns expected as a result of runoff from the land and upwelling of deep waters of the sea. ?he results from the survey will be utilized to evaluate, by a specific activity approach, the possible hazards provided by the incorporation of radionuclides into food webs leading to humans.

Foster anchor dredge with a s
collected for infaunal analys

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Injecting radioisotopes into

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TERRESTRIAL ECOLOGY PROGRAM |

THE RAIN FOREST PROJECT

The Rain Forest Project is a series of studies on one mall area of the montane rain forest 1500 feet up the side of El Yunque mountain in Eastern Puerto Rico. It has three objectives: 1) to study the effects of gama radiation on the tropical ecostem; 2) to study mineral cycling and dispersion in the systems 3) and'to study the basic biological functions of this ecosysten, such as respiration, transpiration, and photaynthesis, to better understand phenonena related to the first two objectives.

The project is in its fifth year. A section of the forest has deen irradiated and many follov-up studies have been con pleted, (For details of the radiation experiment see FRIC-82, Anmal Report 1965). Present effort 1s being directed to long term studies on recovery and succession of vegetation in the irradiated area, and to detailed investigations of mineral cycling and distribution in the tropical ecoaysten, Studies are carried out at both the FRNC Rfo Pledras Laboratories and at the El Verde field laboratory, on the Northwest slope of El Yunque.

Vegetation Indices, ?he objective of the recovery and succes siori study 1s to determine whether gana radiation produces long-term specific effects on the tropical ecosystem after the irra-@lation has terminated. ?he study is carried out by comparing various indices of vegetation quality ani quantity in the irra~ Giated center with similar indices fron areas in the rain forest which have been damaged by mechanical clearing or by application of herbicides, Measurements in the irradiated area include a detailed anmal survey of plant species and size in addition to ?the various comparative indices, Details on the radiation cen-ter measurenents are given in a previous annual report (FRNC-102 pe Va-1h2),

Indices being used to compare the irradiated area with other damaged areas include species diversity, importance values, sin-?larity index, and optical measurement of leaf area index. ?he irradiated center has an area of well drained soils and an area

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ef poor drainage, Since this may influence recovery, the above indices were computed separately fdr both areas.

Species diversity for each area was determined by c
tnatviduals and species, Diversity linea vere plotted sing ©
standard regression analysis techniques, and differences between
Lines were calculated by analysis of covariance. Species diver-
sity for seedlings in the irradiated area in March 196lt, was
measured by McCormick, a former consultant to the project. Sye-
cies diversity aid not differ significantly between the two herbi-
cide areas, nor between the well drained and the poorly drained
portions of the irradiated area. Differences between all other
areas existed at greater than the 99 percent level of confidence
1).

Diversity after the irradiation was greater than before in
the irradiated center. Differences in diversity between one area
and another are probably related to the size of the canopy open-
ing. ?he herbicide damaged areas had the greatest canopy opening
while the radiation center was intermediate and the cut center
the least after regenerative canopy sprouting. ?Thus the greater
penetration of light may have produced a greater diversity in the
herbicide areas. ?here is no reason at this time to believe that
the diversity differences are primary treatment effects.

?To compare quality of vegetation in the experimental areas,
the importance values of all species were calculated, and the
most important values are presented (Table 1). Psychotria berte
riana and Pelicourea riparia are woody species which become es- _

Zgblished in open areas near El Verde. ?They are sub-canopy trees, and can survive, at least for awhile, beneath the shade of canopy frees. Tabebuia heterophylla, Didymopanax morototoni,and Cecropia peltata are canopy trees, and also comionly becone established Fropen areas. Heliconia bihai is a cemi-herbaceous plant similar to the banana tree, Phytolacca icosandra is an herb having a niche similar to Phytolacca americana of the Northeastern United ?States which is that of an early colonizer of forest openings. Fhytolacca icosandra had a low importance value in the irradiated grea at the time of sampling. Most of the plants were decaying, ani there were no new seedlings. However, P. icosandra was the most conspicuous plant in the irradiated area several months after radiation ceased. Although there is a considerable ancunt of natural variation, the data generally show that the same species are invading all four areas of study.

---Page Break---

v1

Light at two wavelengths, and the ratio between the

two, above

the canopy, on lov. 16, 1967.

Figure 2

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we

To quantify differences between plots, percentage sintaritiog vetween all pairs of plots were calculated (Table 2). ?The weit drained area of the irradiated plot was approxinately as sinilay to ali other plots as the two herbicide plots were to each other, This indicates that differences between the irradiated plots ani other plots is not a function of treatment. Radiation recovery studies are continuing although at this time it appears that recovery and succession is not primarily related to the original ?treatment. Within the natural variation of small plots the recoveries of vegetation are similar for all damaged areas,

ytioal Measurements, For many ecological studies, the leat aren Lites (atnre metas of lent surface per ayiane aster ot ground) mst be known. Optical density has been used as a measure of canopy thickness. However, there are several problens with optical density as a measure of leaf area index. One is that the optical density method, which compares photocell read-

ings above and below the canopy, assumes that all light is either transmitted or absorbed. Actually, mich of the light is scattered as it moves downward through the canopy. Another problem is that photocells mst be read similtaneously above and below the canopy.

Leaf area index can be calculated by measuring the infrared-red light intensity ratio (600 m/675 mu) on the forest floor, thus eliminating the difficulties of traditional optical density measurements, ?The theoretical basis of this measurement is as follows. Light at a wavelength of 675 mu is absorbed in propor ?tion to the amount of chlorophyll in the canopy, and thus its attemiation is a better measure of leaf area index than light at all wave lengths. However, the anount of 675 mu light is independent of time of day, at least between 9:00 a.m. and 3:30 pam (Fig. 2), and also time of year. Since there is very little attemation of infrared light as it passes through the canopy, the infrared-red ratio appears to be a gool measure of leaf area index, at least on sunny days. Calibration of leaf area index ?with the 800m /675 mi ratio was repeatable within limits of instrument error and sampling variability (Fig. 3), using direct measurement of leaf area index froma tover.

Insect studies. Dr. Elizabeth McMahan surveyed termite survival during the sunmer of 1967, It was found that 7 out of 13 termite nests in the 80 meter circle around the radiation center were abandoned since the end of irradiation. Four of these nests

were in the region between 30-80 meters fron the position of the

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Retief Light, 8007675 mys 7

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Figure 3

Kline adjusts a plastic Dag used for measure-

ment of metabolism in lea

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ST

eee youre?. Three of these vere alive during the sumer of 1966 but were abandoned sonetine during the following years The Jowest calculated radiation dose to an abandoned nest was 100 R near the 80 meter circle. By contrast only one abandoned nest Gut of 12 studied was found in the 80 meter circle of the control center. the long delayed abandoment of termite nests (rafiation geased in April 1965) may be due to sterilization of reproductives in the nest without actually killing the existing insects,

MOURAL CYCLING STUDIES

The objectives of the mineral cycling projects are to measire existing distribution of macro and micro elements in the rain forest, to study pathways of movenent of these elements, and to measure rates of movenent along these pathways. ?hese studies are expected to provide in the short run an empirical basis for the prediction of the fate of radionuclides which may be released in tropical commnities, and may lead in the long run to a theoretical understanding of material handling mechanisms in tropical, ecosystems. ?the mineral cycling studies are divided for convenence into four categories of activity. These are: 1) Fallout Measurements; 2) Radioactive Tracer Experiments; 3) Stable Element Analyses; 4) Water Budgets.

EALLOUT MEASIREMENTS

13%cg_ Residence Time. Neasurement of radiomclide residence tinea-in the El Verde forest is a contiming effort in vhich the half tine estinates in various coupartnents are revised approxi-mitely at six nonth intervals, ?he estinates are based on a group of samples collected monthly at the field site fron canopy, Unierstory, and litter, The samples are oven-dried after collec-{on and counted in a Marinelli breaker by the method of ganna scintillation spectonetry, utilizing a shielded Nal (17) erystal connected to a 400 channel pulse height analyzer. The complex spectra are resolved into their individual components by ecnputer solution of simultaneous equations, the data for each Muclite aze then plotted as a function of time on a semilogarithmic scale and regression lines are fitted by the method of least squares.

Residence times for 137¢s in canopy, fresh leaf litter, and understory leaves are given in Figure, Understory leaves have

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Eitective residence tines for 137¢s in freshly fallen Litter, Canopy leaves, and understory leaves in the rainforest at El Verde,

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the greatest burdens, followed by canopy leaves and fresh leat Litter. Te lov values in leaf litter indicate a possible loss of ies by leaching since these leaves are collected only once each month. The computed residence tines for each forest compartment are given in Table 3 along with deposition data. Understory leaves have the longest residence half tine while canopy leaves have the shortest. ?The values of environmental half life for ics are shorter than those for 90sr and inply @ less effective retention mechanism for 137cs, similar nea surenents have been made tor Whigs, 95sr, Hm, and 0s,

TRACER EXPERDEENTS:

Behavior of 13's in Soil. A tracer experiment described in a previous report was terminated with the conclusion that

very little cycling of this radionuclide from soil occurred in understory vegetation. (PRNC-102, p. 146). After the conclusion of the vegetative phases of the experiment, soil and litter experiments continued.

13les was leached by rain from the organic surface litter of the plots with an enviromental half life of approximately 15 days, Upon reaching the scil, however, muclide movenent became extrenely slov. Figure 5 shows the depth of penetration of the muclides into the soil after 18 months of leaching. The relationship is exponential and shovs that activity is reduced by about half in the soil for every inch of depth, ?This behavior is unexpected for highly weathered soils in a high rainfall area. A partial explanation for this behavior is given by the results of laboratory extractions of soil (Figure 6).

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The results show that 14¢s reacts with some component of the soil more or less irreversibly and camot be renoved by successive extractions with a neutral salt. When extractions of the sols with HCL were done, similar amounts of the nuclide remained in the soil.

The results of the field and laboratory analyses of soll sige

gest that ??"os became irreversibly bound to, or fixed by, clays of the soil, Fixation of alkali metals is well known in sol? chenistry when expanding lattice clay minerals are present. X-ray diffraction analyses of rain forest soils are planned to determing whether such minerals are in fact present.

Reactions of Nuclides With Epiphyllae. Epiphyllse are mixtures of organisns which grow on the surfaces cf leaves in the rain forest. Their populations may include algae, fungi, lichens, Liverworts, mosses or bacteria. These organisms have been suspected of playing a role in the mtrient cycling mechanisns of the forest because they were found to contain large amounts of fallout radiomclides, Experiments were carried out in cooperation with Dr, Raymond Henzlik, an Oak Ridge Research Participant from Ball State University, to examine some reactions of these organisms with radiomuclides.

Leaves from four species of trees were gontaninated with radioactive solutions containing 134¢s and 85sr for a period of 20 minutes, after which the leaves were washed in tap water for

6 mimites. All species had leaves both with and without epiphytic grovth. ?The results are shovn in Table 4, Epiphyllae were fron 4 to 7 times more efficient in retaining radionuclides than were leaves which had no surface growth. ?This indicates that these organisms may be adapted to deriving their mineral mutrient re-

Quirements by interception of rain water or canopy leachate.

Minerals which are intercepted by epiphyllous leaves might be transferred to the leaves by foliar uptake. If this happens it could be an important source of mitrients for the higher plants of the area. An experiment was done to determine whether leaves received mtrients from labeled epiphyllae. Excised leaf sec. tions containing labeled epiphyllae vere placed firmly against the surfaces of leaves in the field and held there for 2 hourse Teaves in the field were matched for those having surface gravth and for those which aid not. After up to 10 days the lewen mee harvested, sectioned and counted,

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The results (Table 5) show that epiphyllae took up more ra-@ioactivity from the labeled overlays than did clean leaf surfaces. The activity in the tip portions of the leaves probably indicates surface translocation since the leaves are adapted to shedding water in this direction, ?he activity in the basal portion of the leaves may indicate some uptake and translocation by the leaf. It is apparent, however, that most of the activity renained in the region of the leaf which was originally contaminated. It is concluded that epiphytes of this type are not efficiently adapted to furnishing their higher plant hosts with minerals through

foliar uptake. The strong binding adaptation exhibited by these organisms for mineral elenents suggests that the opposite may be true. Minerals leached from leaves by rain water may be the sources of nutrients for the epiphyllae.

Witrogen Fixation. ?The source of biologically available nitrogen in the tropical rain forest is a question of long standing interest. ?This is because there are no significant geochemical sources of nitrogen and also because the enviromental conditions favor rapid nitrification of biologically released nitrogen which may be lost from the systen due to leaching. One possible source of nitrogen in this systen is fixation of atmospheric nitrogen by epiphyllae which grow in abundance on practically all leaf surfaces in the forest. An experiment to test for nitrogen fixation by these mixed communities was carried out in ggoperation with Dr. Joe Ranisten (University of Georgia) using Tig.

Five leaves of a grapefruit (Citrus paradisi) tree were enclosed in plastic bags with an airtight « eat he normal atnosphere was withdrawn from the bags through hypodermic needles and the atmosphere was replaced with an artificial one consisting of 15% argon, 20% oxygen, and 5% nitrogen-15. ?The leaves were allowed to remain in this atmosphere for 48 hours and were then harvested. Epiphyllae were scraped from the leaves imediately, and pooled into one sample. Leaves and pooled epiphyllae were

sent to a commercial laboratory for 19N ratio analysis.

Results are shown in Table 6. ?The epiphyllae had 9.67% of their total N in the form of ION, ?the leaves from which the} been scraped were also enriched above the natural level of 7" which is 0.36. It 4s apparent that N fixation took place and that some transference to the host leaf also occurred. ?This suggests a possible symbiotic relationship in which N may be furnished

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directly to forest plants by these organians, the eplgtytiae

{in turn receive inorganic nutrients fron the Tewea oe nee Sv trees, tether or not the relationship is truly eingeotg, ort epiphyllae certainly add to the pool of available N in ?the forest through leaf fall and cell turnovers ?It ia apparent ther aoe tentially important new source of biologically araitatie et. ihe tropical rainforest has been found.

Radionuclide Distribution in Animals, ?this study was designed to evaluate the utilization by forest animals cf lover Plante groving on tree trunks. Three tree trunks were tagged by spraying each with 1 mCi of carrier free 652n solutions. Abe sorption of the tracer mclide was effective and similar to that

previously discussed for leaves, ?the three trees were spaced in the form of a triangle. Collections of snails, lizards, frogs, spiders and insects are made weekly from within and outside of the triangle by various methods. Aninals are counted live by gama ray spectrometry when possible and released near the area of capture. A11 of the groups of animals mentioned have shown nea-surable levels of ©5zn.

Herbivorous insects have failed to show levels of ©5zn that would indicate direct feeding on epiphytes, even when they are taken from labeled trunks. High levels of tracer in vertebrate and invertebrate carnivores, however, suggest that a herbivorous link exists. Relative levels of tracer indicate that snails my be the principal herbivores utilizing this source of food,

Lizards, frogs, and snails have been captured, marked, counted and released through several repetitions. This procedure has al-owed the acquisition of information on homing behavior and territoriality as well as feeding habits. ?This behavior is well @eveloped in snails and lizards,

re 7 shows an example of homing and territorial behavior of 137 snails of this species are available and indicate that there are 2 categories of behavior following release at the point marked X. Some snails leave the study area in apparently random directions after renaining in one place, usually a tree, for several days.

These are called transients. Others, designated as residents, move at once to other locations, which, when plotted over several releases, delineate a territory, or home range. There seem to be two distinct types of residents, one with a small hone range

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RECAPTURE POINTS

© snot! 028, wt 32.0 9m

(© Snot 095, wt 24.4 gm

Snoil_ 085, wt 304 am

© Sno 086, wt. 30.2 gm

Scole | em* I meter

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dependent of snail sizes the other type has a larger ranee tiny

are classified as narrov-ranging or vide-raneice inna

full significance of this difterence Le not set une ee

transient sails entered the study area voluttariion whine ote

were carried in exporinentally, lone of the latter eoemuiene

home ranges in the study area,

Overall recapture percentages for snails has been 79%, for M6 recaptures. The mmmber of recaptures has ranged foe one to 16 per individual, with no indication of a limit of tolerance for this treatment. ?There is no evidence that snails develop either evasive tactics or increased susceptibility to capture. The mean recapture interval is 13 days based on weekly collections with extremes up to 106 days.

Most of the snails have low levels of 65Zn, which is probably due to foraging in contaminated litter that now sirrounis the base of the contaminated trees. It is obvious, however, when a snail actually grazes on one of the treaged trees, becatse of @ sudden large increase in body burden of ©; Such Jumps in radioactivity are termed a "high-level uptake" (HLU) and are use~ful for describing snail behavior. Table 7 gives a description of snail behavior for various categories of snails. It is apparent that the transient snails contact and feed on the contaminated trees with mch greater frequency than the resident: Among the residents the wide-ranging individuals contact the treated trees with greater frequency than the narrow-ranging individuals in spite of the fact that their greater range should lover the probability of contacting a radioactive tree. the tree climbing behavior of transient snails is so dependable that it has been utilized intentionally to obtain a group of labeled snails for a

bio-elimination study.

Sixty snails were made radioactive by the above method for a bio-elimination study. Thirty were released into their hone ranges while $he renainter were retained in cages. The biological half-1ife of ©5zn in snails released in their hone range vas estimated to be in the range of 18 to 24 days, with an intication that there was more rapid early release, Dissection of individe uals revealed that within one week 80% of the radioactivity was confined to the liver while the remainder was in mscles and other soft parts and almost none in the shell.

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STABLE ELEMENT ANALYSES

?The project received a Perkin Elner Model 303 Atomic absorp-tion spectrorhotoneter during the past year and put it into service inmediately upon arrival, the first analytical project involved the determination of Ca, Mg, Mn, Sr, and Co in canopy, understory, and litter leaves to determine whether stable ele-

ments in natural mineral cycles follow the same pathways as the fallout nuclides. While this project has not yet been completed or summarized, preliminary results indicate that the stable elements are enriched in understory vegetation, as was found with the fallout mclides. ?The results also indicate that there are significant differences in mineral content among species and that ?these contents do not undergo seasonal variation.

A second project was initiated to measure Ca, Ng, Mn, and Na in water cole cted from various points in the forest. Sources of water include rainwater, canopy leachate, stem flow, and soil water. More than 150 samples of water have been analyzed for the above elements thus far, on monthly composites. Significant amounts of the above elements are found in all phases of the forest water although tentative conclusions would be premature at this time. ?he project will contime for at least one year, at which time a calculation of mineral budget based on water flow volumes for each compartment, stand densities, and leaf ?turnover will be computed.

A third project is being initiated at this writing to study mineral contents of secondary successional vegetation. ?The pro-Ject will contime for at least one year and will attempt to characterize mineral cycling in successional communities,

WATER BUDGET

Tritium Experiments. Tritium in the form of tritiated water could be released to the tropical environnent through thermo-nuclear detonations of either a peaceful or miltary nature. The behavior of such releases in the high rainfall tropical ecosysten is not known. An experinent was carried out to measure sone as-pects of this behavior in soil of the rain forest.

?Tritium (HT0) was applied to a small soil plot in the rain forest. The plot was equipped with a lysimiter (sce PRNC-102, ps 1K7) and a runoff collecting device, both of which drained

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27h

into plastic water collection vessels. Water samples were col-lected from the plots at first after every rainstorm and later at weekly intervals for a period of seven months. Samples were counted by standard methods of liquid scintillation counting.

Results of the experiment are shown in Figure 8, Tritium reached a peak of activity at the depth of the lysimeter (18 on) in approximately 16 days. ?The enviromental residence tine of tritium in the soil profile was calculated by least square ana-lysis to be 16.3 days after reaching the peak. ?Tritium loss in the soil litter was shown to be a 2-compartment system. The first

phase of loss had an environmental residence time of 2.9 days; ?the second had a residence time of 35.6 days.

The results for the soil profile ani surface litter indicate that there mst be compartments which do not have rapid exchange by self diffusion of water. Restricted self diffusion could be the result of the tortuosity of clay pore spaces, absorbed water films on clay surfaces, or exchangeable hydrogen, Regardless of the reason for restricted self diffusion, it is apparent that ?tritiated water has a considerable persistence in soils and litter of the tropical rain forest. This persistence mist be considered in predicting the effects of thermonuclear detonations in a tropical environment because it is evident that plant roots growing in contaminated soil will be exposed to this nuclide for consider~able periods after even a single input pulse. Crops grown in forest clearings for human or animal consumption will be correspondingly contaminated.

Water Balance, Measurements of water flov through the forest enviar contime, Compartments measured include total input, water reaching ground level, soil flow through, surface runoff, and tree trunk runoff. A preliminary water budget based _on 8 months of measurenent at one location is given in Table 8. ?The results show that 72.6% of the total rainfall reaches the ground at this location and that 36.9% of the total rainfall moves through the soil. Only 4.5% of the total water runs off the soil

surface. ?The difference between input to the ground and bulk loss must be a measure of evapotranspiration, Computations from Table 8 indicate that this quantity is of the order of 2.65 my/day. Odum (personal communication) has previously measured evaporation from a free water surface at the top ofthe canopy and has given an average value of 1.8 mm/day. A computer program is being written to process the data fron more than 30 lysimeters and 10 rain

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Gages. It is expected that this will allow more precise evalua-
tion of the water budget. * ? ?

Stem flow is an important means by which chemical elenents
are transported from the canopy to the forest floor, Tt is also
an important seguent of the water budget of the forest.

?Twenty-two stem flow collectors were put out in the sumer of
1967. The total ancunt of stem flow per tree collected fron
August through October 1967 is shown in Figure 9. Quantity of

stem flow is independent of species, for the five species mea-
sured. Amount of stem flow increases with increasing size of
?tree, up to the intermediate size trees, and then drops off
sharply with the larger trees. ?This may be caused by the shape
of the crowns. ?the large trees tend to have rounded crowns,
whereas the sualler ones have V-shaped crowns.

SOTL METAROLTSY

Metaboli of decomposer organims and roots in the soil is
difficult to measure, because the respiration rate is influenced
by the rate at which? the air being analyzed for change in

content is passed over the soil. Hovever, by putting a relafively
Jarge box over the soil surface, and meastring CO buildup inside
?the box, soll respiration can be calculated. An objection to this
approach is that the buildup of CO2 in the box inhibits further
Tespiration. Hovever, in a large box, inhibition begins only
after about 20 minutes.

the results (Table 9) are based on the rate of COp increase
in the box during only the first 10 mimtes of measurement. They
show a respiration rate of O. gn. COo/n@/nr. These results are
lower than have been previously reported (PRNC-82, p.143), but

may be more realistic since they agree more closely with known

rates of leaf fall and decomposition,

STAFF

Dr. Geonge Drewry completed requirements for the Ph.D. in Zootogy at the University of Texas. He has initiated nov projects on the cycling of radionuclides through animal population: of the rainforest. sme ee

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Mr, Douglas Krom joined the project as an instrunent technician to operate the weather station. He also has skills in computer programing and has written a progran to process water budget data.

Dr. Raymond Henzlik (Ball State University) spent June, July, and August working with project staff as an Oak Ridge Research Participant. His work consisted primarily of studies on reactions of radionuclides with epiphytic plants.

Dr. Elizabeth MacMahan (University of North Carolina) received support during July and August 1967 to continue studies on the

effects of radiation on termite populations.

Dr. Joe Edmisten (University of Georgia) visited the project during September 1967, to participate in nitrogen fixation studies using 15n.

Dr. Joe Koranda and Mr. John Martin (Lawrence Radiation Laboratory) visited the project in September 1967, to discuss the possibility of doing a cooperative tritiun experiment in the rein forest, Tt was decided to attempt to study the kinetics of tritium behavior in mature canopy trees early in 368, Dr. Jerry Kline visited Dr. Koranda's Laboratory in November 1967, to study tritium analytical techniques. At that time Dr. Koranda agreed to loan the project some specialized equipment for tritium analyses to be installed in the forest laboratory at El Verde. ?The equipment has been received and installed.

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Table 1, Importance values of secondary succession al species in a tropical rain forest.

Irradiated Center

iell Poorly Cut ?Herbicide Herbicide

2

drained grained Center ___1

Psychotria berteriana 118* 16 05* a2 ho

Falicourea riparia 265 20 52 182+

Tabebuia heterophylla 36 aoe 3 2 3

Fhytolacca icosandra, 99 0 aT 18 0

Didymopansx morototont 45 33 25 we 45

Gecropia peltata wae 7 we ge 3

Heliconia bina a) 61 °. °

% Indicates the most important species in the area,

Table 2, Percentage similarities!between pairs of experi-

mental plots.

Paire of Plots Percentage similarity

Well drained - Poorly drained 52.3

Well drained - cut iscr

Well drained - Herbicide plot no. 1 61.0

Well drained - Herbicide plot no. 2 13.9

Herbicide plot no, 1 - Herbicide plot no. 2 4g

Poorly @rained - Cut 30.3

Poorly drained - Herbicide plot no. 2 lero

Poorly drained - Herbicide plot no. 2 39.2

Cut - Herbicide plot no. 1

Cut - Herbicide plot no. 2

1, percentage similarity of 100 means

that the plots are identical; one of

© means they are entirely different.

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?Table 3. Residence times of 137s of fallout ori-

gin in various rainforest compartments.

Enviromental Comartnent	?Leaf Biomass half 1ife (days)	137¢s Burdens ? (gn/nary)
nein		
canoy	588	859 5.8
?Understory	937	D* -
Leaf fall TO	?40.5**	0.2e
leaf litter -	12h	1.2

* ND = Not determined, Included in canopy estimate.

%* Average per month.

Table 4, Adsorption of 134cs ana 85s on epiphyllous and non-epiphyllous leaves of the tropical rain forest.

hig 85 ge

Leaf surface CRY sect CEY/ sect

Epiphylious 9134 5363

Non-epiphyllous 1405 1269

Table 5. Uptake of radiomclides by epiphyllous and non-epiphyllous leaves and translocation of the nuclides within the leaves.

Blog 85 gn

Teat surface ?Region CBW/sect © CY/sect,

EpiphyLlous tip an 498

overlay 1062 60

pase 180

Won-epiphylious tip % 34

overlay nT 332

base 12 8

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Table 6, Anounts of total nitrogen in leaves and epiphyllae and

percent of total Nas 15N after 48-hour exposure to 1n2,

Wt. of Material ??

Sample Kjetdanted_(g) ale) Bn

Pooled epiphyliae 0.2059 0.0224 9467

Seraped leat #1 261703 0.0234 5.65

Scraped leat #2 1.7533 0.0085, 0.99,

Scraped leat #3 i230 0.0280 0.70

Seraped leat # igs 0.0220 0.82

Table 7. Utilization of 65zn trees by various groups of snails.

Munber of Munber of Munber of Releases

snails _releases __HLU*

?Transients 7 5 est

Involuntary a 190 5 x

Voluntary Br 26 6 4.33

Residents

Wide ranging a Bg 20 6.95

Narrow ranging 39 362 35 10.3!

Inner Zone 2B 88 1 8,00

?Transition 35 210 20 10.50

Outer Zone n 6h 4 16,00

?Total 8 ey % 6.43

?*HLU = High level uptake, an indication that

@ snail has grazed on a labeled tree trunk.

?Table 8, Water balance at one location in the rain forest at

HI Verde.

Percent of

Location Water Flux total input

cn/aay %

ower rain gage 0.847 a

Ground rain gage 0.616 6

Lysineters 0.333 36.9

funeff 0.038 45

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Table 9. Results of soil metabolism experinents.

Volume of bax 249.6 liters

soil covered by box -625 sa.meters

Change in CO concentration,

in 10 mimites (2 trials) 100 ppm

Rate of CO produetion +40 g/n2/nr.

Rate of carbon release 211 @/n2/nr.

Rate of oxidation of aa

organic matter 3 22h @/2/r.

Dr. Drewry prepares the gamma

the measurement of radioactive

experiment.

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Miss Mirtha Trujillo, a st

Dr. Alec Grimison and Dr.

the equipment for the detection o

of gamma irradiated samples.

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

The project aims at the trapping and subsequent characterization of the species formed by y -radiolysis of heterocyclic molecules of possible biological importance. Emphasis is therefore placed on direct observation of the usually labile intermediates formed after the absorption of high energy radiation. This is made possible by utilizing the matrix isolation technique, in which the molecule is irradiated in sone forn of rigid matrix, normally at low temperatures. Under appropriate conditions, radicals and molecular ions can be stabilized by this technique for extended periods of time, and studied by spectroscopic technigues. An important part of the program involves the quantunmechanical calculation of electronic properties of heterocyclic radicals and ions, ?hese results are then used in conjunction with the experimentally measured properties to help identify unknown intermediates.

A description of current research projects follow:

1, Absorption Spectra of io Intermediates at T7°K.~

the work carried out in previous yeare with heterocysiic solutes in nethyltetrahydrofuran (WIMP), 3-nethylpentane (3HP), and Freon Glasses has been extended considerebly. In particular, the Characterization of the properties of the Freon mixture under gamma-radiclysis has been reported, denonstrating the importance Of positive-charge migration in halogen glasses. This has led fo the assignment of the absorption naxima for irradiated pyrrole, in Freon at 600m to the pyrrole radical cation, that of pyridine at 360 my to the pyridine radical cation, and thet of thiophene at 320 and 830 mu to the thiophene radical cation. ?his represents the first characterization of these species.

A list of the new absorption maxima obtained from gamma-ir-radiated heterocyclic in MIE?, 3MP, and Freon glasses during the past year is given in Table 1, ?he results obtained for pyridine, pyridazine, and pyrazine in MIHF are particularly interesting. The radical anions of pyridine, pyridazine, pyrazine, and pyrimidine have previously been prepared by Dr. Hush, at the University of Bristol, England, by chemical means. He reported absorption maxima of pyridine anion at 335 mi, pyridazine anion at 352mu, and pyrazine anion at 36 m,, all measured in liquid THF, These reaults are obviously in close accord with the species formed by gamm-irradiation in Table 1, especially for pyridazine. This

represents the first demonstration of the importance of ionic

intermediates in the radiolysis of heterocyclic molecules. ?The

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18h

TABLE 1.

NEW ABSORPTION MAXIMA FROM GAMYA- IRRADIATED

HETEROCYCLIC MOLECULES IN RIGID GLASS AT 77°K

?Substance Glass A max (mu) Effect of bleach-

ing solvent band

- Silica 256 increase

cell (uv bleach)

Indole Freon 1000st, 620, -

600, 565, 550

Imidazole Freon 580 decrease

Pyrazine ?-MIHF_?_340,500 7

Pyrazole MEE san -

Pyridazine MIF 354 increase

Pyridine MoE 350 increase

Pyridine SMP 360,1200 =

Pyrrole MEF 400 decrease

Thiazole MF 330 increase

?Thiophene MIHF 670,370 increase

Thiophene ? 3MP-_??_-830,320 decrease

mee

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results for indole in Freon glass are in partial agreenent with flash-photolysis studies by Grossveiner. Thus he reported intermediates with absorption maxima in the region 600-400 m, and tentatively assigned this to a neutral radical in early papers,

Our results suggest that the intermediate observed by Grossveiner may have been the indole radical cation.

2. Luminescence of Irradiated Glassy Solutions. The purpose of the luminescence experiments recently initiated is two-fold.

The existence of new emitting species formed by ganma~irradiation,

and having different excitation and emission characteristics from the original solute, can be demonstrated. Also, recombination luminescence of charge-separated states formed by ganma-irradia~ tion can be stimlated by infrared or thermal excitation of the matrix. This causes the breakdown of trapping sites in the matrix, and under suitable conditions gives rise to the charac- teristic luminescence of the original solute molecule, subsequent to its regeneration, Table 2 shows some of the preliminary re- sults obtained for a range of irradiated solutes in 3MP, including some aliphatic and homocyclic compounds previously studied by other groups; and for which excellent agreement is obtained. In some cases, extremely long-lived (10 mimes) luminescences are observed which may be due to radical cation-anion reconbinations.

3. Electron Spin Resonance Studies, ?the ES spectra of the irradiated Freon mixture have been measured on a Varian E3 spectro- meter. ?he resonance associated with the degassed, irradiated sample and tube is complicated, extending over 500 gauss with un- resolved and overlapping structures, ?he analysis is further com plicated by hydrogen aton resonances which change on exposure to Visible light. the hydrogen aton resonances are produced from water molecules adsorbed on the silica sample tubes. ?he sensiti- vity of light suggests that an intermediate adsorbing in the visible region, such as the trapped electron or adsorbed Hig0-, may be pre- sent. "ESR spectra of irradiated frozen Freon droplets, without the use of a sample tube, were therefore studied. some experimental

difficulties remain, but an ES resonance at 2800 gauss and 9.2
gigacycles has been? shown to decrease on bleaching with ultra
violet light. This is concomitant with the decrease in the 585
and 330 mu u.v. absorption bands of irradiated Freon. It can
therefore be assigned in the same way to positively charged
species produced in the Freon matrix by gammi-radiation.

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4, Photochemistry of Heterocyelic Molecules in Rigid

Mateiess SE7PK: As an aid to the identification of radiolytic Tniierediates, @ series of experinents on the ultra-violet ir-radiation of heterocyclic compounds and aroaatic anines have

been nate. the generality of biphotonic ionization of a large cinss of compounis via the triplet state has recently been denon-strated, Mis therefore provides an alternative route to the pro-duction of the radical cations of heterocyclic molecules. A large number of aromatic amines were first photolyzed, since many of

these are already known to photoionize, his provided a test for the suitability of the present experimental setup for observing photoionization, and a confirmation of the earlier published work, The results (Table 3) were in excellent agreement with earlier work in almost all cases, and the first steady-state (as opposed to flash-photolysis) photoionization of ethylaniline and Giethylanizine was observed.

Of fifty heterocyclic compounds screened in preliminary testing, only fifteen gave significant production of intermediate absorptions. One particularly interesting result vas the produe~ tion of a band at 20 mu from photolysis of indole. ?This corresponds closely to the spectrum assigned to the indole radical cation in our ganma-radiation experinents and the flash-photolysis work of Grossveiner, described earlier. ?The fact that the photo-Yonization of heterccyelic molecules appears to be an inefficient process is not entirely unexpected, It is already known that the {riplet lifetines of many W-heterocyclics are mich shorter (1/1000) than those for corresponding honocyelic molecules, Modifications in future experimental procedure should permit more effective production of photoionization.

5. Self-Consistent Field Calculations on Heterocyclic

Radicals ?and Radical Ions. A computer program has been completed Which utilizes the input liuckel wave-functions to carry cut Pariser-

Parr-Fople self-consistent field calculations on open and closed shell systems. ?his program calculates wave-functions and eigen-values for up to 10 pi-electron systems. ?The Pariser-Parr-Pople program is then linked to a second program which computes the molecular repulsion integrals, and thus the singlet-singlet and singlet-triplet electronic transition energies and oscillator strengths for neutral molecules, and the doublet-doublet electronic transition energies and oscillator strengths for radicals. ?This produces a theoretical absorption spectrum of a given radical, which can be compared to the experimental spectrum assigned to that species.

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The greatest uncertainty in such calculations lies in the choice of the best values of semi-empirical parameters for radical species, The approach taken here is to first carry out an extensive set of calculations on the parent heterocyclic nole-eule to find the values which best reproduce its known spectrum. These parameters are then used in calculating the spectra of the derived radicals. This approach is extremely time-consuming, since no general search method can be implenented. However, the results obtained in this way for the lowest transition of the pyrrole molecule are:

Theoretical ? Experimental

Transition Energy Energy (ev)

3+ 4 ("BD 5.62 5.88

3+ 4 Ga) 4.19 4.32

?These calculations now yield an absorption maximum for the pyrrole radical cation of 1.2 eV, against the experimental value

assigned in this laboratory of 1,5 eV. In spite of this encouraging result, ancnalies have appeared in calculations on some systens, particularly radical anions, in vhich spin correlation effects may be very large. In view of this, the matrix elenents for a limited configuration interaction treatment of the Pariser-Parr-Pople vave functions have been derived. A program using this is being tested nov. Tt will Link with the earlier prograns and produce configuration-interaction improved wave functions and energy values which should be more reliable.

6. Valence-Rond Calculations on Heterocyclic Systems. ?These calculations are being carried out in cooperation with Professor C. Zauli, of the University of Bologna, Italy, and his group. They aim at calculating the electronic structure of triplet states of simple heterocyclic systems, and doublet states of derived radicals, using a non-empirical valence-bond method. The preliminary calculations are being made on cyclopentadiene as a mode) compound.

The formal expression of integrals anong determinantal basis functions in tena of integrals anong atonie orbitals 1¢ com pleted. During a tvo month visit by Dr. A. Grintson to the Unt-Yersity of Bologna, sone 500 atomic integrals were computed on an Ta 7094, for a net of exponent values, and using a very accurate self-consistent field potential for the ring carbon atoms, These ?values are nov being inserted into a progran at FRNG to produce

the singlet, triplet, and quintuplet energy levels of cyclopenta-
diene, An advantage of the approach used in this project is the
ease of computing radical species by setting certain sets of An-
fegrals equal to zero in a cloved shell molecule calculations

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Or. Lawrence S. Ritchie
fish with cercariae 0:
which have been labeled

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SCHISTOSOMA MANSONI PROJECT

This research program is directed tovard a better understand-
ing of the mechanisn of the host-parasite relationship that could
eventually lead to the control of schistosomiasis, a disease which
affects over 200 million people throughout the world.

During 1967, a special agreement with Walter Reed Army Insti-
tute of Research? enabled us to secure the assistance of Dr. Lavrence
8. Ritchie, an authority in the schistosomiasis field. Dr. Ritchie's
participation in the project since July 1967 made possible the

Standardization of snail culture and the infection of the definitive host used by us (the mouse). Several experiments were also started and others completed under his supervision. Some were presented to scientific meetings; others have been mibmitted for publication, sone of which have been approved by such journals as Experimental

Parasitology.

Cooperation was greatly increased with a group at Minas Girais from Belo Horizonte, Brazil, headed by Dr. Jos Pellegrino, Last year we were visited by Dr. Celio Murilo de Carvalho Valle and Dr. Pellegrino, who worked with us for four months and one month, res~ pectively. Collaboration begun last year with the U.S, Public Health Service Laboratory (directed by Dr. Frederick Ferguson) was continued and various results were obtained, especially in relation to labeling of snails and cercariae, Accomplishments warranted ex- tending this project to include field observations. Cooperation continied with the group from the U.S, Veterans Administration Hos- pital under Dr. Menendez Corrada with reference to certain inmno~ logical investigations; some results are ready to be submitted for

publication,

The following abstracts describe the major projects carried out during 1967.

?The Maintenance of Schistosoma nangoniat the Puerto Rico Muclear Genter, Several changes have been made in maintaining the Tife cycle of Schistosoma mansoni, They are concerned primarily {ith snail culture and standardizing the exposure for mice.

Tap water in this laboratory was found to be toxic for snails, presumably due to copper ions from the piping. Water was then obtained from a river source for snail culture, Since this Limited the size of the stock that could be maintained, an attempt was nade to condition the tap water by passing it through sand and charcoal. ?This proved effective and 15 shallow aquaria (30 x 18 x 6 inches)

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were constructed in tiers of three. ?hese were provided with a continuous flow (fast drip rate) of conditioned water. This in provenent afforded a stock of about 2,500 uninfected and 800 in~ fected snails, Young snails are cultured in small aquaria until they are 3-5 mm in diameter and are then transferred to the aqua~ ria. They normally reach a size of 12 nm in about 2 months. ALL snails are fed a formla of ground alfalfa, pulverized dry dog food, wheat germ and povdered milk (4:2:2:1 parts, respectively), The alfalfa was substituted for Cerophyl recently, since it proved

equally satisfactory and is sold locally as dairy feed at mch less cost.

?The sample of cercariae for mouse exposure is provided by means of a semi-automatic pipette. Before the miltiple samples are taken for group of mice, each of five samples is dispersed in @ serological spot-plate. A drop of iodine is added to each spot and the cereariae are counted. For this series of 5 counts, the standard deviation is determined; a standard deviation of #5 is deemed acceptable for a sample of 100 cercariae.

Exact worm counts have been made for 10 mice from each of 2 series of mice exposed weekly. ?The mean worm counts have been detween 40 ani 50, with a standard deviation of t 10-15. ?he munber of cercariae recovered as worms represents a recovery rate of 40-50%.

Effect of Radiation on the Reproductive Potential of Bion Hularia Glabrata. During 1967 groups of Isboratory-reared Bi Phalaria glabrata were irradiated with a © Co gamma source to Provide exposures ranging from 125-1000 Rads. ?These results con plenented data collected in 1956 which involved exposures ranging from 4,000-64,000 Rads (See 1966 PRNC Annual Report, p. 165).

With 16,000 Rads, marked damages were noted in all parameters, including 100% mortality after 60 days, no movement or ingestion

of food subsequent to exposure, termination of egg laying within ?two weeks, and no hatching of the eggs that were laid, With 8,000 Rads, results were intermediate, while with 4,000 Rads near-normal results were obtained in all the above parameters. However, the development of eggs showed abnormalities even with 4,000 Rads, and it was deened advisable to determine the effects of lesser dosages (125-4,000 Rads). Five mundred (500) Rads marked the threshold of irradiation effects and reference will not be made to the lover doses used.

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Irradiation with 500-4,000 Rads aia not cause significant deaths among mature B. glabrata, the mean munber of clutches laid per snail per day vas reduced for snails exposed to 4,000 Rads,but not with 2,000 and 1,000 Rads. With increase in radiation from 500-l,000 Rade the number of eggs per clutch and eggs produced per ?snail? per day declined sonevhat. gg development was not affected except for eggs laid by snails exposed to 4,000 Rads. Even with this radiation, eggs laid during the first month developed in mn-vers equalling the non-irradiated controls. During the second

month, development of eggs laid was reduced about one-third. Hatching of eggs was the aspect of snail development most sensitive to irradiation. Whereas 13% of the eggs from non-irradiated snails hatched, the corresponding figures for 500, 1,000, 2,000 and 4,000 Rads were 42, 25, 14 and 2%, respectively (table 1).

In comparing the results of the tvo experiments, it was noted that egg production was reduced more by ',000 Rads in the experinont carried out in 1967. ?The most important finding for the ra~ Giations within the range of 500 to 11,000 Rads was the marked reGuction in hatehing.

Spgils exposed to 0, 14,000, 8,000, 16,000, 32,000, ana 6l,000 Rads (Co) were sectioned serially for histopathologic studies. Three snails fron each of the above categories were sectioned weekly for T weeks. After exposure to a dosage of 16,000 Rade, the snails were permanently sterile. The corresponding histopathological picture and the histology of a normal snail are shown in Figures 1 and 2,

Labeling of Biomphalaria Glabrata with Radioseleniun. ?The objective of this study was to evaluate radioselenium for labeling

B

Blabrata. Both "se (1j75se03 in HCL) and 75se-methionine Proved very effective for this purpose; these isotopes should be

effective for studying a wide range of paraneters in relation to the population dynamics of B. glabrata. Since these observations were made in conjunction with attempts to label cercariae, the snails used were infected.

In each of tvo trials, 20 infected snails were exposed to 10 uci of 75seemethionine by mixing the isotope with 250 mg of food formila. Seven weekly feedings with a total of 70uCi were administered in both the first and second trial, but in the case of the latter, 3 additional feedings were given during the 8th week for a total of 100u Ci, In the first trial, radiations were

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19h

?TABLE 2.

Effects of Cobalt 60 Irradiation (500 - 4,000 Rads)
On Biological Potentials of Biom; ia glabrata

ee

Weeks after

irradiation Amount of Irradiation (Rads) |

jontrole

Death rate

(A) 1-8 10 ° °

Mean

clutches/day 1-8 AS 78 +75

Begs/Clutch 1-8 rr 6 18

Bags/snail/

Day 18 6 Boos

& Eggs with 1-4 6 99 99

Embryos 5-8 67 9 99

4 Bebryos

Hatched 1-8 2 wa 25

76

22.

29

99.6

98.5

43

ee _*"

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started 2 weeks after snails were exposed ti

5 afte: were exposed to miracidia. In the

fecond trial, the infections were patent at the onset of radiation

A group of 20 infected imens without the isotope we:

eesals specimens without sotope were kept ag

Snails were rinsed thoroughly before determining radioactivity, Counts were made with a Model 186-A Iclear Chicago Counter, At the end of the second experiment, 4 snails were killed by inmersion in water at 70°C for 30 minutes, after which soft tissues were removed ani radioactivity was detérmined for shell and soft tissues separately. This was also, done for a group of 5 snails exposed one week to 25 Ci of 758 (lig7? 5203).

Iwo days after the first feeding of T9se-methionine (10 ¥ ct), the radioactivity exceeded 200,000 cpm. ?here was no increase

after 12 days, but sone occurred after 26 days. he counte ?exceeded 400,000 cpm after 40 days and increased after 54 days to more than 850,000 erm in one trial and to over 672,000 epm in the other (See Table 2).

Separate comts of soft tissues and shell from infected snails given 100 uCi over 8 weeks in food showed that 7se-methionine was {incorporated chiefly by the soft tissues, the ratios ranging fron Br77 to 17.78 (Table 3). For 5 satis exposed to 25 Hel Tee for only one week, higher tissue and shell counts were obtained but the differences between activity in soft tissues and shell were less.

?The mortality rate for infected B. glabrata exposed to T5Se-methionine was found to be a little less than for infected snails not exposed to the isotope.

Feces accumilated during the final week were found to be highly active (156,624 cpm) while the water had only 2,179 cpa/ml. ?This indicates that, at least in part, 7Se-methionine was acin-lated through food? consumption.

Evidence that B. glabrate incorporated 75se-nethionine was obtained by precipitating honogenates of soft tissue with 10% trichloracetic acid and determining the radioactivity of the super-natant and residue after centrifugation, The activity of the

precipitate was about 7 tines that of the supernatante

Since the lect of 75s is 127 days, relatively long-term

experinents on dispersion and population dynanies of B. glabrata

should be possible when they are labeled with radioseleniume

Studies on radio-damage will be pursued,

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TABLE 2

ist

Labeling of Biomphalaria glabrata with 75se-methionine

Dial Tia?

Days after No. Gpm per Now Cpm per

Exposure Snails fail__?smaile ?Snail

2 20 225,570 19 2a, 26

w 18 211,228 9 21,625

6 6 231,358 19 363,274

ho ak tahoe ag 420,03

oh 10 85,985 12 672,531

TABLE 3

Radioactivity determination on the shell and soft tissues

from snails exposed to 79Se-methionine.

Gail Soft tismes hell Soft tissues

To. oom. op shel

ct 476,192 70,337 6.77

Fe 384,766 21,64h 17.78

3 399,863 36,0h0 12.09

he 523,647 43,788 1473

Se 163,652 «38,547 476

Gun 173,999 38,653 4.50

7% 197,851 9,199 hs.

Geer 13,225 12,397 20.83

Infected snails (Experiment 3)

*

Control snaiis (8-veek exposure)

Control snails (4-week exposure)

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labeling of Marisa Cornuarietis with Radioselenium and

rovede a Or snail against the vector of Schistosoma mansoni), to
P 2 means of studying its distribution when introduced in.
?© BoCOlony of unlabeled snails. Adult Marisa exposed to 2 uci
en ?Sr acguired a radioactivity of about 3,000 cpn/snail. With
0 uci of 7550, juvenile Marisa were much more active, giving
about 3,000,000 cpm, Further tests will be required to compare
the relative merits of these two isotopes for labeling Marisa,

?The time necessary for tagged Marisa to achieve a distribu-

?tion coincident with an untagged population will be computed from

observations on the snails in an artificial canal at the Tropical Disease section of the U.8.P.H.S, ?This information will be useful in planning field assessments of snails by the tag and recovery method,

Periodicity of Cercarial Inergence (Circadian Rhythm), It is knows from the literature that the emergence of S. mansoni cercariae from infected snails occurs chiefly during the day and is dramatically reduced at night (Faust & Hoffman, 1934, Puerto Rico J. Publ. Health & Trop. Med. 10: 1-19; Giovannola, 1936, Proc. Helm. Soc. Wash. 3: 60-61; Maldonado, 1959, Bol, Assoc. Med. Puerto Rico 51: 336-3393 Rowan, 1955, Bull. wid. WIth, Org. 33: 63-71)e In field experiments conducted in Puerto Rico it was found that cercarial densities vary during the day ani a consistent sharp peak was noted between 11 a.m. and 12 noon (Rowan, 1958, An. Je Trop. Med. & Hyg. 7: 374-382).

Determinations of the nunbers of cercariaze shed by laboratory infected B, glabrata were performed every two hours for consecutive days in Belo Horizonte, Brazil and in San Juan, Puerto Rico. Each snail was placed in a beaker containing 50 ml of dechlorinated water. The experiments were conducted outdoors under indirect sun~ light. ?he cercariae that energed within the 2-hour periods were killed with formalin and counted, Practically all cercariae are shed within a 6-hour period of the day. In Puerto Rico the peak

of emergence was found to be between 9 a.m. and 11 a.m, vhereas

in Belo Horizonte the peak was between 1 psm. and 3 pm. ?this fact is clearly shovn in Figure 3. The seasonal fluctuations of cercarial shedding are being investigated in Belo Horizonte, Brazil as well as in San Juan, Puerto Rico.

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Labeling of Corcariae of Schistosona Nansoni with Radio~ isotopes. The imediate goal of the present study was to label S Hansoni cercariae with radioseleniun, ?This is desirable ac a means Of studying a wide range of paraneters in relation to cercariae dispersion under field conditions, and the role of cercariae predators in natural control of the infection,

The study was divided into three parts.

Exp. 1 - Snails with patent infections of S. mansoni were placed in a glass aquarium containing one liter of dechlorinated water. 7550 was added to the water (specific activity 5.5 Ci/mg)

for a final concentration of 2001 Ci/liter. Water containing ra-
oseleniun was changed weekly for 4 weeks.

Exp. 2 - Snails exposed 2 weeks previous to §. mansoni mira
cldia vere placed ina glass aquarium containing 5 liters of de-
chlorinated water. 75Se-methionine (sp. activity 4 Ci/mg) was
mixed with the powdered snail food, A total of 70¥Ci vere ad~
Einistered (for details see the preceding abstract).

Exp. 3 - Snails which bad started to shed cercariae 2 weeks
defore exposed to 79se-methionine through the food. A total of
100 uCi were administered with the diet.

Iabeled cercariae were observed as early as 3 days after ex-
posure of the snails to radioselenium, The counts per mimte in-
creased slowly, reaching the maximm after 3 weeks 6.99 ?cpm per
Greanisn). Although labeling of cerearіae was also observed with
?Bfe-nethionine, the activity per organisa was lover than for 79se
(table 4). A control experinent indicated that feeding the radio-
isotope gave about the sane results as mixing it in the water.

?As soon as the cercariae began to energe fron infected snails
they vere already tagged. Figure, an autoradiograph of the
labeled cercariae, clearly indicates that radioseleniim was in-

corporates ty then with « coneentration occurring, particularly in the penetration glands, Cercariae labeled with /9se-nethionine retained the ability to infect mice. About 20% were recovered as adult schistosomes, in comparison with about 35% for normal cercariac. The vorns were not radsoactive.

Preliminary trials have shown that cercariae labeled with ra~ ioselenium are quite reliable for conducting studies on cercarial

predators.

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Rico

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Figure 4

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TABLE

Nean counts per minute for cercariae of

Schistosoma mansoni exposed to radioselenium

a a

(days) setentun Psereniun Pserentun

No,Gere. Mean Gem No.Cerc. Mean Com No.Ceres Mean Com

7 13 0.90 363 1.10 * *

i 2eT 2.14 835 1.20 * *

e313 "1,3 0.73 * *

a a 6.99 Ee = * *

6 8h 5015 1,038 1.51 520 1.7h

29 64 4.06 - ~ - _-

Bo 853 akg 618 1450

Yoo 831.98 903 (Ons

47 - 1,215 1.63 880 0.57

sh - = 1,185 0.98 3151.70

~ not done

* prepatent period

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"ec rrradiation (C0) on the Host-Parasite Relation-

Effect of Irrat easiee folate

ship in Gils Infected with Schistosoma manso

experinents at the P.RN.C. by Mg, Celio Murilo of Brazil vere nade using 1,000 to 6,000 Rads (0co). The number of cercarise ?that energed from the snails was determined every 3rd day for two weeks, A temporary inhibition of emergence occurred with 2,000 to 4,000 Rads, while 6,000 Rads were lethal for the infected snail,

Radiation of the infected snails did not influence the periodicity of cercarial emergence.

ship in Mice Infected vith Schistosoma mansonp Acquired resistance against Schistosoma mansoni has been conclusively denonstrated, but the mechanian has not been established. Experinents have falied to show that any of the mmnerous antibodies are involved, dutthe possibility of unidentified protective antibodies should not be abandoned. A second possible mechanism is that

resistance is mediates ty cells, or that it is a complex of both hunoral and cellular mechanisns, In order to disassociate these ?tio possible mechanions, waole-body radiation of the host wae used as a meane of depressing humoral antibody formation, where-as cellular conponents such as macrophages and reticular cells are relatively more radioresistant.

In a preliminary experiment, mice were exposed to wholebody radiation with 60¢obalt and then infected with 100 cercariae. The death rate among these aninals was compared with mice that were infected but not irradiated. In a second experiment, mice were exposed to 100, 200, 400, 800 and 1,600 Rads, and each of these groups was infected with 16, 32, 6h, 128 and 256 cercarae.

?The results shoved that 400 Rads was the optimal dosage, since it did not kill significant numbers of normal mice and provided a difference in the death rate among infections with 64 and 128 cercariae; no differences were noted with 8, 16, 32 and 256 cercariae. Moreover, the differences in mortality occurred after 3 - 4 weeks following exposure to infection, as well as later when the disease was clearly manifested. One group of mice, irradiated a second time after 4 weeks of infection, showed a significantly higher death rate than control animals, but only

when the infections were 60 days old.

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A pilot experiment involving whole-body radiation of mice as a means of suppressing acquired resistance induced by irradiated cercariae gave results that warrant further trials.

Correlation Between Worm Burden and schistosome Pigment in the Liver of Mice Experinentally Infected with sohietosona imngoni, It de knovn that red blood cells are ingested by ?schistosones and that hemoglobin is actively metabolized inside the lunen of their gut and finally transformed into a gramlar pigment. ?This pigment is swept back mainly to the liver of the vertebrate host where it is taken up by phagocytic cells. Moetzel & Lewert (1966, An, Ts Trop. Ved. & Hygs, 15:28) claim that the pigment produced by Schistosona mansoni is not a free porphyrin ?but a complex compound soluble in 70% ethancl, containing O.4g potassium hydroxide, A proteolytic enzyne with a marked substrate specificity for henoglobin has been found in ground-up prepara~ tions of § mansoni adult vorms (Tims & Bueding, 1959, Brit. J.

Fharnacol., 18, 08).

In mice harboring bisexual and male §, mansoni infections, it was observed that a linear relationship exists bebveen the schisto-?sone pignent accumiated in the liver and the duration of infection. Daily pignent production, expressed in terms of hemin, was estimated to be 1+19 micrograms per pair of schistosones and 0.2 micrograms per mle in unisexual male infections. (Kloetzel & Levert, loc.Cit).

In order to investigate the relationship between the schisto-some pignent present in the Liver and the worm burden, 5 groups of 10 mice, each weighing 20 grams, were infected with 25, 50, 75, 100 and 125 cercariae of §, mansoni (Puerto Rican strain maintained at the Puerto Rico Nuclear Center, San Juan) per aninal, using the tail inmersion method. ?the mice were sacrificed 8 weeks after cercarial exposure and the worm burden determined by perfusing the liver and mesenteric vessels with normal saline and by a thorough examination of these vessels for remaining schistosones. ?the liver of each aninal was then weighed and minced with fine scissors. The whole liver was honogenized with a sonifier and an acetone powder prepared. _ Henatin was extracted fron a 25 mg sample of the acetone powder according to the technique of Kloetzel & Lewert (loc. Cit). Hematin concentrations were determined spectrophotonetrically at 400 my by comparison with a hematin standard under the sane con~@itions and the total liver pignent was then estimated, Determina~

tion of hematin content in livers of 10 control mice shoved that it ranged from 0.17 to 0.343 mg, with a mean value of 0.255 mg.

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20h

Although these values were rather low when compared to the figures obtained from infected mice, it was found advisable to correct the data from infected animals by subtracting 0.255 ng.

?The results obtained in 46 surviving infected mice are shown in Figure 5. The worm burden varied fron + to 60 schistosones, with an average of 28 worms and with a sex ratio of 1.0 male:0,83 female. he regression curve, determined by the least-square nethod, cbeys the equation y-23.89 x +115, x representing the wom Durden and y the total schistosome pignent in the liver, as expressed in mg of hematin, ?he coefficient of correlation (r= 0,80) was statistically significant at the 0.01% probability level,

Our data demonstrates that a linear relationship exists between the total pigment in the liver of infected mice and the worm burden and confirms the observation of Kloetzel & Lewert Qoc. Cit.) that no "crowding effect" is apparent as far as pigment formation is concerned.

An Attempt to Induce Immunity in Mice to Schistosoma

Using the Millipore Diffusion Chasbeee ?Tevine and Kagan (Js Parecit 16-767, 1960) wore sole te induce some protection in mice against Schistosona mansoni by inoculating them with metabolic products from the cercarise of this parasite. In order to test this concept further, we introduced live worms into the peritoneal cavities of mice, in Millipore diffusion chambers (pore-size, 0.45). We assumed these mice would be exposed to large amounts of antigen in ?the form of excretions and secretions, and that high titers of antibodies would be produced,

?The experimental design was as follows: a Millipore aiffue sion chanber containing 5 pairs of live adult worms of §. mangond was surgically introduced into the peritoneal cavity of each of ~ 25 Sviss albino mice (Group I). They were removed after one week and the liguid that they contained was collected and used for inoculating a second group of 25 mice (Group II). ?These animals Were inoculated twice, over a period of two weeks. A third group of mice received a Millipore chanber without worms (Group IIT), All three groups were exposed to one hundred bisexual §, manson ?This was done two weeks after the capsules were renoved from mice in Group I and one week after immunizations were complete in Group II, Seven weeks later the mice were perfused in onder to

---Page Break---

MG WEMATIN/TOTAL LIVER

Correlation Setueen Korm Burden and Scaistosone

Pigment inthe Liver of infected tee

0 20 30 40 30

NUMBER OF ScHISTOSONES

Figure 5

60

oer ao Roubaaana GABAA EEL

Tentative Classification of Haenolynph Antigens oF

Blonphalaris glabrata, snaty vector of

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determine worm recovery rates.

The slide flocculation test, the Ouchterlony double diffusion method, and immnoelectrophoresis were used to detect serological antibodies, Sera were taken from the animals in Group I one week after Millipore chambers were removed, and from Group IT one week after the last injection (1 day before challenge). sera were again collected at necropsy.

At the time of challenge, Group I and IT had a positive slide flocculation test, i+ and 1+, respectively; the control group was negative. At'the tine of sacrifice ali three groups had 2-3+ reactions, For Groups I and TI, gamma G and ganma M globulin components were elevated at the time of challenge, eape-cially Group I as demonstrated by the immncelectrophoretic method (Hillyer, G.V., L.P. Frick, Exp. Parasit., 20:321-25 1967).

Worm counts revealed that no resistance had been induced against the challenge exposure in each of the two experimental groups. ?he worm burdens for Groups I, II and III were 32, 28, and 29 mature worms.

This experinent provides no evidence of resistance to & mansoni infections. In spite of the presence of circulating

antibodies, protection against schistosomiasis could not be correlated (Hillyer, G.V., L.S. Ritchie, Exp, Parasit., 20:326-33, 19673 Jachowski, L.A., RoI. Anderson, E.H, Sadun, Am H.J. Hyg, 77-137-45, 1953}. "If" specitic antibodies do conter resistance to Schistosomiasis, be it humoral or cellular, one mst determine the type in order to use it as an index of reaistance. We are still confronted with the need to demonstrate this relationship.

The Antigens of Bi ia glabrata ._ Te

Characterization and Enumeration of Bands by Immnoelectrophoresis.

?This study was concerned with immunoelectrophoretic analysis of the haemolymph of normal Biouphalaria glabrata, The objective was to provide a base-line of comparison for changes that might occur when B, glabrata are exposed to ionizing radiation. By means of the latter, attempts will be made to produce strains of snails that are resistant to Schistosoma mansoni, several investigators have studied the protein components of tissue extracts, haenolymphy

---Page Break---

and eggs of B, gisbrata using electrophoretic and imunoelectrophoretic (IEP) techniques. Only Michelson (1966, Ann. Trop. Hed & Parasit., 60:260) hag analyzed haenolymgh by means of IEP, and he reported 5-7 antigenic conpenents in the haenolyush of these

Preparation of antisera: High titers of B. glabrata anti-
sera were prepared in rabbite by means of six injections of 0.5
ml of haemolymph mixed with 0.5 nl Freund's adjuvant (Ycomplete"
for the first inoculation and "incomplete" thereafter).

Zuunological teste: Ouchterlony double diffusion and IEP
were performed as reported by Hillyer and Frick (1967, Exp. Parasit
20:321). Control slides using human serum were used as an aid in
designating the relative electrophoretic mobilities of the haeno-
lymph antigens.

Column chromatography: Haenclymph vas fractionated using
Sephatiex G-75, G-100, and G-200, ?the fractions were concentrated

by water dialysis and lyophilization,

Haemolymph labeling: Adult snails were exposed to 59e for
one week, and haemolymph vas then collected and submitted to IEP.
The slides thus obtained were processed by autoradiograrhy.

Remilts: Agar electrophoresis of haenolymph revealed a strong
band having o-2 mobility. Unsteined alides showed this region to
have red pigmentation, indicating the heme fraction, Heavily
stained slides using a protein triple stain (Crovle, 1961) sioved

trace components in the o-1 and Selectrophoretic positions, Weak hhaenolymph antisera shoved to very strong components in the 0 -2 region, one of which presumably is the heme fraction. On the other hand, higher titer antisera shoved a dronatically different immno-electrophoretogran. When compared to the human serum IEP pattern, fone observes haenclymph antigens fron the fast a-1 region to the slow y (83).

Sephadex G-100 was found to be preferable to Sephadex G-200 for fractionating haenclymph. ?Three or four significant peaks ?were found, the fastest always containing the hene portion, Further analysis will be required to detect fractions in each of

?the peaks.

A tentative classification of haenclymph antigens is proposed

---Page Break---

in Figure 6, ?woo y, five ap, eight #, and one# 3 antigens have been identified as the ainimm maber representing the haemo: lymph antigen structure of B, glabrata. Several other antigens in the 81 and Bp regions still must be identified. Presently, ?twenty antigenic components can be consistently identified,

Autoradiography was used to identify the heme antigens. One component picked up the 59fe but cannot be conclusively identifica, Further trials will berequired for clarification.

Congeneric and heterogeneric studies: Haemolymph from Maris snails was reacted with anti-E-glabrata serum by JEP. No precipitin lines were found. Haendlymph obtained from B. glabrata maintained in another laboratory in Puerto Rico was found to have an extra band in the # 3 region. A comparison was made between Albino and normally pignented B. glabrata. The Albino appeared to have fever bands, both qualitatively and quantitatively, in all areas of the immnoclectrophoretic picture. Further study is in progress on this comparison. Haemolymph of mature snails (12-weeks old) was compared with young mails (6-weeks, 8-10 m). ?he young snails had no precipitin bands corresponding to ¢j-I and 2 -II, ?his, hovever, could be quantitative, not qualitative.

the results of this study are highly significant, at least on two points. The munber and complexity of the antigens in B. glabrata haenolymph exceeds considerably what has previously been reported. ?hese results, along with those of Dusanic and Levert

(1963, J. Infect. Dis., 112:243), also give evidence that inverte-
brates may have the capacity to produce specific antibodies, which
is contrary to previous reports. It is noteworthy that such o
large number of antigens with ® and Y mobilities were found.
Lewert (1968, in preparation) discusses the possibility of immune
mechanisms occurring in B. glabrata,

the, eee of the Effectiveness of Schi stosomicidal Drugs with
the ?The need for a rapid and simple method for test-

ing new schistosomicidal drugs is evident, At present, the only
method for testing drugs is the oogram method developed by Dr. Pel
egrino and J. Paria (1965, Am. J. Trop. Med & Hyg, 14:363)+

Because §- mansoni parasites are fed on the host's blood,
59pe may be helpful to measure the degree of sickness caused t0
?the parasites when schistosomicidal drugs are administered to in
fected aninals.

---Page Break---

Right: Irradiating cer-
cariae of Schistosoma
mansoni with a special
cobalt source. Below:
technicians take care
of mice infected with
Schistosoma mansoni.

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Experimental Procedure: Forty mice, Rastested with 150 cer.
?ise, were used after eight weeks for the preliminary experi.
nent ¢0 tect the effectiveness of Anbiibar. "One tablet contin.
ing 500 ng was ground in a mortar and a few drops of "gin arabie?
added to help homogenize the suspension that was diluted to 333,
the final concentration of this solution was 1.5 mg/nl,

The mice were divided into four groups of 10 each. ?he first
group vas used as a control and the rest of the mice were treates

with 0.15 mg, 0.3 mg, and 0.6 mg, respectively,

?The mice were fed the drug orally through a cannula for 7 days and similtaneously given 5 u Cl of 99Fe intraperitenesliG to tag the blood. At the end of the 7 day period, five conteeas and five treated aninals wore killed with Nenbutel and their livers perfused. The worms were separated from the porta, mesentery and the liver. Males and females were separated ant vewen twice with saline.? the worms were assayed for radioactivity tea well scintiNation counter. Tt vas fount that the realoacteriay in the schistosones fron the control animals was 2 1/2 tos tie higher than the radioactivity found in the schistosanes from the treated animals (Table 5.). his suggests that it my be soserde to evaluate the effectivences of schistoscnocidal amas eahee this technique. Hovever, the technique te long and, Sn an effort to simplify it, worms were chosen at randon and placed on ac fe rey film, ?The flim was exposed for seven days, When develoved, no differences in the radioactivity could be detected with the nethods available to us.

In an effort to investigate this further, another group of 20 infected mice was chosen for a second experinent. This time, the aninals were treated with Anbilhar for 2 days before the 2fe was injected. Iwo animals from each group were killed with Neabutal and the livers perfused. ?The worms were separated and washed ?three times with saline containing a small anount of hydrochloric

acid to get rid of any29Fe that may have been coating the schisto-

somes.

sted at random from each of the groups and

placed on tn foray fline ?It ig aitfieate to evaluate the data

using densitometric techniques because the worms vary in size and

particularly the schistosones fron the treated aninals seened to

have morphological changes. ?he sensitivity of this technique mist

be evaluated further and work is in progress for testing other

drugs.

---Page Break---

?ARLE 5

Incorporation of 59Fe by s&histosona

after drug treatment of the host

CEM Average *

Male 336

Female 752

c

Portal Vein

? Male 183

T

Female 403,

Male ake.

c

Female 815

Mesontery

Male ash

2

Female 164,

a ,,

Male 333

c

Femle 82

Liver

Male 138

:

Female 176

a

¥ Average of 5 onimals

Drug used: Anbilhar

Host: Mice

---Page Break---

Victor Quintana transfer-

ring larvae by aspirator.

Aurea Lugo removing

pupae from artificial

food.

Sugarcane borer moth

on a corn stalk leaf.

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SUGARCANE BORER PROJECT

?he mgarcane borer, Diatraea succharalis (Fabs) (Lepidoptera, Crambidae) causes loss of two to three million dollars annually in Puerto Rico, It is a serious pest throughout the Caribbean, in the United States, Mexico, Central Ancrica, and the northern and western sugar-profucing areas of south America, ?This project began in 1963 to determine if it was feasible to sterilize this species ty radiation, We have found that the gdult stage can be sterilized by radiation exposure to 30 Kr. of 80co gama without adverse effects on longevity or mating behavior.

We first measured the radiation effect on different life stages of the organian, The egg stage and all of the larval stages are extremely radio-sensitive. The late pupal stage, fifth day and older, and the adult stage are considerably more resistant. Adults have survived exposure to 240 Kr. However, these adults do not mate normally.

?he normal mating behavior has been described, and compari~

sons have been made of the mating behavior of treated individuals. Other aspects of the develomment of this species have also been studied intensively.

A sterilizing radiation exposure (30 Kr.) given to the adult aces not reduce the oviposition rate. The average egg production for normal fertile fenales 1s 350, although sone females may lay ae nny ac 700 eggs. Over 90 percent of the eggs laid are fertile. ?A nigh percentage (usually over 90 percent) of the fertile eggs hatch, but there 4s a variation in the hatching rate throughout the years

Adult longevity was observed in 1966 with individuals reared on corn in the field, Average lifespan of adult males was in excess of 5 days, Average life of adult females was 7 days. faults reared on the artificial diet developed at PRNC live 1 1/2 ?to 2 times as long as adults reared in nature.

Field tests have been carried on in a large cage at the near by UPR farm, Population change of the borer has been measured in the plant hosts (corn) growing in the cage when the sterile adults were released, Different test series have been coniucted Gnvolving the release of sterile males and normal males with

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a

normal and sterile females; and the release of sterile males and Meorile fenales simitaneously with normal adults, and with nor-fal adults without sterile adults, When only normal adults were Peleased, the next generation was fifteen times the greater than the released population. In all tests where sterile individuals have been released, there has been a decrease in population, this series of experiments has not been completed. However, it appears that the sterilized individuals behave in nature in a similar man-ner to their behavior in the laboratory. On the basis of our pre-Lininary information, ve have evidence that population suppression will take place under natural field conditions.

The next major objective of the project is the development of our capacity to mass-rear the species. ?The PRNC diet was develop-ed in 1965. Many modifications of this basic diet have been tested since it was developed. We are presently producing from 40 to 60 adults each day on one of these modified diets. Cost per adult is 0.1 to 0.2 cents, or $1,000 to $2,000 per million adults,

Several basic dicts have been tried with this species. Early diet tests were based upon the inclusion of the natural food, or other gramineous products in the food, Corn stalk, cane stalk, grass stem, leaves, and other plant parts were included in the diets being tested. Our objective is a diet that is cheap, easy ?to prepare, and easy to use, that produces a high yield of vigorous

adults in the shortest time possible. ?he present modification produces a 30-to-40 percent yield under mass-culture conditions within 25 to 30 days.

?The adults that we are producing live longer than adults produced in nature, they mate more tines, and they lay more eggs than those collected from natural host plants,

After hatching, the larvae are collected and placed in artificial foot. This food contains carrot poder corn stalk extract, Qrever's yeast, ascorbic acid, vitamin supplement, hydrochloric acid and mold inhibitor. A technique for self-transfer is being sed, so that the mumber of larvae per vial varies fron 15 to 00. Tarvae are manually transferred to fresh food when necessary. At the tine of transfer only five larvae are placed in each 30 ml. Viel. As many as 25 pupae per vial have been produced with this method.

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Above: Life stages of the sugarcane borer: eggs and adults in and near hatching cups, larvae and pupae in food vials and on egg hatchability recording sheet, and pupae removed from vial on

table. Left: Victor

Quintana harvesting larvae

from the egg incubator.

ie.

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Right: Josefa Torres

and Victor Quintana

examining larvae in the

Jaboratory insectary.

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?Tests were made to select a strain of this species that is

well-adapted to laboratory rearing. Desirable traits that were

sought include short larval life span and long adult lifespan,

Approximately two-hundred lines were inbred over five successive

generations. ?here was a great variation in the length of larval

Lifespan among individuals within strains as well as. between

strains.

Further work on diet improvement is in progress at this tine, Handling techniques are also under study to provide the optimn conditions for survival, with minimum labor equipment. We are testing other methods for self-transferring of larvae after hatching. These are based on the attractive substance produced by the natural host plant that stimlates feeding. In addition, improved methods of cleaning vials, transferring mature larvae, and removing pupae from food are under development.

During the earlier phases of the project, occasionally it was necessary to use the surviving offspring from sterility tests for laboratory tests. It was observed that these offspring were partially sterile. On the basis of this knowledge, further tests Were made to measure the inheritance of lethal factors over more ?than one generation. Recently we completed a series of tests where sterility was observed in several different lines over five genera~ tions after irradiation, ?wo main types of lines were established. The first included a series where the irradiated lines were inbred over successive generations, ani the second where survivors were outbred with mates from non-irradiated lines, the lethal effect, as measured by egg hatch, larval survival, and pupal survival was observed through the third generation. ?his data is to be published in the near future.

The U.S, Department of Agriculture has established a progran

of investigation on the Island of Vieques, eight miles east of Puerto Rico. There are approximately 1,000 acres in cane preduction as well as several thousands of acres in guinea grass, which is also a host plant of Diatraea saccharalis. Experiments are planned to measure the effect of an integrated control program for suppressing and eventually eradicating this pest fron Vieques. This program will involve the study of parasites as well as the release of sterile adults, ?This cooperative program includes personnel of ?the Entonclogy Research Division of the USDA and the FRNC.

The field operation is expected to begin early in 1968 b;
Rologists of the UDA. PRIC will produce the sterile insects se
release on Vieques after the initial study phase has been completed.

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PHYSICAL RESEARCH PROGRAMS

Research in physical sciences,
sponsored by the US AEC Division of
Research, represents approximately

one-tenth of PRNC's program.

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Dr. M. I. Kay (left) and Dr. K. Okad

mounting of a crystal on the goniome?

PRNC's automatic neutron spectrometer.

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NEUTRON DIFFRACTION

The neutron diffraction group at the Puerto Rico Miclear Center is working on two types of problems: (1) the chemical binding of atons 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 rays diffracted is proportional to the atomic mmber 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 mclei of the atoms. Diffraction

of neutrons by light elements compares favorably with that from heavier elements, and the coordinates of the lighter aton may be

determined with greater precision than with X rays, Tn 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. ?he last two progress reports listed several completed problems, In the past year and a half several new problems were initiated and new work on different phases of the old problems extended. Some of these problems are now nearing completion and enough results are available to make preliminary reports.

I. Phenanthrene. Damask and Arndt have reported that phenanthrene undergoes @ phase transition about 72°C as detected by heat capacity, electrical conductivity, and polarization measurenents. 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, perhaps to hydrogen atom motion, since no change in X ray pattern was noted on heating phenanthrene through its transition.

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We have not yet done any work at high temperature, and the

room temperature data collection has just been completed. Hiow= ever, sone analysis was carried out when about half the neutron Giffraction data nov available was taken. ?These preliminary results which confirm previous conjectures about the structure of phenanthrene are presented in Fig. la and 1b, and in Fig, 2,

?The structure of phenanthrene was solved in the 1950's by Trotter who reported the three rings (see Fig. 1) to deviate slightly fron planarity, When we undertook the neutron work, Okaya at TEM laboratories took new X-ray data to obtain more accurate carbon position His results confirmed Trotter's on ring puckering in that the hydrogen positions determined from the neutron diffraction data show that it is the close Hk - H5 approach of 1.96 A that causes the deviation from planarity as surmised by Trotter.

?The nature of this deviation is shown in Fig. 2 in which the distances from the average plane of the central six carbons are given for all atoms. (It should be noted that at this point the hydrogen atom positions are known to only ca. O.1 f). the top ring is bent below the plane of the center ring; the botton ring is bent up from the plane of the center ring. ?the three six-menber carbon rings are each independently planar ¥ .01 8, and the top and bottom ring are about 45" fron the central ring.

Tt would be extremely interesting to compare final neutron

and X-ray positions to see if the electron density has any effect on the position of the carbon atons, However, it is doubtful if the neutron data will be of sufficient accuracy to make such a comparison meaningful because of the high inecherent hydrogen ackground and the loy PRNC reactor flux. Another possible procedure that could help shed light on the electrical properties would be scattering electron densities above and below the transition.

II, Spiral Oscillator Problem in Na A1(5,)2 212820. The structures of the Alums were reported in PRIC-9%. On page 9 of that report we note that three of the sulfate oxygens in sodium Alum (Na Al (904)2 .12 120) seem to undergo a translational motion dow the threefold axis which is correlated with a rotation about the threefold axis to avoid a near hydrogen neighbor. The scattering from this "spiral oscillator" is really not well apprexi-mated by the usual form of the Debye-Waller factor which assumes

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Fig. 1(a). Phenanthrene:
Carbon atoms are at the
intersection of 3 solid
lines. Hydrogen atoms
are at the ends of solid
lines. Atom numbering

is denoted by integers.

Bonds are denoted by solid lines with distances adjacent to the lines.

Intramolecular H-H distances are denoted given in dashed lines. Note the short H4-H5. The standard deviations of the hydrogen atoms are about .05 A at the current stage of refinement.

Phenanthrene Bond Angles.

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@ gaussian distribution of scattering density about an equilibriun position,

Tt is easy to write the expression for scattering fron a given distribution, Classically, the average time that an atom spends at point r is dependent upon potential V(r) through the Boltzmann Gistribution, If H is the reciprocal lattice (scattering) vector and the scattering pover of the aton is given by b, then the aver-age scattering amplitude from an atom is given by:

J vexp (2x 4 Her)- exp (-V (x)/x? ar

?The above integral is rather difficult to evaluate in closed form, unless V(r) is rather simple. It and its derivatives may, however, be evaluated mumerically.

?The mumerical values of the scattering, as evaluated from estizated positional and potential function parameters, and their derivatives is ?the information needed for a least squares fit of those paraneters to the measured scattering data, We are now in the process of trying to evaluate the constant for the sulfate group in sodiun alun, If this approach is successful, it could be generally used to evaluate and interpret the Bragg scattering from many types of molecules undergoing varied types of large torsional and other anharmonic oscillations.

IIT. Ferroelectrics.

A, he ferroelectric, sodium nitrite, has been studied

a great deal inthe last nine years, at least partly because the molecular motions are large and therefore more likely to be easily interpreted in tems of the electrical properties than many other compounds. In spite of all this work there is still some doubt about the direction of rotation of the NOp groups during the transition.

?To try to clear up this point, three-dimensional neutron diffraction data was taken at 150°C, about 15° below the transition. The results were anbiguous, i.e. the rams. amplitudes of motion perpendicular to the a axis of the crystal were about equal to those perpendicular to the ¢ axis.

Further three-dimensional data will be taken at about 185°C and 225°C to see if one type of motion predominates,

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Fig. 2. Distances of atoms from the average plane of the central carbon atom ring (C9 through C14).

Note the top ring is bent down and ?the bottom ring

bent up from the central

ring. Hydrogens have

standard deviations of

about .05 A.

Ove Com © sew onorcen

. jum Trihydrogen Selenite projected down

fey axtte ¥ coordinates (in fractions of a unit

ENF ate given for the asymmetric unit. The ree

sults are for @ preliminary refinement and should

pu eegarded as demonstrating the general molecular

geometry rather than details.

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22h

B, ?The room temperature (paraelectric) phase of Na H3 (Se 03)2

Sodium Trihydrogen Selenite has been studied.

The space group 42

b= 565, Be 578 ends eee

Ax},

While the final refinement has not been carried out, the ordered set of hydrogen positions indicated in Fig. 3 was determined. The Sodiun, Cxygen, and Selenium parameters were refined, starting with Unterleitner's positions.

lattice parameters are: a = 10,32,
as determined by Unterleitner

The notable features of the structure shown in Fig. 3 are deseribed as follows: ?The sodium ig octahedraliy coordinated to six oxygens, 2 each at 2.38 X, 2.43 q and 2.48 R ?The Se-0 distances are 1.75 R, 1.70 8 1.74 R for Ol, 02, 03, respectively. Coments on the significance of these distances should probably await the final refinement of the structure. ?he selenite groups are linked ?through two types of hydrogen bonds (Fig. 3).

The Ol - Hl - Ol seems to be symmetrical, although a doyble minimm cannot be ruled out, with an 0 - 0 distance of 2.52 q and 0 - H distance of 1.25 8 . ?the other, 02 - H2 - 03, hydrogen bond which is even shorter seems asymetric. ?The 02 - 03 distance is

2.49 R with 02 - H2 = 1.10 f and H2 - 03 = 1.39 R. ?the aniso-

tropic motion should be analyzed before comenting further on the

above results.

Cross Section Measurements. In connection with a neutron

Liguid scattering project by Dr. H. Ritter (se section on staff),

?the scattering lengths for tin isotopes 116, 117, 118, 119, 100,

122, 124 have been measured, The results are 0.58 7 .0l, d.6h

£2, 0.58 F .01, 0,60 .02, 0.64 # .o1, 0,55 * 203, 0.59 t 02

x 10°12 om, Scattering lengths are the data that describes the

scattering pover of an atomic or isotopic species for coherent proc

esses.

Hew Pauipnent. An experimental dewar for taking diffraction

data at Liquid nitrogen or heliun

The dover f2 now Lekee eget temperatures has been purcha sede

?The U.S8.I. four circle neutron

A spectrometer ha: 4

and is now taking data under punched-card control, een Uta

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STAFF

pr ocporar?d Ritter, professor of Chentstry at ileal Univer:

Joa at Pana? ,cnier returned to Oxford in August 1967 acne

year at FRNC and a month at Argonne National laborstery,

While at PRNC, ?the coherent scattering cross sec-

tons of seven stable tin isotopes. He was gol

the scattering from Molten Cu C135, cu 0137, Cl, and Cu Cl

at Argonne, where the higher reactor flux would provide more

suitable conditions, Since Dr. Ritter's untimely death in

Novenber cf this year, the project has been contimied under the

auspices of the Argonne metallurgy groups

---Page Break---

Mr. daime A. Castel

Jength of a

100 megawatt Q-switched

---Page Break---

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 founda-?tion for a later study of more complex materials including those of direct biological interest. Anthracene was chosen as the ini-?tial material to be studied for the following reasons: (1) large and very pure anthracene crystals can be obtained; (2) a large amount of information 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 dan-age in anthracene after gamma irradiation in the high dose range (larger than 105R) 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.

?EXPERIMENTAL TECHNIQUES

Experimental methods used in studying radiation damage include: (1) Space-charge limited current measurements; (2) delayed fluorescence measurements; (3) electron spin resonance measurements; (4) chemical analysis. A complete description of the defection of radiation by the space-charged limited current technique and by the delayed fluorescence techniques are given in PRNC-58 and

PRNC-107, respectively.

ACHIEVEMENTS

1, Singlet-Singlet Annihilation Rate Constant _in Anthracene.
As destribed previously (PHO-107), by measuring the degradation of fluorescence and delayed fluorescence caused by gama radiation, valuable information concerning radiation damage is obtained. The Juminescence of anthracene is blue and is due to excitation of the ?singlet states. By illuminating the crystel with red light, triplet excitons are produced. The triplet state energy level in anthracene lies more than half way between the ground state and the first excited singlet state. ?wo triplet excitons can annihilate each other, producing a ground state and an excited singlet. The fluorescence arising from this excited singlet is known as the

---Page Break---

delayed fluorescence, By irradiating the anthracene crystals with gamma rays, triplet and singlet quenching centers are introduced, Since the diffusion length of the triplet exciton te about one innired tines larger then that of the singlet exeiten, degradation of the delayed fluorescence will occur by irradiating the crags wih goes gan Ges than tha note for shoving de gradation in the normal fluorescence, ?The equation, Y as (Ks/kn) (a Tt/a alle), that relates the radiation dosse??/* needed to reduce the intensitiev of the normal and delayed fluoFescence to half their original values and the concentrations of the introduced singlet and triplet quenching centers, was derived. In this equation,Y 0/2 and Y 1/2 are the radiation doses in rads That are needed to reduce the intensity of the normal and delayed fluorescence, respectively, to haif their original values. Ky and Kq are the minonalecular rate conetante, and ® g antep aro the binélecular rate constants for the singlets and triplets, respec ?tively. Ng and Np are the concentrations of the singlet and triplet quenching centers tfuced in the crystal by one ?ed. the values of Y 5/2,11/2 and Kp are obtained from the above experients, ?the values of Ky aid Sp are taken fron the iiteravures ?he value of the singlet; singlet annihilation rate constant Found in the literature DS varies fron, 5x 10" end scent to Og = 2.5 x 20-1 end seo?Leve calculated ® g by measuring the fluorescent quantum yield as a function of light intensity using very high intensity pulsed light sources and found 4, = 10-10 nd sceslvUeing that valve in the above equation, it te foam that

the concentration of the singlet quenching centers introduced by one rad is three orders of nagnitude larger than the concentration of the triplet quenching centers introduced by one rate

2. Foenanthreng, Extensive informtion is available on the optical propertios of phenanthrene, However, the electrical, properties and radiation damge have not been studied as thoroughly. The reason appeara to be that optical properties anf part of the

1 giver, M. et. als, Bays. Rev. Letters 10, 12 (1963).

2 Bergman, A. et. al., Phys. Rev, Letters 28, 598 (1967).

3 goistot, NA, and Abranoy, A.P., Soviet Physics Sota Biate 9, 255 (187).

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Instrumentation used in conductivity

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radiation danage can be studied utilizing thin vapor or solution

grovn crystals; while the study of electrical properties and lov dose radiation damage requires the bulkier pure melt grovn eryse tals which are nore difficult to obtain. Attempts are being nale to study low dose radiation danage in phenanthrene along the sane Lines as used in studying anthracene, No delayed fluorescence has been observed in phenanthrene by utilizing a high intensity xenon flashlight in an attempt to excite enough triplets directly fron the ground singlets. It appears that the singlet-triplet absorption coefficient for phenanthrene is smaller than @ ® lo-len"1, which is the value for anthracene. Experiments are in progress utilizing the second harmonics of @ 100 megawatt "Q? seitched necdymium doped glass laser. Results of these experi-nents wight lead to the calculation of paraneters such as the singlet-triplet absorption coefficient, triplet-triplet annihila~ {on rate constant ant the diffusion ccefficient for the triplet excitons,

3. Electron Spin Resonance Measurements. ?he quenching centers introduced by ganma radiation in anthracene are para-magnetic and their EG spectra are studied. ?he ESR signal con-sists of apparently four unresolved lines. The magnitude of the signal increases linearly with the dose. ?The half band width of the signal is 60 gauss. The "s" value calculated is approximate-ly 2, ?There is no difference in the ER spectrum by using the highly purified Eastman X-480 anthracene cr by using the synthetic Bastman H-480 anthracene. A model was proposed * in which a cross-

Linking between the anthracene molecules takes place, ?the validity of that model is now being checked by using deuterated anthracene.

4, Chemical Analysis, Attempts were made to analyze chemically the radiation induced quenching centers in anthracene by using the thin leyer chromatography method. The following solutions were used: Benzene, chloroform, ethyl acetate, heptanol, isopropyl alcohol, acetone, carbon tetrachloride, nitryl acetate, ether, dichloroethylene, trichloroethylene and tetrachloroethylene. No sep~aration could be seen. ?The maximm radiation dose to the crystal was 2x 109 red. By assuming that the linear extrapolation is valid up to such a high radiation dose, the maximm concentration of the quenching centers would have been 10-3 cm-3,

4 Blum, H. et. al., Bull Am, Phys. Soc. 12, 400 (1967).

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LABORATORY SPACE

This project is housed in the Facundo Bueso Science Building at the Rio Piedras Campus of the University of Puerto Rico because of the shortage of space in the PRNC Bio-Medical Building. When

the project was initiated in January 1962, a room with 360 square feet of space was utilized, In February 1965, the project was moved into a room with approximately 900 square feet of floor space. In addition, two offices with a combined area of approximately 240 square feet were provided. ?he increase in space has nade it possible to set up the equipment more advantageously and to make additions to the staff.

---Page Break---

Analysis for Hp obtained in radiolytic experiments.

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HOT-ATOM CHEMISTRY

?Te program is principally concerned with the study of the mechanisn of Scilari-Chalmers processes in organic compounds containing multiple bonds betveen the activated atom and carbon

atoms of the organic radical, ?These organic radicals are either

phenyl or cyclopentadienyl. the activated atons include si, Py 5, He, Bl, Sa, TM, and I as phenyl derivatives, and the cyclopen-

tadienyl derivatives (metallocenes) of Co, Mi, Zn, Hf, Os, and Re.

The equipment available includes glove boxes, and a specially ventilated laboratory to handle radioactive gases. The ana~lytical techniques used cover various forms of chromatography, including radio-gas chromatography and high-voltage electrophoresis.

WORK IN PROGRESS

Metallocenes - with Mrs, M.L, McClin, Previous studies on metallocenes (see following section) are being extended to dicyclopentadienyl osmium and dicyclopentadienyl rhenium hydride. These compounds were activated and processed by solvent extraction ina nitrogen atmosphere. The organic fraction was analyzed ?vy sublimation and the inorganic fraction by paper electrophoresis.

Organic Silicon Compounds - with Miss J.B. Trabal. The neutron activation products formed from tetraphenylsilane, triphenylsilane, and diphenylsilane are being separated by rapid colum chromatography and electrophoresis.

Recoil Labeling with Iodine and Bromine - with Miss H. Lépez saoneo (graduate sbulent}, Liquid aromtie compounds such as benzene, nitrobenzene, aniline, and methyl benzoate, are being

labeled with 181 and G0pr by recoil from dissolved iodoform, car-
von tetraiodide, bronoform or carbon tetrabronide.

WORK COMPLETED

Szilard-Chalmers Reactions in Metallocenes - 0.H. Wheeler and M.L. McClin. The radioactive products formed in the neutron activation of cobaltocene and nickelocene have been separated by solvent extraction in a nifrogen atmosphere. This rapid procedure permitted the study of o (half-life 10.5 min.). Nickelocene

---Page Break---
23h

shoved 65% retention of activity, and 35% as nickelous ion. Cobalt. ccene gave 25% retention, 15% as cobalticinium ion and 5% as covaltous iron. The activity in the cobalticiniu ion fraction was greater for ©0¢o, thermal annealing increased the retention in

doth cases.

Diclyclopentadienylzirconiun dichloride and dicyclopentadieny hafnitin Gichloride vere similarly activated and the products separated by solvent extraction, ?the retention was only 1.8 and 0.54, respectively, in these compounds. This mst be due to the low probability of reforming mltiple bonds. The inorganic zirconiun

activity anounted to 611,24, and inorganic hafnium 80.9%. The re~ mainder of the activity appeared ina polymeric fraction. Thermal annealing did not increase the retention in these cases but led to a redistribution of the activity between the inorganic and polymeric fractions.

Hot-Aton gmthests of Hhenylnercuric Compounds - 0.1. Wheeler and Mb, NeClin, The products fomed in the neutron activation of diphenylmercury and phenylmercuric chloride and acetate have been studied using chromatography on alunina, Diphenylmercury-203 and Iabeled phenylnereurie conpeunis vere formed in low epecifie actiyity, and exchange was noted between inorganic 203g In solutions The highest retention for diphenyinercury was obtained waen the compound vas activated in benzene.

HotcAtom Reactions in Aronatic Bismith and Thallium Compounds 0.H, Wheeler, J.£. Trabal, and M.L. MeClin. ?the products formed in the activation of triphenylbiemth were separated by column chromatography on alunina. ?the triphenylbismth fraction anounted to 27.5% of the total activity, with 35.0 and 23.5% appearing in the diphenylbismith and phenylbismth fractions. Activation in benzene resulted in 92.0% "retention." Diphenylbiamth chloride afforded 24.6% triphenylbismth, little MroBir(2.4g), PuBI2*(15.4f) and a large (56.5%) inorganic Bi fraction.

Similar studies on diphenylthalliun chloride showed an in-

crease in retention with activation time as a result of radiolytic decomposition. Thermal annealing led to an increase in retention and an increase in the @0/T inorganic fraction, at the expense of the PT1®* activity.

Radioactive Decay Correction Tables - 0.H, Wheeler, A.S. Kay ana J.E. Trabal. A FORTRAN progran was written to compute the fraction of activity remaining at intervals of time for a series of short half-life isotopes.

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ARE

?The group consists of Mrs, Marfa Laisa MeClin, M.S., Miss J: Eliofn Trabal, 3.8, (part tine) and Migs Hilda Lopez Alonso, Bese Miss Carmen Lecunberry, instructor, Chemistry Departnent, Univer: sity of Puerto Rico at Mayaguez, also participates in the programe

Both Mlss Lépez. Alonso and Miss Lecusberry are graduate studente

in chenistry. Mrs, Carmen I, Gonzdlez, MeS., resigned in May 1967,
In order to accept an appointment ae Chemist? in charge of the An.
lytical Laboratories, Puerto Rico Public Health Service in Mayaguez,

Dr. A. Gordus, University of Michi A.P, Wolf, Brook-
haven National Laboratory3) :
Institute; visited the Cem

Dr. Oven H, Wheeler
of Aromatic Phosphorus Comp
University of Puerto Rico at

Miss Elisin Trabal a
(research assistants)
unstable radioactive ¢

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PEACEFUL NUCLEAR EXPLOSIVES

PRNC's studies in this area are
financed by the U. S. Atomic Energy
Commission's Division of Peaceful

Nuclear Explosives (PNE).

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At right: Mr. Samuel Rodr
guez observes the operation
of a column used in dynamics
studies of leaching with sul-
phuric acid. Below: Dr. Dan
Taylor lectures on Project
Gasbuggy at a Plowshare Work-
shop session.

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MINING WITH NUCLEAR EXPLOSIVES

Pee ae eee
vision of Peaceful Nuclear Explosives (PIE), The project con-
chron of Reset ete Bene (Pm) pode Sn
Saeee of os feethtty iy of the ae of in trent ste
eo tas esta elem males
cesta eames eran ltl

WORK IN PROGRESS

Effect of Heat and shock Wave on Chalcoyyrite. With 8. Roarfguez. and Carmen Vincenty, Chaleopyrite type copper ore was obtained from the Puerto Rico Mines at Utuade, Puerto Rico, and its physical properties were determined: density, humidity, and screen analysis. Data is presented in Table 1. Based on screen analysis data, a statistical procedure was mde following recon-mendations given by Rodean (Geophysics 4, 616 (1965)), and from Figure 1, one can see that the logarithmic size-weight distri bution Found in the rubble material of miclear chinneys can also be applied to study the size-weight distribution of a pulverized ore.

Several analytical techniques for copper quantitative deter-mination were put in operation: ?spectrophotonetric determinations, electrolytic techniques and titration vith soliun sulfate solu-tions. Satistical analysis of the tine enployed for analytical neasurenents indicated the convenience of using titration methods. Using Nlag8203 complexed with iron (Fe***) and amoniun bifluoride, Yhe ore sanpies were separated fron silica with hydrofluoric acid, folloved by evaporation to dryness with concentrated sulfuric

acid, Following this procedure, the content of copper in the Utuado ore was found to be between 3/l) and 1%, The precise data are contained in the scientific reports of this work.

Studies on the differential thermal analysis of chalcopyrite
up to 850°C have been made. A Cahn electrobalance has been
modified to permit thernogravimetric analysis in atmosphere of air
or nitrogen. statistical analyses of available results are being
Gone; the structural changes corresponding to thermal transitions
are being analyzed by X-ray. Procedures to study the leachability
of the copper from the chalcopyrite by pumping the acid through an

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2ho

aerated column of mineral, as well as a method for determining the
free-acid content of the copper leach solutions, are being consid-
ered.

WORK COMPLETED

Teaching of Chalcopyrite Ore: 0.H. Wheeler, F. Mufioz-Riba-
deneira, and 8. Rodriguez Morales.

Preliminary studies on the
leaching behavior of the Puerto Rico chalcopyrite ore with

0.5N HeS0l have been initiated, using batch type operations when
no air is present during the leach tine, After 3 days, 13.2% of
copper was leached; 26.7% after 8 days and 35.9% after 18 days.

Exposure of the ore to gamma irradiation either in the dry state, or wetted with water, did not alter the leachability. After heating to 500°C, 60% of the available copper could be leached in

6 days, Heating to 650°C released 75% of the copper in a similar period.

OUER ACTIVITIES

Fuerto Rico Sumer Workshop on Nuclear Civil Engineering.
Dr. James A. Cheney and Dr. Wilson K. Talley from the University of California, Davis, California, attended a sumer workshop on Flowshare technology during June-August 1967, at the invitation of PRNC Director, Dr. Henry J. Gonberg. Representatives from the departments of chemical civil, mechanical and miclear engineering, physics, and staff menbers of PRIC also attended. At the end of ?the workshop, each participant presented a detailed analysis of a specific engineering or scientific use of mclear explosives. The topics covered in the sumer workshop are listed in Table 2,

ABC International Exhibits 1» During the Atoms in Action
Exhibit In Quito, Ecuador, Eng. Mufioz-Ribadeneira offered a series of lectures at universities and other institutions, describing the cmrent status of Plowshare, as well as applications of nuclear explosives in modern technology. Only two lectures at the University of Guayaquil were originally scheduled, but broad local press cover=

age prompted invitations to speak at other institutions. Economie assistance is now being sought to permit several young Ecuadorian engineers to take graduate studies at UPR and participate in Plow= share-related research projects at FRNC. See Table 3 for details on the lectures offered.

---Page Break---

% Weight of Passing

20

30

40

50

60.

70

80

90

95)

10 2 3 4 56789100 2 3 4 56781000

Size of Screen in Microns

Figure 1- Logaritmic Size- Weight Normal Distribution (Rodeon)

for @ Pulverized Chalcopiryte Type Ore, Utuado Mines, PR.

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FLOWSHARE APPLICATIONS IN ECUADOR

?The Houadorian Institute of Hydraulic Resources (INERKT) ais-
played strong interest in Plowshare, as related to water Paani
thie eACcording to INERIT staff menbers, it appears that two pos-
sible applications of mclear explosives for irrigation purposes

presently exist. One is to dig a channel through a mountain range;

another is to excavate a huge reservoir.

1. The Channel -- The Province of Manab{ is one of Ecuador's
most fertile regions, but sparse rainfall and few rivers hinder

agricultural development. ?here are several rivers heading south-southwest for one-third of their length, but a series of small mountain chains diverts them in a north-northwest direction, INERHI has studied the possibility of tunnelling through these mountains to permit the water to reach the other side, but the time and money involved make it prohibitive for Ecuador to undertake such a project. ?The proposed cut is 8 kilometers long; the peak height is 280 meters.

2, ?he Reservoir -- INERHI believes that between the mountains off Chimborago and Carihuayrazgo there is enough water to irrigate the Province of Tunguratua, where most of Ecuador's temperate zone fruits and vegetables could be planted. A huge reservoir is needed to contain rain water and melting snow on ?the mountainsides, INERHT states that a crater similar in dimension to Project SEDAN would hold an adequate water supply.

The staff consists of Dr. John D. Weaver, Chairman of the Department of Geology, University of Puerto Rico at Mayagiiez, on

a part time basis, and Mr. Samel Rodriguez-Morales, B.S., research assistant and graduate student in chemistry. ?he leaching studies are directed by Dr. 0H, Wheeler, Associate Director and Mr. Fausto Mufioz~Ribedeneira, M.S., Associate Scientist. Miss Carmen Vincenty,

(B.S.), is research assistant in charge of computer calculations.

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TABLE 1.

Physical Characteristics of the Copper Ore,

Chaleopyrite Type Orte (Utuado)

8) sereen Ana

) vais ~o

7 Screen Weight % Weight Sereen Average

Number Retained Passing Microns Diameter

aa 0.1 99.89 1190235

20 0.81 99.08 840 01s

28 3.16 95.92 590 ns

35 4450 90.52 420 505

48 7.85 82.67 207 359

65 dan 1. a0 25h

200 14.70 6656 ag 229

150 13.18 43.38 105 127

200 13-70 29.68 7 89

270 5.20 abLMB 53 co

270 UB - e -

b) Other properties: Density (by volume of water displaced)

2.76 + 0.13 ger/ce

Humidity (4ried at 110°C for 48 hours)

0.54 * 0.02%

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ab

TABLE 2

Topics Covered in Sumer Workshop

+ Mechanical Action of Nuclear Explosions

Equations of hydrodynamics

?Thermodynamics and statistical mechanics

Equation of states

?Thomas-Fermi model

Rankine-Hugoniot relations

Reflection and interaction of shocks

Physical and mathematical instabilities

+ Engineering Principles Applicable +

?to Iuclear Explosions

Planning and organization of con-

struction projects; CBI

Theory of elasticity

Waves in elastic media

Failure theories in mechanics

Soil mechanics; slope stability

Flow in porous media

Seepage forces; settlement of

saturated soils

Structural dynamics;

spectra,

response

Descriptive geology

Drilling of large dianeter holes

Fhenomenology of Nuclear Explos!

Size, shape, cost and yield

Nuclear radiation and hazards

Radioactivity production

fission and fusion

Distribution of radioactivity

fallout and groundwater

Contained explosions: cavity,

chimney formation

Crating explosions:

formation

crater

Measurement of parameters:

instrumentation

Prediction of parameters:

scaling laws and hydrocodes

Hazards due to groundshock

and airblast

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Engineering Applications

Scientific Applications

Earthmoving Applications: Neutron physics

Canals and mountain cuts Tuclear structure

Harbors

Water resource development Sei mology

Contained Applications: Neteorology

Aggregate production Chemistry

Petroleum reservoir stimilation

Underground storage Material science

lar sands and of] shale

Mr. Fausto J. Munoz-Ribadeneira

problems related to temperature on

bility of chalcopyrite type ores.

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M6

?TABLE 3

Plowshare Lectures Offered During

?Atoms in Action in Ecuador

Place where they Attendance

lecture Title

were offered

sere offered

Characteristics of Nuclear Explo- College of Engineering

sives and Muclear Explosives

Civil Engineering Applications

of Nuclear Explosives

Flowshare, its nature and its

goals

Plowshare, its nature and its goals

Industrial Applications of Nuclear Explosives

Application of Nuclear Explosives in Water Conservation Programs

Plowshare its Nature and its Goals

University of Guayaquil 49

College of Engineering
University of Guayaquil 39

Association of Former Students of "La Salle," Quito 82

Professors and students, Univ. of Manabi, at the Exhibit's Conference 32 Room, Quito

Professors and students

Univ. of Manab{ at the

Exhibit's Conference

Room, Quito 28

Institute of Hydraulic

Resources, Quito 42

College of sciences,

Catholic Univ., Quito 120

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ISOTOPES DEVELOPMENT

PRNC's food irradiation program

(08 Program) was started during the

latter part of 1965 and is supported

by the US AEC Division of Isotopes

Development.

uy

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Technician C. Asencio determines the weight av
molecular weight of pectins by viscometry.

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249,

RADIATION PRESERVATION OF TROPICAL FOODSTUFFS

Research has continued in our base program of determining the feasibility of preserving tropical fruits by radiation. Emphasis is placed on those factors of pre-irradiation condition, radiation dose, and post-irradiation treatment which produce maxinal delay of ripening and extension of shelf life, Quantification by chen-ical assay of changes in food quality due to irradiation treat-nent and post-irradiation storage has permitted evaluation of the feasibility of radiopasteurization of important varieties of ba-nana, plantain, and mango produced in the Caribbean area. ich program emphasis is now directed to evaluation of the economic feasibility of radiation treatment of mich fruits. study of the narketing potential for mangoes in the United states has been initiated and similated shipping studies using air and ocean ship-tent have begun,

Bananas of the Montecristo variety were studied intensively during the period October, 1966 to March, 1967, since in earlicr work ripening patterns were highly erratic, The factor of fruit age becane recognized in the course of the later work, in that in 15-day old fruit after 20 days of storage, only 26% of fruit irradiated at 40 Kr were ripe, compared with 72% ripening in controls. On the other hand, in younger fruit (90-95 days) at this storage tine there is litte difference in extent of ripening between irradiated and control lots, ?The young fruit showed no significant shelf 1ife extension, whereas in the more miture fruit 25 to 6 day extension vas observed. Frutts--at least of the Montecristo variety--younger than about 100 days or older than 130 days do not show marked shelf 1ife extension within normal tenperatures (65-70°F). That ripening may be delayed from the 21st to the 2th storage day offers considerable pronise of irradiation treatnent at 40 Kr levels. In the older fruit, there is no significant loss of vitamin C with doses to 40 Kr. While the younger fruit show sone loss of ascorbic acid with irradiation after 0-3 days storage, at longer storage tines (1819 days) there is no real difference between controls and irradiated fruit, nor between the two lots of bananas. The data for changes in sugar content, total acidity, and starch tend to correlate with the obscrved stave of ripening in all fruit, Research in the radiation treatment of the ?banana has not been continued, despite the favorable response of this fruit, due to the apparent lack of economic feasibility for

such treatment.

?The plantain or "cooking banana" is an important food source

in the hunid tropics and large quantities are shipped regularly

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250

aboUe 9 day ey, 28 complete ripening, {soe extension

shout 9 days, This delay, eoushee with the insignificant losses

tains amin content, indicates @ very fevespse Fesponse of plans

doses £0 Tadlation?troatnent, ?that nies delay is induced at

Shon rept 82 20 Ke de interesting, Buchea aeaye se a in radia

thongregponse in the plantain as compared. cath ie! Danana, even

Mangoes of the Mayaguezano, or "Native", variety have been

Joo uated in the mature or alnostaripe stage at deeds 50, 75,

Aon 20s and 200 Kr, stored at 68°F, checked date eee ripening,

acid any ea, St Antorvals tor sugars, starchy aclalty: ann

previons nemde carotenoids, For thie variety, we hive sree

Prostous results, vhich indicate «6-8 day sheit Lite ce

than PRE doses. The effect of a hot vater eip (ces fort nin,

shen, mine cooling) followed by irradiation $050; fs, cryin

doses has been studied for the Redondo variety mango.? Heres om

Piste Control of fruit spotlage due to anthrasnose intern ons

irradiated only. An hitial loss of ascorbic acid (about 15%) oc-
Sure Une to, the heat; no significant difference between cotecls
apd irradiated fruit, with or without heat, was noted after 8 act
16 days storage,

Simlated shipping experiments have been sttiated on tre
radiated mangoes, Mayaguezano variety fruit vere sent on a
Bile ito trip, extenting cree five tayee heise Cina hry
or 100 Kr doses, plus non-irradiated controls, were packed aiety
in a crate using shredded paper as packaging haterial between
layers of fruit. Following the travel, the fruit were stored at
68°F and analyzed chemically at intervals. ?The vibration and ex-
posure to tenperatures up to 64°F during travel speeded ripening
in all fruits, but the radiation doses caused a considerable ree

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Ors. Graham and
Deshpande and
Miss Asencio chemi-
cally measure meth-
oxy!) content of
mango pectins fol-
lowing microdis-

\ tillation.

Iodometric

for cha?

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tardation of ripening (li

tion of anthracnose spott:

Vitamin content in the fruits. Data obtained fron shipping mangoe,

Miami and back to Shn Juan are nov beige

by air from gan Juan to

collected.

of gamma radiati

6 days later than controls) and elimina

?ing. ?There was no significant 1oss er

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APPENDIX

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PUERTO RICO NUCLEAR CENTER

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?Radioisotopes in Organic Chemistry,

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Fedro Juan Santiago, Associate Scientist T, M.D., U. of Puerto Rico (Pediatrie

Norma Géndara Cruz, Res. Tech. in Clinical Applications of Radioisotopes,

Leila Crespo de Garcia, Res, Tech. in Clinical Applications of Radioisotopes,

Adriana Rodriguez de Calderon, Res. Tech. in Clinical Applications of Radve. isotopes)

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Medical Sciences and Radioblology Diviston

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(Bacteriology; Pathology) aan Suh oeaimaaonaie

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Juan Jesiis Pérez Mufiz, Nuclear Reactor Operator

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Physics)

Femando Valleci1lo, Associate in Health Physics

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Michael Gileadi, Health Physics assis!

Miriam H. Vega Soderstrom, Health Physics Assistant II

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Rico (Nuclear Engineering)

Juan Silva Parra, Research Associate TIT

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Biology

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Ecology)

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Allan G. Gordon, Research Associate It

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?Terrestrial Ecology Program-I - The Rain Forest Project

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Barbara Bannister*, Research Associate 7

Radiation Chenistry

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culture

Felix Liard Bertin, Research Assistant 11

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Sugarcane Borer Project

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Wietoriano Quintana, Research Assistant Ty nce? Division)

Neutron Diffraction Program

Mortimer I. Kay, Head, Chief Scientist I, Ph.D., U. of Connecticut (Chenisti

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Seymour F. Kaplan, Associate Scientist II, Ph.D., U. of New Mexico (Geology)

Solid State Physics Program

?Amador Cobas, Head (See also Office of the Director)

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Hot-Aton Chemistry Project

Owen H. Wheeler, Head (See also Office of the Director)

Josefa Elisa Trabal, Research Associate I (See also Muclear Sciences Division)

Maria Taion McClin, Research Associate I, M.8., U. of Puerto Rico (Chenistry)

Peaceful Nuclear Explosives

Donald S. Sasscer, Head: (See also Nuclear Engineering Division)

Fausto Mafioz Ribadeneira, Research Associate III (See also "Atons in Action"

Exhibit Project)

Radiation Preservation of Tropical Foodstuffs

Robert A, Inse, Head (See also Agricultural Bio-Selences Division)

Horace D. Gratam, Chief Scientist I, Pa.D., U. of Illinois (Food Technolosy)

Jose Cuevas Ruz, Research Associate T (See also Agricultural Bio-Setences Division)

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Ramon Muiiiz, Jr., Administrative Officer IT

Juan Lopez Rodriguez, Administrative Officer I

Pedro Velez Mendoza, ?Administrative Officer I

Technical Services

Héctor M. Barcelé, Head (See also office of the Director)

Ro Piedras:

William A. Moore, Electronics Tech. Supervisor

Guillermo Torres Carmona, Building and Grounds Maintenance Supervisor

Mayague:

Victor Lequerique, Scientific Glassblower

Alfredo Carmona Trutten, Electronic Technician Supervisor

Nelson Quifiones, Technical Supervisor

?Ad Honoren

Waldemar Adam, Ph.D.

Chemistry

Gustavo Candelas Reyes, Ph.D.

Biology

Graciela Casanova de Candelas, Ph.D.

Biology

Maximo Cerame Vivas, Ph.D.

Oceanography

Bawin Roig, Ph.D.

chemistry

Angel Rodr{guez Olleros, M.D.

Gastroenterology

Conrado Asenjo, Ph.D.

Chenistry

Julio I. Colon, Ph.D.

Microbiology

Antonio Ortiz, M.D.

Pediatrics

Inis Otero Villaderté, Ph.D.

Biochemistry

Américo Ponales, Ph.D.

Bacteriology

Nelson Biaggi, Ph.D.

Sanitary Science

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gesis M. Tharrats, Ph.D.

Prysics

Alfredo Torruella, Ph.D.

Physics

arthur Block, Ph.D.

Chenistry

Julién Roldén Regus, M.S.

Soil Chemistry

?Arturo Roque Perez, M.S.

Genetics

Jose A. del Castillo, M.D.

Pharmacology.

Mario Rosa, M.D.

Internal Medicine

Tawrence S. Ritchie, Ph.D.

Parasitology; Zoology

Victor Davila Cintrén, B.S.

Mechanical Engineering

Jose Noel Correa, M.D.

Radiotherapy

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WEEKLY SEMINARS, RIO PIEDRAS

Drs. W. L. Russell and Liane Russell, Oak Ridge National Laboratory, Recent Developments in Radiation Induced Genetic Changes, January 4.

Dr. George Simpson, Recent Advances in the Matrix Isolation of Intermediates from Ganma Irradiated Heterocyclic Compounds, Jamary 13.

Dr. Mortimer Kay, Crystal Structures of Transition Metal Foruates, Jamary 20.

Dr. Martin Pope, Radiation and Solid State Laboratory, New York University, Electric Currents in Organic Crystals, January 27.

Dr. Owen H. Wheeler, Radiolysis of Proteins, February 3.

Dr. Howard L. Andrews, Clinical Applications of Whole Body Counters, February 13.

Dr. Ezra Khedouri, Inter-American University, San Juan Campus, On the Mechanism

of Action of Glutineaminesynthetase, February 2h,

Dr. Jean P. Changeux, Pasteur Institute, Paris, Allosteric Interactions and ?Their Relevance to Membrane Problems, February 28.

Dr. Adon Gordus, University of Michigan, Ann Arbor, Chemical Effects of Niclear ?Transformation, March 3.

Dr. Efrain Toro Goyeo, UPR School of Medicine, Substrate Specificity and Possible Mechenien of Action of Pinguinain,the Proteolyticinzyme of the Naya Fruit, March 10.

professor Malcolm Dole, Technological Institute, Northwestern University, The dee of Ultraviolet Spectroscopy in the Study of the Effects of Radiation on Polyethylene, March 16.

br. Peter Paraskevoudakis, Total Absorption X-Ray Calorimeter, March 17.

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Dr. William A. Mosher, University of Delaware and Anerican Chenical Society, 1, 3-Rearrangements, March 21.

Dr, Alfred P, Wolf, Brookhaven National Laboratory, Non-Synthetic Methods of labeling, April 7.

Dr. Michael Byer, University of Puerto Rico, Microdistribution Analysis ty Correlation Between Species Abundance, April 14.

Dr. Evelina Ortiz, University of Puerto Rico, Hormones and Manmalian Sex Differentiation, April 21.

Dr. Shrinivas H. Kanath, Myeloperoxidase, April 28.

Dr, Glen A, Russel, Iowa State University, Addition Reactions of the Methyl-sulfinyl Carbanion, May 5.

Dr. Heriberto Batiz, UPR Agricultural Experiment Station, Experimental and Theoretical Measurenents of Geminal Spin-Spin Coupling Constants, May 12.

Dr. Mortimer Mendelshon, University of Pennsylvania, Tumor Models and Cancer Therapy, May 17.

Dr. James Mair, Preparation and Properties of a New Semiconductor, May 19.

pr. Inds R. Otero Villaderté, UPR School of Medicine, Structural and Functional Aspects of Mitochondria, May 26.

Dr. Aldo Ianaro, Tratamiento de Afecciones Tiroideas con Iodo-131 (Treatment of Thyroid Disorders With Iodine-131), June 2.

Dr. Thonas R. Tosteson, University of Puerto Rico, Biological Effects of

Nelanocyte Stimlating Hormones, June 9.

Dr. George Drewry, Hybridization and Behavioral Analysis as Taxonomic Tools,

gune 16.

Dr. John H, Martin, Diurnal Variations in Zooplankton Abundance, Species Coa
position, and Elemental Composition, June 23.

Mrs. Rosa Tirado, Exchange Reactions in Inorganic Coordindtion Complexes, June 3

pr. J. R, Plinner, U.S. Departaent of Agriculture, Maryland, Pesticide Bresk
down: Some Chenical Studies, July 6.

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Dr. Williom H. Hamill, Radiation Laboratory, University of Notre Dame, Funda
mental Ionic Process Observed by Mass Spectroscopy; Tone Processes ia Glasses
Relevant to Radiation Chenistry; Ion Dynamics in Viscous Liquids: Rate of
Charge Recombination, Charge Separation, Evidence for Ion Pair Correlations;
Chemical Consequences of Ionic Processes in Organic Liquids: Charge Transfer,
Electron Capture, Proton Transfer, Recombination; and Unsolved Problens ani

New Appronches With Low Energy Eléctron Impact and Thin Filns; July 10, 11,

Dr. Martin Feldman, Oak Ridge Research Participant, Howard University, Blectron
Affinities of Carbonium Ions, July 21. panty ?

Dr. Carl F. Jordan, Recovery of Tropical Rain Forest After Ganma Irradiation, July 28.

Dr. Wilson K, Talley, University of California, Davis, Phenomenology of Underground Explosions, August 4,

Dr. James A. Cheney, University of California, Davis, Critical Path Method for Scheduling, August 11.

Dr. Raniro Martinez Silva, Radiation Effects on Trypanosoma cruzi, August 18.

Dr. Biuardo Touya, "Centro de Medicina tuclear," Uruguay, Ganagratia de Cerebro con 990s (Brain Gonmagraphy with 998), September 1,

Dr. H. Harry Semant, Dethionylation, Septenber 8.

Dr. Iais Anorés, University of Puerto Rico, Synthesis and Reactions of Dibenzo-quinoziliniun Salts, September 22.

Dr, Art Bloch, University of Pierto Rico, Radial Intensity Distributions of Infrared Super-radiant Sources (All about lasers!), September 29.

Dr. Owen H. Wheeler, Hot-Atom Chemistry of Aromatic Phosphorus Compounds, October 4.

Dr. Jerry Kline, Resonance Times of Fallout Radioniclides in a Tropical Rain Forest, October 6.

Dr. Willian Caldwell, Vanderbilt University School of Medicine, Hyperbaric Oxygen in Radiotherapy, October 13.

Dr. José Pellegrino, University of Minas Gerais, Brazil, Science Against Schistosomiasis, October 20.

Dr. Anthony E. W. Mas, Christie Hospital and the Holt Radium Institute, Effect of Continuous Irradiation on Cell Cultures, October 27.

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Dr. Jesis Tharrats, University of Puerto Rico, Monte Carlo Methods, Hovenber 3,

Dr. Antonio Bosch, Results of Cancer Radiotherapy, Novenber 10,

Dr. Robert A. luse, Status of Radiation Preservation of Food Project at Pat Hovenber 17. ?

Dr. Angel L. Rodr{guez Olleros, UPR School of Medicine, Experinental Cirshosis Novenber 24, ,

Dr. José A. de Jesis, UPR School of Medicine, Alcohol in the Central Nervous Systen, Decenber 1,

Dro. Fred F. Ferguson, J. Miles Butler, and Byron Chaniotis, US PHS Ecological Investigations Program, Conparative Ecology of Four Iuportant Puerto Riese Snails--Biomphaleria, Marisa, Tarebia, and Iymnaea, Decenber 8.

Dr. |. Harry Szmant, Advances in the Study of the Wolff-Kishner Reaction Mechanism, Decenber 15.

WEEKLY SEMINARS, MAYAGUEZ

Dr. Julio A. Gonzalo, Radiation Effects on Ferroelectric Crystals, January 30.

Dr. Owen H. Wheeler, Radiolysis of Peptides and Proteins, February 6.

Dr. Frank G. Lowman, The Application of the Specific Activity Approach to Environmental Assessment of Hazards fron Radioisotopes, February 13.

Dr. Adon A, Gordus, University of Michigan, Ann Arbor, Neutron Activation Analysis in Archaeology, February 27; Chenical Effects of Nuclear Trans-formations, March 1,

Dr. Mortiner Kay, Crystal Structures of Transition Metal Formates, March 6.

Rev. Dr. Ignacio Cantarell, Research on Color Centers in Alkali Halides, March 13.

. José A. Ferrer Monge, Aberraciones Cronosénicas Inducidas por Radiactéa (Chromosome Aberrations induced ty Radiation), March 20.

Mr. Antonio Macias, Indiana University, Quantum Mechanical Calculations in the Hy; Molecular Jon, March 21.

Dr. Robert Carter, National Bureau of Standards, The Reactor Progran at the National Bureau of Standards, March 27,

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Dr. Alfred P. Wolf, Brookhaven National Laboratory, Non-Synthetic Methods of Iabeling, April 4; ?Reactions of Energetic Carbon Atons, April. 5-

Dr, Donald J. Swift, late Quartenary Glaciation and Sea Level Rise in the Bay of Fundy, Canada, April 10.

Mr. Antonio Rivera Cordero, Investigation of Puerto Rico Nuclear Center Reactor Beam Tube Explosion, April? 13,

Professor Kenneth G. Soderstrom, University of Puerto Rico, Free Convection Heat Transfer to Air Through Narrow Vertical Channels, April 24.

Dr. Wilson K. Talley, University of California, Peaceful Uses of Muclear Explosives in Outer Space, April 28.

Dr. Don 7. Cromer, Los Alamos Scientific Laboratory, The Crystal Structure of K,cu(c),, and the Determination of its Absolute Configuration, May 1.

Dr. Walter Snyder, Oak Ridge National Laboratory, Tritium Retention in Humans,

May 3.

Dr. George C. Summerfield, University of Michigan, Neutron Scattering and the Dynamics of High Polymers, May 16.

Mr. Frank Kabot, Perkins Elner Corporation, Program on Gas Chronatography,, May 2,

Dr. Dan Teylor, University of Puerto Rico, Computer Control of Chenical Plants, May 29.

Dr. William H. Hamill, University of Notre Dane, Chemical Consequences of Ionizing Processes in Organic Liquids, July 12.

Dr, David Fisher, University of Miani, Potassium-Argon Dating of Oceans and Meteorites, October 10.

Dr. Kurt Bostrom, University of Miami, Exhalation from the Mantle Into Pelagic Sediments, October 11.

Dr. Koud Pedersen, Measurenent of Stut-down Margin, October 16.

Dr. Florencio Vézquez, Band Structure Studies in Sentconductors gain, Mgate, and MgoSi, Through Electroreflectance Measurenents, Novenber 13.

Dr. Fred H. Pollak, Brown University, Piezoelectro Reflectance in Semiconductors,

Tovenber 21,

Dr. José A. Ferrer Monge, Efectos de Radiacién en Crouosomas (Effects of Radia~

tion on Chronosones), Decenber 4.

Dr. Rupert A. Lee, Radiation Chemistry of Gases, Decenber 11.

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PROGRAMS AND COURSES vowsis Bae Su. Tae ? Sen

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Radloteotope Techniques Course

Chenistry-Theats Research

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Clinical Applications of Radtotsotopes

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Special Sraining on Managenent of Scanner 25

Radsotherapy and Cancer Residency x

In-Service Training in Radlotherary and Cancer

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One Month Concer Couree

Radiological Physics Conferences

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Biol 379 = Reading ant Reooarch tn Radiobiology

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Training on Radioisotope Applications in ro

Special Training in the Operation of a Co-SO Gamma Pool

Social Training in Solid sate Mysice

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Radiation Protection Course

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Radicbiology Institute

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The United States Atomic Energy Commission

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10th Anniversary plaque presented to Puerto Rico Nuclear Center by the U. S. Atomic Energy Commission. See Introduction and chapter on Office of the Director for more details.

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