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PUERTO RICO NUCLEAR CENTER

?An Examination of Program Objectives

OPERATED BY UNIVERSITY OF PUERTO RICO UNDER CONTRACT

canner ia-t)-1633 FOR U. S. ATOMIC ENERGY COMMISSION

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TABLE OF CONTENTS

Foreword

- General Background ? 1

Latin American Development Opportunities . 8

Raw Materials seeeecees seeeeeneseneeeeesees 10

- Social Factors seeeeeeseseeeeeceeeeee a

Industry and Agriculture seeeeeee B

- Latin America: Surplus to Deficit . a

Benefits in the Advancement of Latin-American Agriculture 22

- Nuclear Energy in Latin American Development «2.2.4 3

. The PRC in Latin American Scientific Development ..+.+++ %

Progress of PRNC in Relation to the Five Year Plan... 2

- Conclusions and Recommendations seeeeeee see BD

- Appendices

Report of Advisory Committee for Biology and Medicine

- to Chairman ABC, October 26, 1960 43

- B, Five Year Plan (Appendices omitted) .seeeeeseeesee 2

- Letter, John C. Bugher to General Manager, AEC,

August 2, 1963. seevenenceceessses 9B

- D, Narrative: PANG FY-1966 Budget Submission . 103

---Page Break---

---Page Break---

-FOREWORD-

The special report which is here submitted is the result of a discussion at ARC Headquarters in which it appeared desirable that T should undertake a review of the objectives of PRIC with an analysis of the present status. In the main text and appendices, T have brought together what seem to me the most illuminating materials for the purpose.

Inevitably the document reflects my personal experience in more than 25 years of work in connection with developing countries in South America, Africa and Asia on behalf of The Rockefeller Foundation. The opinions expressed, however, are strictly my own and the Foundation has not been asked to endorse them. The same is true for the University of Puerto Rico.

My personal involvement with the program in Puerto Rico

naturally introduces some degree of bias in judgment. As far as possible, however, a detached position has been maintained,

Since this is not a scholarly treatise, a complete listing of sources is not attempted. However, I wish to note four excellent sources from which material has been taken!

Man, Land and Food, by Lester B. Brown. Foreign Agricultural Economic Report No. 12, J. 8. Department of Agriculture, 1963.

Resources in America's Future, by Hans H. Landsberg, Leonard L. Fischman, and Joseph I. Pisher, The Johns Hopkins Press, 1953.

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Atomic Energy Commission, 1962.

A Comprehensive Agricultural Program for Puerto Rico, by Wathan Koenig. U.S. Department of Agriculture and The Commonwealth of Puerto Rico, 1953.

Since developmental and educational programs are inherently possessed of a long time scale, they can bring little political reward to any administration. "To the extent that the beginning of new venture becomes politically identified with the administration in power at the time, the ultimate success of the program is likely to be handicapped. Quick results of substance are usually impossible and by the time the real values have emerged, the political leaves have changed and frequently the initiators themselves may have long since disappeared from the political scene. There is a long time

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a

continuity to educational and technological development. that precludes any marked partisan political benefit. In this respect, Technological development, both national and international, resembles the arena of foreign policy and defense in the long lead line between the initiation of projects and the emergence of the practical results.

Notwithstanding this characteristic, it is also possible to blend long term and short term values so that a mix of benefits may be achieved in the time scale. In developing the Puerto Rico Nuclear Center, the effort has been made to secure such short term results and, while so doing, to strengthen the base of the longer range

Progress

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September 15, 1964

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?An Examination of the Program Objectives of the

?Puerto Rico Nuclear Center

by

John C. Eugher, M.D., Director

GENERAL BACKGROUND

Among the various efforts to complement the "Atoms for Peace" program which was initiated in 1953, was a special one directed toward Latin America. Generally, this arose out of the belief that (2) the nonmilitary applications of atomic energy could serve to

Latin

accelerate greatly the processes of development, and (2) 2 American countries were facing economic problems of increasing

severity which could only be met by more effective technological as well as social development. Generally, the underlying consid

erations for both of these assumptions

were not clearly stated.

Under the pressure of weapons requirements, the ABC itself

had not pursued with conviction its own program of yeastine applications, The ultimate necessity of switching to nuclear power on a wide scale was not known but the generous reserves of fossil

fuels tended to alleviate any

sense of urgency, At the policy

level, the technical problems of nuclear power reactors and the

large scale of their solution were generally underrated. The ex-

ploration of radioisotopes

in medicine, agriculture and industry

did not have the emotional impact of those developing foreign policy that costly and massive atomic power stations possessed

this factor, combined with a widespread misunderstanding of the

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With the desire to accelerate atomic energy development in Latin America, it appeared to those in charge of the program that considerable benefit could be obtained if the United States were to establish a modest training center somewhere in Latin America where the work could be pursued in a Latin environment and where Spanish would be the dominant language. By this means, it was considered that the "cultural shock" received by a student would be lessened and that his attention to his studies could be more effective than

if he were to be received in one of the Continental centers.

Study of the possibilities rather quickly led to the conclusion that for practical purposes the only location in Hispano-America where the AEC could maintain both supervision and operational control, was in Puerto Rico. Since a reactor was to be the center of activity, operational control for the assurance of safety was indispensable.

Following the usual contractor pattern, the natural choice was the University of Puerto Rico, a young institution that as a consequence of "Operation Bootstrap" had been compelled to grow at a prodigious rate and had at the time (1956) approximately 15,000 students.

Contrary to the pattern previously followed by other universities
4h their development of AD programs, the University of Puerto Rico
aia not begin on e bacts of existing posteredunte studies. A fev
nenbers of the faculty nad tnd personal experience in reseaeen in
nuclear piyfsice end radiation chenietiy, tut there was no well

eotmblighed interest in muclesr sctance in the University. AL

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available funds and resoarces had been sore then absorbed by the
exceedingly rapid growth of the student body at the undergraduate
evel.

Notuithetanding the problene implici: ir this acadente
stwation, conversations were initiated with the authorities of the

sed An 1957 eatabe

University as a result of vaicn @ contract was sik

Lithing the Puerto Rico Melear Center es a training center for
atin Americans. A training course in radioisotope techniques

ite of Muclear Studies

modeled on that given at the Oak Ridge Tn

wag initiated at once and tulling plass wore fonulated,

Because the College of Engineering was located at the Mayaguez

Campus at the western end of the island, the decision was aade that

?the reactor and the maiz canponeats of the Center should be constructed

there. Medical activities vere being centreLiced ut Rfo Piedras,

near San Juan, in a large Mesicul Co!

was constructed as part of that Center to house radiation therapy

find the medical applications of radioisotopes together with the

basic radioisotope techniques course,

With the availability of the facilities of the new institution

and the widespread publicity given its establishment, the immediate

response was good, with most of the students being interested in

Learning the basic techniques in handling radioisotopes. Interest

for the part of students in the University of Puerto Rico was

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cultural climate of the University of Puerto Rico was still an

ndvantage in permitting visitors from other countries to concentrate

on their studies asa result of the reduced problens of adjustnent.

?The rapid development of grauate studies in the Nuclear

Center accelerated plane in the University, and Master of Science

degree prograns becate established an

wntstry, physics, biology,

engineering and agricultare. While the number of students from other

countries remained fairly constant until the prezent year, their

qualifications and general preparation have steadily increased.

During the current year, there has been an upturn in the minter of

students from other countries, largely as a reflection of the

Amprovonent in the level of educational effort.

?Te Ampact on the University of Puerto Rice has been striking.

Too number of graduate students of Puerto Rican origin has increased

sharply and gives indication of contiming to increase further. The

ew graduate program in Miclear Bngineering has been received with

enthusiasm. Chemistry and physics attract an increasing number of graduate students and in the process these disciplines have acquired additional scientists so that special research supplementing that associated with graduate teaching has been a natural result. A vital part in the development of the physical sciences in the Nuclear Center has been the close cooperation with the Departments of Physics and Chemistry of Brookhaven National Laboratory. Through the efforts of several staff members of these two departments it has

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It has been possible to develop fruitful research in a short span of time

It was evident from the beginning that a project of the

expansions of PRIC, while operating in several disciplines, could

not undertake to cover adequately all of their contents or would

it be desirable that the institution should attempt to pursue

programs which would require a large installation for their use

successful completion. It was the consensus that FRIKC should undertake
to emphasize work in those areas which are best attacked or an
stand in the tropics; it would give especial attention to those
major problems of importance to the United States whose solution
requires a laboratory in a tropical setting. The physical sciences
forming the foundation upon which the biological sciences must be
erected, a major effort would be made in mathematics, chemistry and
physics, but with a focus on research which can be conducted to
advantage in a tropical operation and also which would give the greatest
ultimate support, to the biological and medical activities.

The evolution of the program along the lines outlined has
resulted in an institution whose general orientation is toward Latin
America but whose program in great part is directed to significant
problems of continental United States. Some of these problems
are will be set forth later in this discussion, The essential point
is that PREC is no longer simply training center for Latin Americans
but a teaching and research institution, located in the tropics, which
is deeply engaged in scientific problems of major significance to

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the United States. There now exists a flexibility of organization

and a pedagogical and research competence that make it possible to

respond to any one of several program plans.

[LAPIN AMERICAN DEVELOPMENTAL, OPPORTUNITIES

During the past 15 years these bs

been much play on words in

considering assistance to other countries. Terms such as "developing",

?emerging?, "nations in tranettion", etc. have tended to obscure

certain hard principles. ational development ie & continual process:

and {ø never ended. Crow

fe arices when economic progress in some

cous lage behind she pots

Ja] Amplied in the state of political

fand oociel developuent of thove arese and in the world at large.

Wnetever may be the degree to which ostetde stimulus may be

applied, ultimately the econom!

and social development of a region

mist depend upon the efvores of the people of the region themselves.

Without @ dedication to the appropriate goals on the part of the

peoples cone

sped and without the will to achieve these goals, no

important, benefit can be expected from outside assistance.

Modern development cannot simply repeat the past experience

of the more affluent societies.

ration which is part of

the spirit of the time requires that modern technology be applied

to

1e provlens to te solved, even those of primitive societies,

"These technologies require ar educationel sophistication which in

5 does not exist locally. To talk of industrial,

many 1n8%

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velopment without emphasizing the reguirents placed on edueation

te to insure fatlure of any program so constituted. Education is @

Intorious procese which does not lend iteelr to grest acceleration.

?The time scale ts that of humgn development. Yet Af the Improvement

of @ socity is to be achteved, the eduontion aud training of the

youth are indispensable. Political stability is necessary and
?this end programs such as improvement of housing and the development
of desirable services may do much, but the absolutely vital factors

lie in the educational system both at the elementary and advanced

levels.

Although in the present context we are concerned with scientific
?and technological development, it is essential to bear in mind that
?the educational effort must embrace many and diverse disciplines.

Technological development must necessarily

proceed from a reasonably
stable economic and political base. Technology which does not
contribute to economic improvement and an increase in productivity

is self-defeating and will be of only passing importance. Further-

nore, even @tverse technologies must be integrated and weintained
in an overall balance. uiectrical power production implies an
industrial structure to absorb it and employ it creatively. Trans-

portation and communications are vitel-

Despite industrialization,

fan expanding and efficient agriculture, capable of freeing ?he
country from importing foodstuffs that can well be produced locally,

must be achieved if economic and social balance is to be atvained-

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[RAW MATERIALS,

Technology involves th: vringing of scientific knowledge and
practical ekillte operate upon the ray matersais of a region to

caremuy

sen and defined ends. The availability of the raw materials of a modern society then becomes of substantial importance.

Primitive societies are limited to the use of raw materials which occur in easily processed form. Thus, metals such as copper, tin, gold and silver were early used in place of stone implements

Decrease of the ease of separating them from other substances and their occurrence in nature in high concentration, Later, iron

became of utility and as technological resources increased in

sophistication, aluminum and numerous other metals difficult of

extraction and fabrication came into common use.

Although hydroelectric plants have been of substantial importance in industrial power development, the industrial strength of modern nations has depended chiefly upon power derived from abundant supplies of fossil fuels. Far more is known about the reserves of coal and petroleum in Europe and North America than in South America, giving the impression that the latter continent is seriously deficient in these materials. This may well be true, but it is also obvious that vast regions which have either been explored very super-

fictitiously or not at all, any comparative estimates are almost

certain to be pessimistic with respect to fossil fuels in South

America, Notwithstanding this, it does appear that in most countries

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Of the southern continent, fossil fuels are either scarce, difficult

of recovery, or remote from any prospective market.

On the other hand, large deposits of minerals are known in

Brazil and the Andean countries and it is almost certain that vast

ore deposits exist whose presence is not now suspected. Large

deposits of copper, tin, platinum and gold have long been known in

the Andes but in recent years great resources in iron, uranium,

thorium, uranium and zirconium have been uncovered. It appears that

although Latin American countries are generally energy poor, this

need only be a temporary state. The potentials for energy from

fossil fuels and especially from nuclear materials are impressive

and probably more than sufficient for any foreseeable demand, it

may well be that much of the fossil fuel may be found to be uneconomical

for energy purposes in comparison with nuclear energy by 1950.

Agriculture in Latin America in the technology is at least a

generation behind that of North America. Large areas of the

equatorial portion of the South American continent have relatively

low fertility and much of the western portion of the continent is

mountainous. However, there are vast areas of high fertility in

the great span of latitudes and there is probably no crop of agricultural

importance that cannot be produced to advantage in Latin

America.

Portions of Latin America are arid, especially along the

Pacific borders of South America

and, notwithstanding this, rainfall

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in the totality ie abundant and vast quantities of water rush to
the sea in the river systems, the greatest of which is the Amazon.
Watershed redistribution is possible on an increasingly substantial
scale so that huge areas exist which may be opened to agriculture
through irrigation. One of the first of such projects is being

pushed to completion in Peru east of Lima where a tunnel 10 miles

long penetrates the continental divide at high altitude to bring
water from the wet eastern slope of the Andes to the arid west,

also producing a large amount of electrical power in its descent

to the lower levels. It may eventually be economical to move great
quantities of water over mountain ranges by a combination of pumping
followed by hydroelectric power generation on the descending side,

using nuclear power to achieve energy balance

In summary, Latin America possesses all the raw materials

eeded for the future and has then in abundance and of types especially

vell gutted to a nuclear power economy. Critical rev materials, in

amount and

failetility, are more than adequate for the tmnediate

future and modest exploration will undoubtedly bring to Light

aeatvionat resources

tine progresses.

DOCEAL FACTORS

?The Opantsh and Tortuguese keritege ir the Mew World was a

society essentially fecal in outlook. Those in @ favored position

of wealth and political power could enjoy the best that Europe could

afford in culture and education. The great aces of the people,

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however, could anticipate Little in the way of education save

the innovations of the Catholic church. There were

?through

2 gap between the cultured and educated aristocracy on the one

hand and the mass of unlettered peasantry on the other. There was

Little tendency to develop creative and effective middle class; even with the introduction of modern industrial technology, there was a striking lack of the "foreman" category of worker, one who could translate advanced technology into practical accomplishment and act both as leader and teacher in developing craft skills.

For many years this gap was filled in some degree from Europe but

in the main continued to exist as it does, with some exceptions

to the present day.

The onset of World War II brought a profound change to the orientation of Latin America. Culturally linked to Spain and France and commercially to Germany and England, the countries comprising the Spanish and Portuguese portions of the New World, by necessity rather than by choice, turned to the United States. They were suspicious of the "Colossus of the North", an attitude not discouraged

ages by

influential European elements, the rapidly elaborated

Links with the United States were viewed with considerable apprehension, especially by the older and governing generation.

There was great concern that the driving together of the countries of this hemisphere, enforced by the sweep of world events, would

result in the economic, political and cultural control of the entire

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ab

region by the United States and the loss of national and cultural identities. While this concern may have lessened with time, it is

a potent factor in determining the manner in which Latin American

countries associate themselves with the United States and with each

other.

Because of the European orientation of Latin America, the

educational system that developed in the various countries followed

the pattern then prevailing in Spain and France. Mass education at the elementary level was not the objective so that the scholastic interest touched only a fraction of the children. Here and there, forward looking leaders attempted to achieve a more adequate access:

to education, at least at the elementary level. Generally, however, the educational base remained wholly inadequate with the situation in

the universities even worse.

With respect to higher education, one must recall that there were universities in Spanish America long before any such educational

centers were established in what is now the United States. There it

was an unresolved debate as to whether the National University of Mexico

or San Yago University of Lima, Peru is the oldest institution in the New World. San Yago University was operating over a century before Harvard University was established in the Massachusetts colony.

To a marked extent the universities of Latin America have followed

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the pattern of organization of San Marcos which in turn was modeled on the structure of the University of Bologna, a format that was so satisfactory that it was finally abandoned in Europe. To an

unhappy degree this pattern of isolated special colleges, serving as active political centers, of faculty subservience to student domination, and the lack of continuity of strong leadership has remained with the

national universities throughout Latin America. In the last

decade has effective movement toward the reform of higher education made every headway.

The strong dissimilarities between the universities of the United States and those of Latin America in administrative structure, intellectual objectives and approach to national issues and problems have made effective cooperation difficult. As mutual understanding advances, the

International communication will become essential

but extensive readjustments in the structure of higher education are necessary throughout Latin America if these countries are to achieve full use of the scientific and technological advances of the present

It is frequently assumed that the feasible solution of such difficulties is the sending of large numbers of students to the United States or to other countries to study in the universities. There are several reasons why this solution would be futile, not the least of which is the fact that there is no room in existing American institutions for the large number of students that would be necessary. Of almost equal weight is the consideration that the academic structure of Latin

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America must be reformed at the same time and that this must be a growth from within.

Ultimately, we arrive at the conclusion that the production

of the large number of teachers required must be accomplished in

the countries concerned. The key to the academic reforms would seem to be the selection of a much smaller number of outstandingly competent and dedicated persons for advanced education in the crucial disciplines with the expectation that they will become the university

anchors for the training of a new generation of teachers and educators.

At the same time that is going on, there must be a massive effort to widen the coverage of elementary education, to create the necessary physical facilities, and to emphasize the training of good elementary teachers contemporaneous with vigorous university reform and the drive toward academic stability. All of this must spring from the conviction

if the leaders; external assistance cannot be a substitute for the

national dedication of a people to the improvement of their own country.

In every country of Latin America there now exists a high rate

of population increase.

© accomplishments in health and sanitation

have lowered death rates but birth rates have continued high with the

result that South America shows the world's highest rates of population

increases (

fig. 1) At the same time, there is a shift in age distribution-

as adults live to greater ages and share in the

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WESTERN HEMISPHERE POPULATION

GROWTH IN THE 20TH CENTURY

MIL. PERSONS]

400

200

oO 1 i!

1900 1920 1940 1960* 1980 2000

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B

general increace of Life expectancy.

?the

fact is that the continent is grossly underpopulated and will continue to be so for many years to come. Sound economic development requires some reasonable level of population density if satisfactory progress is to be made. The disturbing character of the current South American population growth is in the tendency for the people to concentrate in a few large urban centers and neglect the utilization of the great resources of the region. It becomes as much a problem of distribution as of numbers.

Education, as in all development, must be preoccupied with the nature of the society to be served in the ensuing decades. As an example, medical education must be formulated in terms of the social structure and health problems the mature physician will serve, not those of periods already past. This, of course, is not a problem unique to Latin America, but becomes critically important in any society which is undergoing rapid change. The exceedingly high rate of population increase of Latin America aggravates a host of social problems upon whose acceptable solution we

"e politics and econeate

stabi:

will depend.

TNDUSURY AND AGRICULTIRE,

Purely ggricultural countries are generally economically

handtcapped and fron thie arises the common belief that the reneyd

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iz to achieve a rapid conversion to an industrial econeny. Too

often thie results 4

e neglect of agriceliare with the ©

of new problems

It may be even more difficult than the original

set. Food as an absolute necessity:

dependence and reliance on external supplies

creates a situation of permanent dependency.

Traditionally, Latin America has been self-sufficient in food

and has been able to export significant amounts. In recent years,

however, Latin America has become a net food importing area, thus
Joining the Communist Block, Asia, Africa and Europe in accepting
either chronic and widespread malnutrition or, as in the case of
Europe, dependence on overseas food supplies. The United States

studies of the J. 8.

and Canada have become, according to rec:

Department of Agriculture, the breadbasket of the modern world,

(fig. 2) Upon the great increase in agricultural productivity of

the North American area, the minimal nutrition of a large part of

the world now depends. The agricultural surpluses of which we

could explain would be rapidly eliminated if the power of the free (or

enough) world were to be met in significant degree, There is
no net overproduction of agricultural products; in fact, the
contrary is the case and the substantial increase in total and
per-capita agricultural productivity is one of the greatest of
world needs.

With over one half of man's calory intake along derived from
the direct consumption of grains and most of the remainder indirectly

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NET REGIONAL TRADE IN ALL GRAINS

EXPORTING REGIONS IMPORTING REGIONS

MIL, METRIC TONS ? Oo

1

1934.38

ee |

1957/58-60/61

30 +] ?????{}+

Figure 2

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from grains through meat, milk, eggs, etc., the production of grains is the best single indicator of the general state of agriculture of a region. A succinct description of the relative deterioration of Latin America in grain production is quoted from the U.S. Department of Agriculture study: Man, Land and Food

?Latin America: Surplus to Deficit

"No other geographic region has experienced

Getertor

on in its standing in world grain trade comparable to that of Latin America. During the Late 1930's the region dominated the world grain market as a supplier. It exported more grain than North America and Oceania

a combined; 1¢ was an important supplier of wheat and its net corn exports accounted for almost three-fourths of those of all regions. By 1960/61 Latin America had relinquished its pre-eminence and, in spite of its vast natural resources, emerged as a net deficit region.

A not inconsiderable effort was made in Latin America, especially during the 1950's, to raise output by expanding the area used for grain production. This effort resulted in an expansion of the grain producing area by nearly

one-third over that of the prewar period, but population increased two-thirds and efforts to push up yields met with

Little success.

total production gains of some 42 percent during

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2

?the period did not compare unfavorably with many other regions but population grew 66 percent, much more than in any other region. Latin America's population was growing at a rate easily in excess of 20 percent per decade from 1930 to 1960. This stage of rapid population growth, with all its attendant problems is only now being approached in Africa and Asia.

"In spite of the decline in per capita grain pro-

ton from 25! kilograms in 1936-38 to 21h tn 1960/61,
availability hee rises from 180 to 216 kflograne per
person This has been achieved ty sacrificing net
exports, which anounted to Th kilograms per person in
1g3ke!

2 kilograms per person in 1960/61. Of this 76-xtlogran

2, and becoming © net isporter +o the extent of -

change in the per capita trade posttion, 40 kilograms
were required to offset the decline in output per person.

?The reesining 36 kLlograne represent an improvenent in

er capita consumption. Thus valle per capite output -
was declining 16 percent, per capita consumption vas

ristag 20 percent, tut at

© expense of exports and

"the foreign exchange 20 vitally needed for industrialization."

Part of the solution to the agricultural problem 1a Latin

America lies in the

Additional methods of plant breeding and crop

Improvement along with th

Continuation of the losses from plant

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3

Atseases and insect pests. Another large and highly important area

ie in the application of power to the agricultural procese- As

industey, the worker must gutde and control the application of po:

?Yo his operations; he cannot be the prine nover hingelf In 9 pros-
Perous cconey. Even animal power te no longer esonomie eave ia

?the most unusus] ctresstances. ural electrification and the an

cation of electrical pover to farm operations, especially those vith
fixed wachines, and the uec of Liquid fuels for mobile machine
operations are nov part of agricultural development. All these
imply a well developed aysten of roads, communication and electric
pover distribution.

A third essential element in the advancement of agriculture is the
an imaginative and balanced chemical industry. In nearly every
country and certainly in every region, all of the raw materials for

the manufacture of fertilizer on large scale exist. If power

be produced where it is needed, then fertilizer manufacture may
profitably proceed close to the areas to be served. The utilization
of nitrogen from the air for conversion to ammonia can yield large
amounts of oxygen together with significant amounts of noble gases,

11 of which find their market in a balanced industrial economy»

Approached in this manner, agriculture is essentially a
chemical industry in which solar energy is converted to chemical,

energy in a great complex of synthesized products. The feed materials

for this chemical operation are the elements of the soil together with

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ah

?the trace elements, water, and fertilizers, themselves the products:
of other chemical operations. For the crucial step of solar energy
conversion we have no prospect of any system even remotely approaching
the efficiency of the enzyme associated with chlorophyll.

In a balanced economy, therefore, agriculture is not so much
a way of life as it is part of industry, depending upon mechanical,
and chemical manufacturing for its equipment and part of its raw

materials and in turn delivering to the society a series of elaborately
synthesized products, some of which can be consumed immediately while
the remainder become the prime material for other manufacturing

processes:

The generation

of power where needed makes it possible to

reverse industrial manufacturing in the same sense that agriculture

?may be dispersed without loss of efficiency. The growth of industrial
lure becomes no longer inevitable nor even profitable, and @ far more

harmonious distribution of population and resources becomes possible

It is not suggested that each Latin American country should

be self-sufficient in all things. There is every reason, however,

for each country to develop a balanced industrial-agricultural complex

that will produce locally most of the items consumed in large volume,

leaving to international trade those products which require extremely

elaborate technology or very large capital investment

order to be

profitable. The pattern of the industrial-agricultural complex will

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2%

4irter from country to country, depending upon local regourene snd

needs.

Tt should be st once ressonskly obvious that the key v0 si

developsent of the balanced economy fe the evallability of low ce:

power at the aites where it is needed, Tn 2

2 long rans

power Je the only form which can meet all of the criteria. Although

the time coat

in a protracted one, it appears that electricity and

process heat will be produced in Latin America from nuclear reactions

far sooner than could have been anticipated only a few years ago.

The radioactive and fissioning atom is not of interest solely

because of the liberation of energy as heat for power. Nuclear

radiations constitute the most powerful tools known for biologists

biological systems, especially in the genetic sense. The radiation

geneticist uses nuclear reactions as a means of rapidly compressing

the genetic time scale by which he can bring together within a few

years specific genetic changes that in the natural course of events

might well have required a century. The application of nuclear

energy to

agriculture is still) stout as embryonic in terms of its
ultimate possibilities as in the case of generation of electricity!

However, We have scarcely taken the first steps.

SUCCEEDING ENERGY IN LATIN AMERICAN DEVELOPMENT

In the foregoing sections it should be apparent that nuclear
energy has an important and at some points key role to play in the

---Page Break---

future development of Latin American countries in much the same

fashion as in the United States. Cultural and socio-economic dif-
ferences will modify the patterns but the fundamental principles
are good for all. The benefits to be achieved in accelerated
developmental development will require the investment of huge amounts
of capital but the prospects are dismal indeed unless there is

brought to a high level of competence

(S the proper time the large

numbers of well trained

engineers, scientists and managers that

will be required. A greatly increased emphasis on education at all

levels is necessary, together with a series of reforms in the ec:

structure and functioning of universities throughout its span

mic

It should be further apparent that while nuclear energy has a

vital part to play in the future of the Americas, it is not a panacea

for all of the problems of society. In the utilization of nuclear

reactions, man has made available to himself a new way of adapting

?te forces of nature to his om well. being.

?THE PROC IN LATIN AMERICAN SCIENITPIC DEVELORENT

If one accept:

?the needs for socto-econenic development. of

atin Anerica that have been sketched an this paper, then one aay

Inquire as to what role, if any, should be assigned to Puerto Alco

?and especially to the Puerto Kico Muclesr Center. What advantages

are attached to the location in Puerto Rico? To what extent are

Govelopmental prograns and methods pertaining to Puerto Rico

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ar

applicable to the problens of geograptically huge county

fas Breztit

?The main thesis of the entire Aiscussion Ls that ths great

Imperative in Tatin American development {s education, education

that fs puched to a high level of excelience and competence tn alt
phases of intellectual life, but especialiy in setence and technology:
The main job mast Le done by the eftizens of the countrise involved
but the first seed must cone from without. ?There should be an op-
portunity for advanced students to observe ab the operating Level

?the advanced technology vnich they are studying; and the elreunctancer
of that demonstration should be as closely related to thove of their
om countries as is ponotble. There te Littie doubs but tit the

recent nistory of Puerto Reo, after allowing for the important

aitferences, exhibits many of the sane perplexitice that now are

vecoming crucial in South Anerica. With its mixed racial origins,

the Hispanic derived culture, its original reliance upon primitive agriculture, its peculiar character and the tropical location, It

this microcosm which contains many of the most difficult problems

that Latin countries have to face. In addition, they possess political stability, a population of sufficient size to be significant yet small enough to be adaptable to new programs, a

society receptive to new concepts of development and an imaginative

generation of public officials of high standards of public service

and personal integrity.

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28

While the solutions to problems of Puerto Rico may not be directly applicable to those of other regions, the situations

fare sufficiently similar to arouse expectations that the manner of solving the problems in Puerto Rico might suggest the appropriate approaches in other countries. Stated in more direct terms, the Puerto Atomic Nuclear Center will best serve its mission in aiding Latin American development through the utilization of nuclear energy by attacking fundamental problems of Puerto Rico and the general region, including the southern part of the United States.

The dimensions of the project: and the economic and cultural climate in which it operates tend to give confidence that the manner of solving Puerto Rican problems in Puerto Rico may bear closely on practice? solutions to similar situations in the continent to the

south of us:

It was with this general philosophy in mind that the University of Puerto Rico began a series of academic "sight liftings" in the Atomic Center, pointing the program to graduate and post-doctoral studies of @ caliber to attract outstanding young scientists from the faculties of South American universities with the objective

that they would return to help build up the departments with which

they might be associated. The emphasis was placed on quality and

entific advancement rather than on numbers- 4 significant and
vigorous research program was obligatory and this has been progress

ing rapidly in development with the research projects being pointed

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at problems of dire:

3) State and especially

to Puerto Rico. The graduate student or scientist who

comes to the Puerto Rico Nuclear Center works on problems whose

nature and dimensions he can study at first hand and where the

results of his research may be put into perspective 4

together with

all of the other factors that =

are the problem. Thus he leads

to the restoration, their design and operation and the economic and

engineering problems that can be solved. A practical project pro-

cedure is to be gained. He conducts his studies in an environment

wuere he can otseere a pow

ee which exp:

sits av @ high level

of efñictonry

hydroelectric, focsit ?uel and x

\clear power slants

a1 subject to the same ba:

sralyese ana all Seeding

into the sate power grid.

cam otaerve, if he wishes, the

interreletions of vara: electsifisation, omni tndzerrtes ara
sgricaiture, sii with unsolved problans and in some instances

cceontilly with the sone dilemma: that he [ede sa ne ow: country.

The Mucluar Center thus does not atteupt co tell the veitor

what the solutions to his country's developmental problems are;
rather he participates in a Puerto Rican effort to solve what are

aretar

ntally U. S. problems. In special cases and where the

circumstances are favorable, the visiting scientists may work on

8 scientific problem of primary importance to his country,

ear this is the exception rather than the rule,

?The concept of ?training? can be extended to a much higher

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30

level of performance than is usually meant by the term. Graduate education and its associated research become in themselves training at a higher level. In the process the student is stimulated to think of his national problems and to project possible practical ways of attacking them. ?The scientific output of his work becomes available to all and, with time, some of this work may have an appreciable economic impact in the area. A good example of values obtained in this way is in the studies of retardation of spoilage of tropical fruits through moderate doses of radiation, The arrest of ripening

. can permit a marked reduction of losses

in shipping and of the requirements for refrigeration. All of this

work has been done continue for a

graduate students and cui

considerable period of time into the future.

?At the same time that the level of performance in training

fund education was ral

, A major effort was undertaken to develop

research which could be supported by the program divisions of AEC.

research itself, rather than training;

Here the objective is the

but these activities have had a profound effect on the vigor and

content of the training programs.

The present status is that slightly more than one half of the

total program of PEIO is devoted to train:

ing and education with

the other portion being concerned with advanced research. A

condensed progress description is given in Appendix 5. ALL of the

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32

research is directed to matters of concern to the United States

ard to the immediate Caribbean region. Among these activities
are those devoted to developing knowledge concerning the long-

term effects of radiation and fission products

and similar questions pertaining to the cycling of radioactive

elements in tropic:

1 forests, questions which are

Antinately

Linked with the feasibility of constructing a new canal through
Central America or the Isthmus of Panama using nuclear explosives

for the earth removal.

Also, the present dynamic program of PRI in training radio-

therapists for the treatment of cancer opens up unusual opportunities

for significant reseas

an this area,

erto Rico, for reasons

unknown, has @ very high death rate ?von carcinoma of the crophagus

and the cervix uteri, with a strikingly low rate of malignancy of

?the testis. The organization of medical and health services permite

ready access to the entire population for sbudies which, while

Important to Puerto Rico, vould ke relevant to the situation da

other countries, especially the United States, (See Appendix ϕ).

As the result of these progran developmente, the Muclear

Center 46 now in such a state of balance thet St can redily

respond to a change of emphasis as desired; that is, it can ine

tensity Ate graduate education activities, or it can exert more

drive in the area of primary research. The point 42 made here

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?that policy choices need not be forced by the Mnitations of
circumstances but rather should be wade in terms of national and
international needs and policies.

?PROGRESS OF Fano IN RELATION TO THE FIVE YEAR PLAW

Tn Februsry 1961, an snalysis of the Latin American needs
for training and education vas made the basis of a five yesr plan
for FRUIC. The text of this ie attached ae Appendix 8. Program
develoment has rather closely followed the plan and most of the
specific projections have alzendy teen implenented and, in some
Inetances, have already advanced beyond

fe level. contemplated at

?she four year point.

th

scientific progres has generally advanced well save in
Agriculture. There have been serious handicaps resulting from the
inabi1ity to expand the plystcal plant in phase with the program

eu

The Lack of space has been partially offset ty the generosity
of the University of Puerto Tieo in making available a number of

Aaboratories or the several,

spuses.

As graduate programe have cone into operation there hae been

?a sharp upturn in PRNC students from Puerto Rico. (Fig. 3+ table 1)

Participation from Latin America has been slow in development as

far as numbers are concerned. In FY-1964, of the 35 foreign students,

19 (or over one half), were in medicine and public health programs

at the professional level.

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xB

aa PRC will develop as the institution

2 excellence and so it becomes

develops & reputation for content:

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better lacuna +o the universities of the various countries!

visits by staff members to heads of departments of leading univer-

sities in Latin America are indispensable for developing mutual

understanding and cooperative interchange.

fan would result in

A revision of the Five Year plan is relatively

minor change. As events have moved, we would probably now give more

weight to the early development of nuclear power in Latin America,

In the fourth year of the plan, we are already much farther along in

nuclear power activities in Latin America than we had anticipated.

Marine Biology and Terrestrial Ecology have progressed at a

rapid pace as has the University's program in Marine Zoology. The

five year schedule.

Solid State Physics program is about on the anticipated

We now are moving toward a joint KIH-ABS cancer program which will be much more broadly used than that outlined in our original

plan, Puerto Rico should become one of the major United States

for cancer research.

Although the Five Year Plan stressed the development of research,

4s was essentially a program for Education and Training. Table IZ

shows the operations and equipment cost, projections with which can

be compared the actual costs for the respective fiscal years, It

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Oper.

Equip.

?Total

oper.

Bui.

Total

Oper.

Equip.

Total

TABIE IT

?unpandson of PRNG Costs with Five Year Plan Projections

Program 07 Training and Bau

11998

: Actua)

- 119,068

- bo, 952

- 159,620

59,000] 753,764

27,000 | 108,683,

1,231,000] ge, uu7

1,203,500

228,000

1,831,500

e199,

son

?Actual

1,208,593,

97405

1,305,998

225,395

1,405 37

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?TABLE IIT

Comparison of PRIC Total Costs with Pive Your Plan Projections

?ALL Prograne: 05, 06, and O7

?Operations and Equipment

& Prog. OT

Fiscal Year Projection Actual of Total,

1958 - \$ 159,620 100

1959 - 509,373 00

1960 : 672,869 100

261 \$1,232,000 ohehur 300

1962 1,432, 500 hol, 647 3

1963 1,700,000 1,938,994 B

16th 1,750,000 1,901,657 6

1985 1,890,000 2,117,000 8

1966 2,020,000 2,998,000 (st) 69 (Est)

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8

is evident that if Program 07 alone is considered, there has been a persistent underfinancing in terms of the Job to be done. The remit is that Program OT is about where it could have been and

should have been at the end of FY-1962.

om the other hand, special research has been developed rapidly with the introduction of Programs 05 and 06. Programmatic research, although not primarily designed to serve the research needs of graduate education, does offer a substantial opportunity for a limited number of graduate students. In Table TIT, therefore, the total costs of all programs are compared with the projections of the Five Year Plan. From this it is evident that the total expenditures in PRC by AEC are now appreciably more than projected in the Five Year Plan.

As noted, special research aids a program in graduate education, but the one does not substitute for the other. At the level of funding now available for Program 07, it is not possible

to operate adequately in all of the disciplines involved. Considering all factors, it would appear that a fully effective program in Training and Education will require approximately \$1,500,000 yearly in operations and \$100,000 for equipment, or \$1,600,000 total. This level should permit a productive effort in agriculture and medicine,

with parallel emphasis on reactor applications and physical sciences.

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It is suggested that Program O7 should hold at approximately

this level until further experience has indicated a definite

need for additional expansion,

CONCLUSIONS AND RECOMMENDATIONS

1. The utilization of nuclear energy is an essential

a,

in some instances, critical factor in Latin American development.

?To the extent that the United States participates in

sie develope

ment as a matter of 2

{tional policy, the nuclear energy activities

should be pursued at an appropriate level,

2, The necessary base for technological development <n atin

?America is @ great acceleration in education at all levels with @

rapid strengthening of the defenses in the universities together

with the necessary reforms of university structure and function.

3. Puerto Rico is highly suitable for advanced training in

the application of nuclear energy to developmental problems since

In this microcosm the student may explore, not only the theoretical approaches, but also may observe at first hand the applications to the practical problems of a small society in rapid development.

4. Agriculture, for the purposes of this discussion, is a complex with industry and both may be greatly benefited through the introduction of nuclear energy.

5. The Training and Education Program of the Atomic Energy

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bo

should be further developed along lines similar to those now in operation. For the foreseeable future, it should level off in costs at about 25% more than the current level. Research, which is essential to graduate education, should continue to be directed to problems of primary importance to the United States, or to its foreign policy, so that direct benefit to the nation may be forth-

coming from taie operation in the tropics.

6. Programmatic research should continue tts orderly develop
ment to the extent dictated ty the national interest. The inves-

?stgations should ve those unique to @ tropical enviroment or those
whose nature indicates that the tropical Location of PRIC ean confer

a definite scientifte advantage.

7. the primary mission of the Puerto Eico Nuclear Center shoulé

continue +0 be in relation to tatin Anerican development, but the
doors should be opened to a greater extent to advanced students from
the United States. To the extent that 1t 1s AEC poltey, the sane
consideration should be extended to a small mamber of nationals of

other countries.

8, In conformity with the policy decisions, the physical plant
should be axplified to achieve greater efficiency and coordination.

?The University of Puerto co should continue to serve as the
operating contractor and encouraged to aaintain the pace of unt~

verity developaent in the sotences that it hes recently denonstrated.

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9. The integrated medical services of Rierto Rico ant the
umsual freqienctes of some foms of cancer, establish an at-
?tractive opportunity for cancer research in cooperation with
ama,

20, The Five Year Plan, written in 1961, still constitutes
?@ reasonable statenent of progran objectives. ?The Training and
Blucation activities have not reached the full Level projected
in the plan but generally now stand in reasonable hamony with thet
plan when special research is consSdered,

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43

APRIODE A

ADVISORY COMMITTEE FOR BIOLOGY AND MEDICINE

to the

UNITED STATES ATOMIC ENERGY COMMISSION

Washington 25, D.C.

Box 1823-U.P.R. Station

San Juan, Puerto Rico

October 6, 1950

Memorandum

To Mr. John M. Stone, Chairman ABC

From: The Advisory Committee for Biology and Medicine

Subject:

The Role of Atomic Energy in Inter-American

Development

The renewed crisis in Latin America demands reappraisal of the

position, policy, and procedures of the United States.

in simple terms, the great need of Latin America is a substantial increase in productivity -- an increase not only in absolute quantity but above all in unit output. Without a substantial augmentation in man-year output, there can be no real improvement in the general standard of living.

Our policy of aid has been: (a) to send technicians to Latin America who know how to increase food production or improve public health, (b) to keep our hands on the purse strings. These two policies carry their own built-in weaknesses:

With respect to (a), we do not encourage our youth to take up foreign service as a career and we have few schools to train foreign technicians. Often the technicians we send abroad have never been out of their home environment before and they cannot wait to get back. They seldom can speak the local language and they want to escape the fleas and the flies and get home as soon as possible.

In regard to (b), to give people money and then to tell them
One 1t must be spent? according to the gospel of the G.A.O. is,
stultifying and self-defeating.

ideas of the Committee suggest that a new approach is needed.

Clearly, the ABI cannot revise Auer:

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a
"to lighten the load" by setting up a pilot plant, possibly through the
Inter-American Nuclear Energy Commission or the Puerto Rico Nuclear
Center.

of concern to us is the application of modern technology in a
reasonably sophisticated and industrial society. This is equivalent
to saying that one of the essential requirements is a radical and
rapid elevation in the quality of education, particularly in the
Scientific fields. The education program in science must be directed

to the establishment of a broadly based scientific competence from which can emerge the specialists upon whom the pace of development must ultimately depend. This is the seed corn for the great crop of technological progress.

Nuclear science can play a definite part in accelerating the pace of development, to a degree commensurate with the development of the educational system of each country. Here one finds the uniquely powerful tool which in the hands of the expert may dramatically compress the time scale of human progress. In the short time that nuclear energy has been available for peaceful development, only the most superficial application of these remarkable tools has been attempted, especially in agriculture where Latin American needs are among the most crucial.

The contribution of nuclear energy has thus been seen to be a very broad one in a general upgrading of science and technology. Taking Latin America as a whole, the areas of top priority for nuclear activities are agriculture and medicine with nuclear power development coming a close second. A much more deliberate pace except in special areas where it can contribute economically to the prompt utilization of proven

net approaches are feasible and also most productive? The most important ones in the long run are in the field of education. There, as in other areas of development, programs of immediate benefit must be combined with those of long term values. An underprivileged populace will not be content with rewards in the indefinite future. Some results must be obvious in a short span of time and these are likely to show at different levels of education in the various countries.

Is Education

The pace of development in education is that of human growth. The expansion of good education depends upon the development of capable and dedicated teachers. Ultimately, this is a national responsibility. In the meantime, however, certain

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ovts say bs made ds the quality and, effective

Y edacstional syesons.

chars of science

?here bas deen sufficient experience in the U.S. to

st apECIAL training or high achool acience

os van be made highly auccessaful through com

jevation with university science faculties. Such @

cogminy with enphasie cn auclear colenew, cold be

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and a climate in which scientific research may progress are essential. Implied are standards of student selection and Limitation of enrollment in the universities and a strong administrative authority in mature and Responsible hands. Most of the Latin American universities require some degree of reorganization to provide the cultural and scientific basis for professional education and to establish the structure of post-graduate studies.

The encouragement of national research and educational councils could facilitate the organizational changes which are necessary.

2, Research

Both the tradition of scholarship in the sciences and the

physical means for its activity must be encouraged and assisted.

Equipment for research can be provided from external sources but

the intellectual climate is the responsibility of the institution.

A few major research centers are needed. These generally

should be associated either with a single university or a group of

universities. Group associations of this kind are still very new

and experimental in the U.S.; they are unknown in Latin America,

but the prospects are reasonably good in some countries,

Again, all fields of science are included but special emphasis

should be upon the physical and biological sciences that bear upon

basic agricultural, medical, public health, and engineering problems.

3. Program emphasis

For the generalities to have meaning, the program must

be expressed in terms of specific goals and priorities. These

need to be stated as a result of consultation among experts who

have special knowledge of the problems and resources of the various

countries. Tentatively, the primary emphasis in nuclear science

might be upon agriculture and medicine in terms of man nutrition

and the secondary one upon the development of new power sources:

a, Agriculture: In the agricultural field, neither the production of calories nor contemporary market value is an adequate goal. The complete nutritional requirements of man should determine the direction of Agricultural development. A program giving special attention to research and development in the following fields could be exceptionally rewarding:

|

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ar

Blant Sreeding. Generally, the work of the plant breeder is directed to achieving the most satiafac~ tory reassoriment of extsting genes end the pace i detemined ty the growth characteristics of the plants Entirely ney characters, or mitations,

occur relatively infrequently. However, the adaptation of important food plants to different environments may require the presence of mutant characters in order to succeed. The various forms of nuclear radiation, and especially neutrons, may be the means of achieving this objective through their capacity of increasing the frequency of mutations.

It would be desirable to direct primary attention to improving the quality, productivity, and resistance to disease of food plants already established in the various climatic zones, but especially in the tropics. On the basis of new knowledge thus gained the second step could be the adaptation of plants of desirable features from other parts of the world and from distant

ferent climatic zones.

In many tropical regions, the effective development of a dairy industry is hampered by the lack of nutritious forage capable of growing on poor land and upon hillsides. For example, in Puerto Rico, the trailing indigo meets these needs excellently save that it is toxic for cattle. The development of a mutant variety lacking the toxic factor could make possible the profitable use of marginal land in a highly desirable nutritional shift involving the expanding consumption of dairy products.

Soil Fertility. Throughout Latin America, with great range of soil types and conditions, far more must be known concerning the availability of essential elements if productivity is to be increased substantially. Particularly with respect to the trace elements there is need for a large amount of work for upon these elements not only does the vigor of the plants themselves depend, but also much of human malnutrition is the result of their deficiency. Radio-

Isotopes are indispensable for these studies and may be the only means by which some of the problems may be resolved.

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48

Of outstanding interest in this field is activation analysis which enables the rapid detection of extremely minute amounts of many elements. This technique requires a source of neutrons so that the

must be carried out in those countries possessing:

Winter Kasourses. he study of the vater resources of a country including underground storage and movement may be greatly facilitated by nuclear technology.

The measurement of natural tritium is of the greatest value and may distinctly indicate the degree of dependence of underground supplies upon local rainfall.

Radioisotopes such as tritium may be added in small amounts to critical points of

volume of underground flow.

becomes an adjunct to other procedures

delineation of the water resources of a country, & study that is essential for intelligent planning of agricultural, industrial and urban development.

Medicine: The significant contribution of nuclear

energy to clinics and medicine and public health in the

next decade will probably lie in the broad areas of

Diagnosis. While many of the health problems of Latin America result from infectious disease, complex and little understood metabolic disturbances are frequent and also often intermingled. Some of these disturbances are multifactorial in origin while the basis of others is completely genetic. Procedures involving the use of stable and radioactive organic compounds must be moved from the research laboratories to clinical practice as rapidly as possible. This requires the closest of cooperation between the nuclear centers and those of medical and biological research.

see Seals of

areas of interest in high nuclear science may

have significant contributions. for example, radio-

isotope tagging of mosquitoes in their natural

environment. «0 ae"

span and other population chara

very little up to date; yet there

Walter eseer

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©. Nuclear Powers We have stated that the development of nuclear power in Latin America must inherently proceed at a slower pace than the nuclear applications in agriculture and medicine. Partly this is due to the state of the art, but largely it is related to the rate of growth of the power market in any given country which in turn is linked with other economic factors of industrial and urban development.

Waste must be prepared to accept delayed returns

in this regard, we feel that the most serious consideration should be given to the establishment of a few nuclear power stations in regions of critical power shortage. In this connection, we feel that the choice of Puerto Rico for a development plant was particularly appropriate as a first step of a sound Latin American program.

4k, Method of operation

A development program for Latin America should presuppose the active financial participation of all the associated countries. Unavoidably, it would fall to the U.S. to carry a large

burden of the financial burden. It then becomes tempting to some to insist that the U.S. should directly control the expenditure of its contribution. Experience indicates, however, that operation through an international organization such as the Organization of the American States in the long run leads to the greatest degree of real cooperative endeavor with the preservation of national integrity. In the recently established Division of Scientific Development of OAS, with the associated Inter-American Nuclear Energy Commission, there appears to be at hand the necessary organizational structure for the purpose.

Long experience in cooperative undertakings has shown that the best results are obtained when there is only a small minority of foreign nationals of high competence engaged in a project. Further, for each foreign national, there should be a counterpart from the host country. These pairs should work together in complete unity. The termination of service of the foreign national will then always leave a well trained and competent local person to carry on.

We stress our conviction that ARC should not develop its international program in isolation but rather that it should take the lead in achieving close integration with all other agencies of government which have responsibilities for economic development and for the improvement of education. The program operations of

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50

?these agencies should be based upon comon philosophy and should nove along lines that are mutually reinforcing.

nally, we recognize that the scientific development of &
countey ust take place vithin a sound soctologic and economic
Structure. Forward planning mist take cognizance not only of the
fopirations of people bat also of the resources vchich nature ha
provided. yith the studies of resources for the future must be
leeoclared those of population trends. The achievenent of a favor-
ble distrtoueion of population fe vital to intelligent planning.
Hanan health and happiness may be vitiated by excescive vopulation
Geneitice on the one hand and gross underpoptlation on the other.

We are confident that the various Lines of inter-American development may be directed within the broad perspectives of foreseeable social needs:

Recommendation:

to advance the purposes of Inter-American development, we recommend that the Commission that it:

recognize the potential contribution of nuclear energy to Latin American development in scientific fields and

Yo economic progress ané human health;

2. tye the eportoring by the U.S. Government of @ strong

Gevelopmental program along Lines set forth in this

memorandum;

3. Lnvite the consultation of experts under the acgist of

the Inter-American Thelear Energy Comission to

deterne the specific objectives of a program of

feoonoie and selentifie Sevelopment and their order

Of priority; ana

Coneider the desirability of aseigning the operating

Fesponsiility to the Organization of American States

Respectfully submitted,

John C. Bugher, Chairmen

H. Bentley Gla

Fred J. Hodges

Janes H. Horsfell

Robert Loeb

Leonidas D- Marinelli

Carl V. Moore

Janes ii. Sterner

Herland G. Wood

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APPEIDIX B

FIVE YEAR PLAT

1, ErEcoverton

The Puerto Rico Muslear Center, oper et

A by

veceity.

of Puerto Rico under a contract with the U. S., Atomic Energy

Commission, was established in Oct

ber, 1957, as part of the Atomic-

Energy program. It grew out of the propo-

sition made by President

Eisenhower on July 22, 1956, at the Panama Conference, that work be

concentrated to "hasten the beneficial use of atomic forces" through-

out the hemisphere - both in industry and in combating disease,

"The main objective of this Center is to serve as an effective teach-

ing and research organization in the principal applications of nuclear

energy. "The University of Puerto Rico gives graduate credits for the

majority of courses offered by the Nuclear Center and its principal

teaching staff are members of the Faculty of the University.

The Michener Center is bilingual with the

2 proton

notably in Spanish. Knowledge of English is not required for admission to the courses given. However, a reading knowledge of English as well as Spanish is to be encouraged and, in fact, the great majority of

graduate students in the universities

Latin America today not only

read English well but also possess reasonable,

fe kL in speaking the

language.

?The Center operates on the three campuses of the University:

Mayaguez, Rfo Piedras and San Juan, At Mayaguez, near the campus of

?the College of Agriculture ani Mechan

Arts, are located the reactors

and associated facilities for instruction at the Master of Sctence

level in Miclear Soience and Technology, Health Phyoiiee, and Agricule

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se

tural Bio-Science, The expansion in rural forestry

plant physiology and variation genetics.

At the RFO PhO

6 and San Juan campuses, the program 15

medically oriented in great part. However, training in reproductive
technology is also given here with increasing attention to radio-

chemistry and physical chemistry, in the medical area, the primary

emphasis is upon new methods of diagnosis and treatment. Sm

wine

?the applications of radiation for the treatment of cancer,

Since World War II, there has been a great acceleration in

scientific progress throughout Latin America. The extent to which

there is a constant improvement in the quality of education to students

and in research in the leading universities has not only

generally,

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where in Brazil and Chile there is today « an inverted pyramid of young

geneticists of high competence

strength as weavers? countries,

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the genetic connections have been

achieved in South Africa, The worldwide circumstances to beanteate mala~

is largely based on technology developed in South Africa, Suostantsai

competence already had in South Africa, in Brazil,

Argentina, and Chile

Certain characteristics of Latin American development

operate to retard scientific development, especially

which are fundamentally inhuman

sional schools ndunte education

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In order for Mull progeegas tn setence to be achieved,

certain changes must take piace in the

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American universities, Adequate conditions to permit full time teaching and research are essential. There must be firm standards of student selection and limitation of enrollment, with strong administrative authority in mature and responsible hands rather than in those of an adolescent student body. Most of the Latin American universities require some degree of reorganization to provide the cultural and scientific basis for professional education

and to establish the atmosphere

of post-graduate studies.

TET, INTER-AMERICAN COOPERATION

TM ADVANCING THE USES OF NUCLEAR ENERGY

?A single center such as the Puerto Rico Thuclear Center

cannot function properly without reference to the needs and resources

of Latin America and without close cooperation with other scientific

centers in the various countries, MacLoughlin's report must find the

proper place in the perspectives of science of 1950s to make its full
contribution to the general welfare.

In a recent report to the U. S. Atomic Energy Com

its Advisory Committee for Biology and Medicine said:

telear science can play a definite part

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pool seacter of 100 Kijevatts and is developing a graduste program

around 11 with participation ty the medical school. Venezuela has

now in operation in the research center @ three megawatt pool reactor
which constitutes one unit of @ multidisciplinary research center of
about four times the magnitude of MWC. Radionuclides (often from
industry) are used

large quantities in practically all of the
countries south of the Rio Grande. A variety of accelerators

are in use in Mexico, Brazil:

, Argentina, and Chile.

as well

at effort of its kind on the part of the T. 8.

outside the continental boundary, the Puerto Rico Weather Center is

neither the first nor the

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the long range mission? Clearly,

a vast expansion to take it another

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countries.

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the Indies

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only research certeve in the tyepiee where neutrons are avatieble in

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Second, Puerto Rico is not only in the tropics, it is an island in the tropics, and

is part

of sharp ecological boundaries

which greatly facilitate:

many phases of agricultural and real

research, this variety of

fibonaeat makes Et possible to approxi-

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?ceditions of goat of tropical America,

Third, Arto Riec ds tteel? a nedel of rapid latin Anertean

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snmaxy Clelds have dizect application in other countries.

From these considerations, it would appear that FRIC should function competitively rather than cooperatively with the

other centers

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fa, it should be an institution prposed-

pled with the principles of the tuples which, by their

ture, must be

solved in the tuples. However

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depth of support autchea by ss ?ity oP national center tn

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may be regarded as a unit of a Pan American system of scientific development and research which should take as its primary interest those major problems which have special tropical reference. Similarly, the other centers and institutes should be expected to give their most active attention to the special distinctive of their region. One of these should undertake programs that are better executed elsewhere.

To achieve the full benefits of the cooperative endeavor, reasonably frequent conferences should be held and a considerable amount of consultation should be encouraged. Program planning and execution should be benefited and a climate of cooperative se

undertaking gradually established.

The composition of the program of MHC must be determined by the needs and resources of Latin America. Until the present year, the

center has been directed almost exclusively to the

teaching of techniques

in the application of nuclear energy and in the teaching of courses

substantially at an undergraduate or elementary level. A few years

ago, this was the type of education for which students

generally in

Latin America were qualified and which was primarily needed. Take

now no longer the cage, ?The rapid progress of higher education in

Latin America and the Movement of graduate students to academic centers

of the U. S. over the past decade have now made it possible for all or

nearly all of the leading universities to offer satisfactory courses

of elementary and technical character.

?A FRYC program devoted to the level of purely technical,

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To nalntain tta effectivmess ac a regicaal center, FRIC

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to the forwart planing of the PRC progras. ?The UFR faculty eaniot
supply all of the scientists with the alvanced acadente qualifications
which aze needed. The development of strength through the training of

young Puerto Ricans in U. 8, institutions would require several yer

1a delay wateh would be fetal to the objectives of HRIC. ?The path to
foliew ty necessity appears to be that of strengthening the eetentific
staf? by recruitment from outside Buerto Rico, chiefly from the U. 6,

untverai tics bat wico from other countries vien suitable candidates

may be so oncountered, At the sane tine advanced tratning of young

Puerto Alcan sclocttets ts easential for the futuse.

Hoe of mattste recratted fron outside Puerto Rico

will probebiy be texporary but some should be willing to identity

?themselves permanent

with PRIC. Obviously, such Individuals mst

be acceptable to the University as tenure faculty members 1° they are
to be vonsidenad pemmanent members of the academic community. In ay
case, sowvice on a izave of absence basis of less than two years would
not be generally proviuctive and there should be @ reasonable prospect

that the visiting selantict will continue nie

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nie activity in his om untveraity.

These re

urko tn the university fraxeverk apply equally to

those whose actmal ye!

sts are in the national aborutories or other

npectal sesoarch Insti tstions. There shold be a epectal elats on

the national Isberatcates because cf their complete identi fieation

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for the Mayaguc? canpus, these 1s a building with approxi

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the following location, the various programs are to be

located in a building of approximately 22,200 square feet floor area

vn tion. The new structure is part of the

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Puerto Rico Medical Center now unie~ development and is close to the

Few Cancer Hospital and also conven! University Hospital

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land other units of she growing Kidscat Center. A ual? amount of

space will still be held at the Medical School in San Juan and in

the school of Natural Sciences on the main campus.

Major AFT equipment available to the San Juan-Rio Piedras

programs consist of a complete radiology training laboratory, an

6,000 curies fixed-field Cobalt-60 teletherapy unit, Cobalt-60 needles

and capsules of various sizes totaling about 800 radium milligram

equivalents and other items of counting and radiation measurement

The Radiotherapy and Cancer program utilizes

the following equipment: In addition,

the following equipment will be donated by the Dr. T. González Oncology-

gleal Hospital:

. Potattocat, of gpproximately

koe curse

erherspy obait-60

Two deep therapy X-ray untns

fe: Que superficial therapy Xeray uctt

4. Approximately 700 eilligremms of radiun in the form of

needle and cells of various sizes and activities.

The use of the above equipment by the Radiotherapy and Cancer
Division is strictly dependent on the work load of these units as shown

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The general organization is shown in the accompanying
chart. The program functions under a Director and two Associate

Directors, each of the

Lutter being prizartly responsible for one

of the geographic subitvialons of the Cont

Tee Tirector reports

to the Chascelloy of the

versity through the Bean of Medicine in

matters pertaining to the Mo Pledvas-San Cuan campuses and through

?the Vicethmeriice in martes

concerning th: Nayeque area,

This major prograx arese are

represented by Divisions, each

with its respective Head, which is responsible for the operations in

the program area.

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the program will tend to involve

the entire center and examines must be taken to effect

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Amposes by the separation of 100 miles between the two halves of the

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vi. PRESAIT

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nit progvars of the Tuclear Center at Mayaguez

comprise @ series of ccurses of instrustion viich lead to a Master of

Science degree:

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?Delusles Goiense and Ingeineccine Prosrage: The
PRG offers a full curriculum leading to the degree

of Bachelor of Science in Nuclear Technology. The
course of study starts with the summer session
and requires one r

The curriculum:

clear science and engineering follow-

2 bows approves by the Consteston Tor

by these fellowship holders, The currt-

sm was first given in FY-1958 and is designed

to give the students an understanding of the theory

and operation of nuclear reactors and the associ-

Chemical and metallurgical processes.

sop bat og: This to

was first given in 1959-60 as a

leading to the degree of Master of Science in
Public Health. The curriculum is designed

to provide the fundamental knowledge in ra

public health, epidemiology, and the principles of
preventable exposure and prevention of unde-
sirable exposure. The student will also intro-

duce a course of the legal and public relation
aspects of radiation protection.

now Division was
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new programs which

The prospectuses of tr

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Research activities of the Division have

already been initiated with the equipment cur-

rently available, A preliminary study of the

Effects of neutrons and gamma radiation on a
number of tropical plants, both as seeds and
in the vegetative form, are under way. Irradiation
of several species of plants is being utilized as high
intensity gamma sources. Other studies in
plant physiology are being conducted in co-
operation with the Federal Experiment Station
of the University of Puerto Rico Experiment
Station.

Research projects are directed mainly
in the fields of plant physiology, and medical and bio-

These programs are as follows:

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Tecr-woex cosnae patterned

after @ similar course offered ty the sk Ridge

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Obtata training in the use of radioisotopes

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raining in the Radiobiology Division has been Limited
to the use of facilities ty nine (9) nadia) school! students to de
specialized experinents in biosynthesis of radioactive sulfur
components by yeast and ths incorporation of raitoactive phosphorus
Into the phoephclipids of different tissues of albino rats, These
experinents were perfoned wider FRUC supervision. Training by this
tviston has been Limited by the Illness and eventual resignation
of the division head.

YL, FUTURE DEVELOPMENT AND EXPANSION

The future development and expansion of FRIC programs should be determined by the needs of Latin America and Puerto Rico and the availability of qualified staff for the programs. The discussion of future development is primarily on organizational

Lines for clarity and presentation.

The contract for the Center provides that it will be

training and research institution. To date, however, emphasis has

been placed on training with little attention being given to

research. Experience indicates that the measure of competence of

an institution offering graduate programs lies in the quality,

vigor, and support of its research. The development of research
is a prerequisite to the offering of sound graduate level training.

Indeed, graduate education and research in a university may properly

be considered as high level training,

---Page Break---

Ay Mayaguez Program

Le Reactor Division

The Reactor Division is basically a

service division in charge of the physical plant, running the

reactors, hot

²¹s, gamma sources and irradiators according to

the needs of the other divisions, Also it de a technical assistance
and the reactor supervisors must know how the reactor works, how

Its performance can be maintained and improved, how utmost safety
can be achieved consistent with efficiency.

These are precisely the aspects that many Latin Americans
will wish to learn, so training courses are planned for them.

But to maintain the vitality of the staff and to contribute to
knowledge of reactor design and operation, the staff members must
have the opportunity to engage in research and development work
along these lines, This work will be done jointly with the Atomic
Science and Technology Division for maximum effectiveness.

It is evident that there are many possibilities for suitable
research, development, and testing progress in reactor operations,
and these aspects should be encouraged, both for the sake of the
staff and that of potential trainees.

The research reactor has been operating since October, 1960.

It has been checked under the manufacturer's supervision, and the
tests have subsequently been repeated. No significant difficulties

have been encountered.

Procedures have been written for the principal training and

research operations, such as start-up, rod calibration, neutron

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irradiation, etc., and operator training courses will be

established.

It is planned that all graduates of the Nuclear Science and Technology

Program will be eligible to obtain a reactor operator's license,

Neutron irradiation techniques will also be established for the

routine irradiation of samples for research and instruction in TRIC,

and for any other approved organization.

As they develop, all services by the research reactor will

be put under regular procedures. A number of instructional experiments,

such as control characteristics and operation, approach

to criticality, control rod calibration, pile oscillation, void

reactivity, etc, will be developed

student use.

A six-month to @ one-year program for reactor supervisors

Will also be initiated, A study of reactor operation will be carried

out, in cooperation with the Meteorological Station, to determine

conditions under which high

power operation of the reactor might

be permissible. These procedures may merely require suitable weather

conditions, or may involve installing and testing a semi-enclosed

coolant circuit within the pool.

Other appropriate services and activities, such as neutron

activation analysis, gross radiation exposures, public inspection

tours etc. will be established.

2.

end Technology Division: The present

activity and received obligation of this division is the teaching
of the courses that make up the curricula in Nuclear Science and

Technology; the responsibility for scheduling faculty, students and

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facilities for these curricula; and the

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Gtviston expands into the various sct!vittes with waieh it ie charged,

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3. Health Mhysies Civision:

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Without endangering the health of those in the vicinity.

Environmental surveys will be, in part, the responsibility

Of this Division. There is special interest in adequate ecological
studies of the Rincón region before operation of the Bonus reactor.

4. Curricula: the Center at Mayaguez has offered the following

curricula leading to the Master's degree: a Master of Science in
Solar Sciences and Technology and a Master of Science in Radio
Physical Physics. Based on the experience of the last three years,

it is apparent that these two curricula do not adequately meet the

needs of the students

requesting to attend the Puerto Rico Nuclear

plant

It is proposed to substitute the following degree program,

which would require the same total number of semester credits

for the master's degree - (at least 30 and not more than 36). Each

ny edutsston requinments appropriate to the Tiold of spectral=

Seation, 412 would requit

a portion of the tctal effort to be

applied to a special project, thesia, or design problem, as appro-

Brite, Moreover, {na mancer afetlar to that of most proven: aay

evaduate schools, the curricula would be abost one-half epectfisd

and the other taflored to the individual needs of the etuden,

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preceding the regular full admission would be available for the

fulfillment of satisfied admission requirements,

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Master of Science in Health Physics: This will be quite similar to and will replace the present MS.

On Radiological Physics. The change in title 12 in Line with recent actions of both the Health Physics Society and the AEC Committee on Health Physics follows.

Master of Science in Nuclear Engineering: This will be
designed for the students interested in the practical
aspects of nuclear engineering. It will acknowledge the
particular engineering bias of the candidates for
admission, and will allow the student to specialise
in any aspect of nuclear engineering related to
their undergraduate training. For instance, the
applicant with a Bachelor's degree in Chemical
Engineering could logically continue specialising
in the chemistry and technology of nuclear fuels.
The electrical engineering candidate could specialise
in reactor instrumentation and control problems.

Master of Science in Reactor Physics: This will be
designed for the students interested in the practical
aspects of nuclear engineering. It will acknowledge the
particular engineering bias of the candidates for
admission, and will allow the student to specialise
in any aspect of nuclear engineering related to
their undergraduate training. For instance, the
applicant with a Bachelor's degree in Chemical
Engineering could logically continue specialising
in the chemistry and technology of nuclear fuels.
The electrical engineering candidate could specialise
in reactor instrumentation and control problems.

Integrating reactor, it offers Tron nuclear engineering
in many significant ways. There will be some emphasis
on reactor physics, the dynamic behavior of reactors,
the electronic aspects of reactor instrumentation, and
the instrumentation of problems associated with the
use of reactors, teaching us to solve more

As important as reactors become, there are numerous other varied

Aspects

of Nuclear in Nuclear Science: This is

needed for the broad spectrum of students interested

to meet the needs of the biological and physical
sciences. We will carry a specification of a
major in some topic, such as Astronomy, Nuclear Physics,
Radiation Biology, Radiochemistry, etc. The curriculum
will be primarily undergraduate, but will require those
common to all of these areas, such as Health

Physics to design to fit with the back-

ground of the student. Courses will
be developed in the departments of the

---Page Break---

will include the thesis representing an investigation

of some nuclear aspect of the student's specialization.

The above recasting of curricula is based on the presumption that there will be available, either on the Center staff or on the faculty of the University, the variety of professional capacities that are necessary. Although such a diversification of offerings will represent some increase in average effort expended per student, it does not represent any great proportional increase in teaching load. Many of the courses will be common to several curricula. By

means of the thesis research, design problem, or special project, the

student will in turn contribute to the research program of the Center.

San Juan-Rio Piedras Programs

1, Radloteotope Techniques Progra: In the Radiotsotope

Applications, the needs for training in Latin America: should increase due to the present trend and enphasts being placed on the use of redio-Asctopes in medicine, infustry, and agriculture. Along with this increase there mst be an increase in the number of persons trained in the uses of radtotsotopes.

Tt 1s evident, therefore, that for the Redtoteotope Appli-

cations raining Progran ve shoul

fa, Continue the basic radioisotope courses at the present level.

b, Discontinue the Radiation Protection Techniques course in favor of an amplified program in Health Physics

fe, ?Introduce specialized courses in the baste techniques a5 applied to industry, agriculture, and clinical

Ategnosis.

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4. Trelude research prograns In support of the above
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staf. ?Such research could very generally encom
pass the use Gf radiaticas tor sterilization and
Chesca procesiezs the explcynnnt of radlciso-
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cheaistry: ana tie applteation of partiels exltters
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2 Radiotherapy std Cancer Frogras: [4 ig folt that the

Rabiotherapy end Zaccur paogean, sows than any ot

wer FRIC progres,

fat present, has boon acet generally accepted 4

Latin Averice xd has

had the least difrieuity tn attracting trainees, Thy usofuirase of

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Ausrica ea, vest be tates by the fact thet to

Yate thers ars no createed training progsane {x Zallotherany in Latin

America, yet those eountetes aor Pacing a constant ?acreage in the Cancer

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potential of the Center in radiation therapy, radiobiology and radio-

logical physics. The current research programs in the evaluation of

the radiation response of tumors to conventional and supervoltage mod-

alities by cytological techniques will continue. New programs to be

started include tumor and tissue culture studies, effects of pharma-

cological agents on radiation responses, and alteration of tumor bed

circulation and oxygenation. Training course content will be altered

and improved as new equipment and personnel are obtained.

5, Clinical Radiobiology Program: The increasing use of

radioisotopes in clinical medicine also makes the Clinical Radio-
isotope Program important to Latin America, As in the case of the

training in Radioisotope Techniques there is a demand for personnel),

qualified to use radioisotopes in Clinical Medicine throughout Latin
America, There is every reason to believe that within the next few

years this

Organization will have many more legitimate requests for training
which can be accommodated.

It is expected that there will be no major change in the
functioning of the Clinical Radioisotope Division in the near
future except to introduce new techniques as they are developed and

proved, The research potential is good and the current research

projects in vitamin B₁₂ absorption in tropical sprue, fat absorption

in dyepoal spone ond fron setabollen In vartous anentas will be

continues. tte setivities VILL also be expanied to include pediatrics,

Istnology, urology and gynecology in adaition to medicine.

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Aasitional sqvizment required for che instrmuction dn new

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techniques in elintesi aiazne: py WiLL be procared 48

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Raitotiology Progra: The bi

bbe activated as rapidly ws tn consistont with other pregran decanda tn

vier that It may Ve sespensitie for the teaching of the principles of

raatobtology viteh =

medical prograns. ?Tho Interaction of vardou

modalities of radiation

with living systems, both unicellular and multicellular, will

be concerned in considerable part: the effects of these interactions

as manifested at the various levels of tissue organization will be

discussed and will form the basis of a series of laboratory experiments.

Both the genetic and somatic effects of mutation at various stages

of development will be considered,

and will require a considerable amount of

ston will have to be prepared to render

a number of service functions: to the other Divisions of the Center.

Among these are: vitals

trifurcation, ultraviolet and infrared spectro-

scopy, tissue culture, statistical consultation, microlelelorteal

pathological services.

5. Medical Biometrics Division

activated in the teu Mtuce 4s provide the Dread cevemge tn the redd=

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CLinteal Radlotuctuyos ?tvststen ty prtnan tly conenmed with the problxs

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?the Division of Medical Biscecfences to conduct those special stuaes

and do graduate teaching in those areas of medicine for which the

nuclear tools are essential to understanding, In this Division should
be performed those investigations which may ultimately lead to new
diagnostic techniques which can be applied by the Clinical Research
Department.

The primary activity of this Division will be medical research
of first order concern

and post-graduate medical teaching in broad areas:

in the tropics. Areas among the fields to be considered will be tropical

nutrition, As the faculty has to overcome, the more abstract aspects

of which:

sition because Trogressively were important. Gross malnutrition

ta generally received as an outstanding problem among primitive tropical

peoples but the £

structure of nutrition in the tropics is not still

well understood

1. Biochemistry, especially that of enzyme systems,

must play a major role and must include an examination of the dynamics of

trace elements, a

nore present day knowledge in fragmentary tr

?the exons.

This Division should also concern itself with the tropical,
parasitic diseases that exist in Puerto Rico, and attempt to devise:

new attacks upon those with the objective of eradicating them, Fore-

most in the 11th 13th centuries; which not only persists in Puerto

leone but elsewhere is the ts

.e3 has stubbornly refused to yield to the

existing public health sanitation techniques, New approaches are

needed in cases

his people and it is possible that useful answers

will be found in the =

integrated approach.

---Page Break---

9

These are examples of problems of high priority which await

the activation of the new program, Further study of the racial

patterns of Puerto Rico will doubtless disclose numerous other disease

entities are now suspect

14. Among them, one can anticipate, will be

2 number of genetically determined metabolic deviations or defects

which can only be recognized and studied by radiological methods.

---Page Break---

80

VIII, RESEARCH PROGRAMS

In addition to the comments regarding research activities

that have been made in connection with the divisional plans, cer-

tain general statements are desirable. In the perspective set

forth in the introduction, it is clear that PANG cannot attempt

to be competent in all aspects of nuclear science, It must one

phasize those fields which are of paramount importance in the

tropics and especially in Puerto Rico, and which at the same time

are within the capabilities of its equipment and manpower, Its

research, therefore, cannot be conducted in all of the fields in

which it gives instruction. instead, the research program must

be somewhat restricted in that it should be directed at those

problems of the region which are of primary importance and the
Investigation of which can best be done in Puerto Rico.

In the bs

Logical area, there is a great opportunity and
need for new Lines of exploration in medicine and agriculture.

Indeed for the near future, as has been reiterated many times in
the past, the greatest returns from nuclear energy will probably
be found in these two fields. Further, the two may be profitably
linked, The study of nutrition in man should establish Lines of
prior concern for the developments in agriculture. In the medi-

cal domain, PREC can

act as the sparkplug for the activation of

medical research:

of a kind new to Puerto Rico and may contribute

both directly and indirectly to the advancement of knowledge

---Page Break---

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The medical program, which should be primarily directed to the deficiency diseases and cancer, will enjoy the close cooperation of the new laboratories for clinical research now being established by the Medical School. It may look also to the other units of the Medical Center and especially to the brilliantly conceived Regionalization Program of Medical and Health Services for assistance in conducting its research. The Regionalization Program gives immediate access to most of the population of the Commonwealth and will make available to PRIC its great resources in records and statistics.

The potential is outstanding for a highly productive cancer research program on the part of the Medical Center. The new Cancer Hospital, in juxtaposition with the PRIC building at the Medical Center, will have 102 beds together with an additional 50 beds for ambulatory patients in the rehabilitation hospital under construction. This hospital, supported by the Puerto Rican public and

operated by the League Against Cancer, is an unusual one in the degree with which it is integrated with the medical activities of the Commonwealth. As part of the Medical Center, the Cancer Hospital will be even more effective. For the past 10 years there

has been practically 100% followup of

2 cancer patients, and

through the Hospitalization Program the quality of this activity.

may be substantially improved from the standpoint of medical

records and investigation.

---Page Break---

be

For all practical purposes, PHI has available for research

purposes over 100 beds for which it does not have to provide the

capital costs or the operating expense. Through the Commonwealth

Department of Health and the community health centers, es:

entially

all cases of malignant disease on the island can be known, so that

the statistics can be practically complete, These features,

together with the fact th

there are unusual frequencies of some

types of cancer, we have a program of clinical cancer research espe

cially attractive

ribed in some detail,

To addition to the research program de

in the prospectus of the

vision of Radiotherapy and Cancer, there

is the opportunity for an advanced study of chemotherapeutic con-
pounds as adjunct to radiation therapy and surgery. This would

involve the use of:

isotopes of such compounds tagged with $O-14$ and tritium,

and in some instances with $Pa32$ and $S935$. Tissue distribution and

the metabolism:- pathophysiology of the

Je cenpounds in tuman beings would be compared with that in tissue cultures of neoplastic and non-neoplastic

magn solls and ve @ Lindted extent of laboratory animals. If the

in PANG and the Meical School, then

these studies should be extended to the steady flow of Leakenia in

entldrens ants would sume to the Medical Center and the Ganser

Hospital if there wore a 2

Le encouragsnent.

Stilt another Line of dnvestigation which 1 already incor=

porated in the progres plan 1s tne experimental study of the use of

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83

neutron capture reactions in neoplasms.

is not presently done

?templated to use the reactor for man

rather than to confine

?the study to transplanted neoplasms in small Laboratory animals.

is part of the program would function in close collaboration with

the Medical Department of Brookhaven National Laboratory.

Agriculture:

is an area wherein the Atomic Energy Commission has major

contributions to make. During the past 20 years, Puerto Rico has

Put primary emphasis on social and industrial development, and

agriculture has received less atten

tion so that its slower progress

has resulted in

relative lag. The nuclear scientist has much to

contribute to plant genetics, plant physiology and soil fertility.

Agriculture to a large extent involves applied science, but the

research which is required is often of the most fundamental charac

ter. Photosynthesis, enzymatic conversions, ele:

ments and water

movements, cell respiration and the physical chemistry of inorganic

systems of low solubility are but some of the areas of research

?that are vital to the development, of agriculture. Naturally, there

is especial interest in those systems of major economic importance

Fundamental research may be conducted with plant systems of economic

importance just as profitably as with those species of little

economic interest. The problem of experimental design is one that

requires intellectual scope that goes

beyond the immediate scientific

title problem.

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It would be the expectation that from the research program of PRIC there would ultimately result a substantial increase in productivity in tropical agriculture relative to Puerto Rico.

There would presume cooperative operations with the various expe-

iment |

ions, the College of Agriculture and the College of Engineering.

Earlier mention was made that one of the advantages possessed by Puerto Rico is that it is an island in the tropics.

There exists, therefore, the opportunity to carry nuclear technology into marine biological studies. There are many arguments in

favor of having PRAC participate in this general field. One of

the most cogent arguments is that our ignorance of the functional

biology of marine organisms 18 by year. We cannot predict with any accuracy the ultimate effects of radioactive contamination in any part of the ocean. The practical side of this is that policies of waste disposal in the sea cannot be formulated on a sound basis

at the present time

because of accurate scientific information concerning the differential uptake of individual radioisotopes by

components of the

plankton which in turn become part of the food chain leading to man.

The University of Puerto Rico already possesses a marine biological station located at La Parguera, a situation of rich coral growth. A second station is being discussed for the eastern

end of the island where the conditions are quite different.

---Page Break---

8

Because of inadequate starting and the lack of a competent and dedicated marine biologist, the existing station has had a low order of productivity from its inception. The possibilities inherent in the use of radioisotope techniques have not been at all appreciated.

The contribution of PRIC to this program should be of minor magnitude in terms of budget. A reasonable participation would be to add to

the staff an outstanding marine biologist with a few technicians to lead a program, the major support of which would come from other sources through the University. The other sources would be the National Science Foundation, the Office of Naval Research and the private foundations.

In the physical sciences, again, careful selection of the areas of research activity must be made, and it is difficult in

nuclear physics to identify specific problems that can be better executed in Puerto Rico than anywhere else, there are other considerations that assist in making the choices. It would be desirable, for example, for the research at PRC in physics and chemistry not only to have sound value in its own right, but also to be directed to problems the solution of which might have good prospect of leading to substantial progress in other areas of research activity. For this reason, study of the phenomena of the solid state, particularly those concerned with molecular structure and forces, would, with small probability, lead to similar investigations of substances of primary biological interest.

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Additionally, there are sections of nuclear physics where present knowledge is incomplete, but where the equipment of PRNC would be admirably adapted to graduate work. Neutron activation cross sections at precisely known energies is an example of this type of study. The potential exists for carrying such measurements to very low temperatures.

In the nuclear engi

wring field, again the reactor forms

?a center about which the research program may concentrate. Studies of radiation damage to materials and components of reactor systems are well adapted to Master of Science thesis work and should yield useful scientific information about materials for which knowledge is now insufficient.

Plans are now being formulated for the study of the thermal emissivity of various surfaces under neutron and gamma irradiation.

This program, which should begin in July of the current year, will utilize one of the reactor ports and will begin with studies of thermal emission from graphite at about 2,000°K, later, it is contemplated that similar studies employing single ceramic fuel elements will be undertaken.

?ALL of the new research programs discussed in this section will utilize the reactor in one way or another. Some of them are wholly reactor centered; in other cases reactor services are necessary for their implementation. The production of radioisotopes of

short half life is one important function, Another is the

---Page Break---

development of activation analysis, especially in connection with

the

vertebral and metal

1 programs. The reactor is admirably

designed for these irradiations. Much remains to be done, however,

in the exploration of the neutron energies to be favored in the

activation and in the efficiency of pulse height analysis for the

quantitative estimation of elements present in small quantity.

This will be essential for the program in nutrition mentioned

earlier.

Some of the research program would address

jointly arise simply

because of great personal interest on the part of members of the

start, Research of the

Kind should be encouraged even though it

could be conducted as well elsewhere, as long as such research is

permitted to

be encouraged and would not involve the neglect of

higher priority work.

In the last analysis, the case for emphasizing research

throughout the PENC program is very simple: No scientific program

devoted solely to technology will long survive. A program of ap-

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Attract good stuianta nor old superior teachers. Without a

Founded scst dynamde scadents structure and character, the Puerto

Rico Muciear Conter would not only fail to ennance the repatetion

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eds of the region 1t should serve.

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In summary, the advanced re:

research programs which have been

discussed in this section may be listed as follows, together with

the operating Divisions of PRIC that would be involved:

Program Divisions of PRIC concerned

Human Nutrition and Medical Bio-Sciences

Radiobiology

Reactor

Agricultural BioSciences

Cancer Therapy and Radiotherapy

of Cancer Radiotherapy and Cancer

Medical Bio-Sciences

Radiobiology

Clinical Applications of Radionuclides

Cultural Bio-Sciences

Nuclear Science and Technology

Radionuclides

Solid State Physics, Neutron Nuclear Science and Technology

Distraction Molecular Reactor

Structure

Mass Transfer under

irradiation

Science and Technology

APPLICATIONS

In Gable T {page 36 are pre-coated the actual costs for operations and equipment through FY-1960, Table TE (page 37/* exhibits the previously witnessed and now revised costs under these categories Shnvugh F1-65. In table, which begins with the

date of assumption of duty by the present Director, the total

values

are on following pages.

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FRNC CSERAT:

58 THROUGH FY-60

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operations \$119,068 \$283,180 \$467,500

Bautpaent 10,552 206, 193, 225 5000

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maneyears are broken down into their components in order to show

the shifts in character of the personnel that are now in process.

The activation of research programs requires « much greater

proportion of the staff be of a

technical or supporting level. It

is possible that a greater ratio of technical to scientific personnel should be contemplated than is here shown (scientific personnel are here defined as being composed of persons responsible for planning and directing the actual research and teaching), but it is felt that the proportion is about right when one considers the amount of graduate teaching that will be involved.

The cost figure per scientific man-year during these early years is somewhat unstable as a result of the variable relocation costs for those men who have to be recruited from outside Puerto Rico. As time passes, and as staff members are recruited from among those receiving their training at PRIC, this source of cost should become relatively smaller although it will always remain an appreciable item if the policy of drawing upon the universities

and the national laboratories is followed «

constantly.

The annual cost of operation per total man-year appears to be a somewhat more stable figure at the present time. Because of the shift in the composition of the staff to include a greater portion of technical and assisting personnel, the revised estimates for FY-61 and FY-62 show a decrease in the cost per total man-year.

This cost, of approximately \$5,700 per total man-year, has been

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92

escalated as shown to allow for the maturation of the program and foreseeable cost of operations. No allowance has been made for possible inflationary or deflationary movements in the economy generally.

The estimates for operations being determined on projected total man-year costs, the cost per scientific man-year has been calculated and is shown in Table IT, there is implied a rising cost per scientific man-year from approximately \$21,500 in FY-62 to \$25,600 in FY-66, this appears reasonable in line with the costs of other programs of similar magnitude. It should be borne

{in mind, however, that the program in Puerto Rico is actually an overseas one and that costs will tend to be higher than for the continental U. S. if experience in other fields may be taken

a guide,

One major piece of construction is shown to be budgeted at \$1,630,000. This is an addition to the biocedical building at Bo Piedras which would approximately double its floor area. The addition would involve extending the present building to nearly twice its present length. The land is a

table for the purpose

and since site development has been largely accomplished in the construction of the present laboratory, the cost of the additions is estimated at somewhat less than for the existing structure. Pending the availability of this addition, a temporary

sninal house \$8 a neces

ty, there being no animal quarters in the

---Page Break---

98

present Medical Center. By sharing the problem with the Medical

School, it is probable that the necessary temporary animal space

may be constructed within the funds available for minor plant projects

As to further expansion beyond FL-66, it is difficult to give a clear prediction. If the program will have fulfilled its functions properly, there would probably be a need for further

expansion, One can estimate that about 70

entiate in the

minimum for effective operation in as many scientific disciplines
8 PRIC is committed to serve. A very much larger institution
would overshadow the University and tend toward isolation from
the academic community, It seems reasonable to say, therefore,
that growth beyond that projected for 1966 should depend not only
upon the needs in Latin America, but also upon the progress in the
sciences that the University of Puerto Rico has itself shown by
that time.

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ATTACHED

PURRICO MICHEAL CARTER

operated by

University of Puerto Rico

for

U.S. Atomic Energy Commission

August 2, 1963

Gen. Alvin R. Lueders, General Manager

U. S. Atomic Energy Commission

Washington 25, D. C.

Dear AL:

Your letter of July 27 re:

difficulties in defending the financing

of the difficulty is historical, the motivation for the original

establishment of the program in 1946 was political to an

unfortunate extent rather than scientific. It is generally true

that political considerations may change with great rapidity while

the real scientific problems may be resolved on a different and

generally, are.

to a focus the essential aims

of the Atomic Energy Commission. Part

Since you bring out the basic question so clearly, I will say that, in my personal opinion, the training of Latin Americans in the applications of atomic energy is a reasonable but not a sufficient reason for the formation of a center such as the one you have mentioned. I am more concerned with the problems and needs of the U.S. In this connection, I believe that there is a pretty good case which I will try to state,

With the exception of Stockholm National Laboratory, our major centers of research in the non-military aspects of atomic energy grew out of the structure of the wartime and postwar weapons

Development operations. This was inevitable for economic and
Staffing reasons principally. But one result has been that the
greatest impact on the science and industry of the atomic energy pro-
gram has been in the northern portion of the United States. The
Scientists of the country, however, have no such geographic
bias. We have a good number of research centers working on the
agricultural, medical and engineering problems of the more wintry
portions of the country, but the Center in Puerto Rico is the only
Center of research which can be directed to primary problems of the
tropics. It is in this framework that I feel that PANG will justify
itself toward which I have been striving to direct it.

activitien.

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A few examples from the present program may serve to illustrate the point:

1, One of the courses of serious loss in sugar production, especially in Alebaa, is the cane borer (*Diatrea saccheralis*). A considerable portion of the crop is lost each year throughout the cane growing regions, a loss that amounts to many millions of dollars annually. It is basically a tropical problem and is most profitably attacked on an island. It appears from the work we have so far accomplished that there is some prospect of eradicating the borer through radiation sterilization of the males, this moth whose larvae cause so much damage, will be a part of our program of increasing the yield of sugar in proportion to the labor involved. Another phase concerns the genetic structure of sugar cane itself which we are attempting to modify through neutron bombardment of both sugarcane seeds and plants to achieve a more efficient plant.

2, Tropical Marine Biology and Oceanography

PANG is now conducting highly significant marine research in the tropics. Most of this is related to questions concerning the effects of power reactors and nuclear rocket propulsion. Food cycles of the tropical seas. These cycles are quite different from those of the temperate seas. The investigations of the tropical seas are of great importance, not only for the study of the life of the sea but also for the study of the life of the land.

zone do net subst

These operations are also yielding significant new
crning the geology of Puerto Rico and the adjacent
Of substantial, althouzn incidental value,

ire the measurement made of the total productivity of the
Ocean at various depths and areas, ?These Pires, which indicate

?ultimate potential of fisheries, wts., can only be obtained by
the use of radioactive tracers and radioisotopes since the
basic measurement of the total photosynthesis per unit volume
OF the sea, The research reactor has made these measurements
possible.

3. Bavinsenental, Raddobtology of Teopical Forests

rine studies, the new

y 18 moving rapidly in quantitative

evaluation of the effeste of tusLear radiation on the growth and

forvival of fore: "sin the tropics when subjected to miclear

radiation. This ls le first step of a prose: tne Division of

Biology afd Medicine plans to extewi co forests of bigher latitudes,

Tt ta & study whieh 18 vital to predicting the ultimate damage of

Ta any ways

program In Terrestrial Eco!

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Microbiology of arthropod Borne Viruses

This second phase of ecology is just becoming established and may produce information of the greatest public health value. While designed to investigate the effects of radiation on naturally occurring virus systems important to man and domestic animals, its operations will yield much information concerning the movement of viruses as yet little known between North and South America by way of the Greater and Lesser Antilles. The recent outbreak of encephalitis in Florida will probably be found to be associated with other centers of virus activity in the Caribbean area and the Department of Health of Puerto Rico has been so advised. Because of the broad interest program, both NIH and the Communicable Disease Center of FIM are cooperating with us in this work.

5. Cancer in the Gnipies

There are some marked differences in the frequency of certain types of cancer in Puerto Rico as compared with the United States. These special characteristics plus some reasons make Puerto Rico a natural location for major research. A copy of a letter I have written to Dr. Badicott is attached for further information on this page of the

see attached;

Th 4 not generally realized that PRIC in its training and research activities in cancer care is the direct medical responsibility for more cancer patients than all other ABD cancer projects combined, in terms of the number of qualified radiation therapists produced yearly, I believe that FRSC is now second in the United States, the No. 1 training center being Dr. del Regato's Service at Penrose Memorial Hospital, Colorado Springs.

6. Solid State Physics

With financial support of the Division of Research, its vigorous activity in research dealing with molecular organization in the solid state, the program utilizes neutron and X-ray

diffraction at Mayaguez; and an (for Plotras, involves studies of

wtdvity a2 a measusy of radvation damage in pare crystals
of organic semiconductors. These programe are being developed in
close cooperation. with Brcokiaven Bational Taturatory and, especially
in the cate ef che neutrox aiffvaction work, the establishment of a
coud progran ig» ghort time wu. made possivie by the active particl-
pation cf the Eeparumnt ef Pyeios of PM.

SMe research Ze not related to problens of the

tropies tat bine the necessary resources and the

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scientists who are interested in doing the work are here. Eventually, I anticipate that this fundamental physical research will lead to new concepts and methods in the biological field, this affecting both medicine and agriculture.

7. Radiation Effects in Schistosoma

The parasitic infestation of man which causes much misery in tropical Africa and Asia is one of the few public health problems in Puerto Rico which has not been at all relieved by the developments of recent decades. The research going on here is concerned with the possibility of using irradiated parasites to produce immunity. It is actually the only new idea concerning the prevention of this disease that has developed in the last 20 years.

A similar study is being conducted at Walter Reed hospital and there is also interest on the part of the Public Health Service. Cooperation is being developed with both groups. A very important point is that the problem is a serious one in Puerto Rico and that this island is the logical place for such research.

These are a few of the activities which for the most part deal with major issues of the tropics and which are of special concern to the United States. It is a fair statement that a moderate success in any one of several of these projects would repay the total PENG effort many times over.

The opportunities for participation in advanced research are making the PRIC increasingly attractive to mature scientists in other countries. This is particularly true in organic chemistry, a field in which PRIC, through having attracted some outstanding people, is showing real strength. The educational impact on Latin American countries this seems to become a valuable by-product of an increasingly strong attack on fundamental problems of this part of the world.

I hope that these remarks may be of some assistance in clarifying the nature of the transformation that has been in process.

I am also aware that the delay in getting out an annual report dealing with the program content so far accomplished has been an additional handicap. I have given the issuance of this report the highest priority and we should have it available within a few

I would be glad to come to Washington at any time that you

suggest. Most of our problems arise because the program is moving
at a brisk pace on several fronts simultaneously. That is a much

---Page Break---

more satisfactory position to discuss than one in which no activity
is present.

Although not expressed in specific project terms, the location
and the special mission of FR have made it possible to improve
greatly scientific communication with the Spanish speaking countries.
Scientists, who otherwise would not have been available, have been
brought into programs of direct benefit to the United States and for
which United States personnel could not have been recruited. In

the long run, these activities will strengthen the scientific resources
of the respective countries and in the interchange resulting in
an conviction that the best interests of all will have been served.

any thanks for your interest and help, and best regards to
all of the family.

Sincerely yours,

Joba 2. Bagher, M.D.

Farector

Encls: 1

endicott

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PUERTO RICO WCLEAR CENTER

Operated by

UNIVERSITY OF PUERTO RICO

for

+ ATOMIC ENERGY COM

Poston

Slo-Medtoal Butlaing

August 1, 1963

Dr. Kenneth Endicott, Director

National Institute of Cancer

Bethesda, Maryland

Dear Dr. Endicott:

The Puerto Rico Nuclear Center, supported by ABC, under a cost reimbursable contract with the University of Puerto Rico, is a multidisciplinary project operating on the major campuses of the University. It is oriented especially toward Latin America programs in graduate education and research. The medical activities are concentrated at Río Piedras where the Honorary Medical Building of PRIC forms one unit of the new Medical Center and is adjacent to the new T. G. Martinez Oncology Hospital-

In the field of cancer, PRIC conducts training in radiation therapy and, under the aegis of the Cancer Hospital, administers all radiation therapy for the Medical Center. It is also developing a research program emphasizing cellular radiobiology and the epidemiology of certain forms of malignant disease which show unusual frequencies in Puerto Rico. In the latter field, the program operates closely with the Cancer Control Service of the Commonwealth Department of Health by which complete patient follow-up has been maintained over the past years.

The Cancer Hospital, physically connected with the Nuclear Center, is another and distinct operating unit of the Medical center. It has 106 beds exclusively for cancer patients and, in addition, operates a large ambulatory service for which another 50 beds are available in a neighboring convalescent hospital. At the present moment, these beds are primarily devoted to medical care of cancer patients but potentially they are also all research beds. Under the existing agreement between the Cancer Hospital and the Nuclear Center, patients who remain in hospital for special examinations and studies beyond the minimum required for routine care may do so with the additional costs being carried by the Nuclear Center.

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Des Hy Endteott

?The close working relationship between the Cancer Hospital,
?the Commonwealth Department of Health and the Nuclear Center makes
possible an unusually effective access to nearly all of the cases

of cancer occurring in Puerto Rico and direct contact with the
majority of them. It is expected that as the Medical Center organiza-
tion becomes completely operative, a more intimate association
between the Medical School and the Cancer Hospital will develop

and that teaching and research activities within the Cancer Hospital,
will increase

It seems to me that there is developing an unusual opportunity
for advanced research in the field of human cancer.

?The Nuclear Center has already established a subcommittee

in the radiological and radiotherapeutic areas. This is a limited effort, however. Such subjects as chemotherapy, epidemiology, etc. belong more specifically in the program responsibilities of III.

The logical result of these considerations might well be a joint or strongly cooperative program in which the available resources would be used to the maximum advantage in advancing knowledge concerning cancer in the tropics.

I would like to invite a site visit on the part of yourself and your staff in order that you might have a first-hand knowledge of the advantages as well as the difficulties in the evolution of the program such as I have suggested. I would hope that Dr. Denham would also join us and that all the factors in this essentially unique situation could be discussed. It is my hope that ultimately the proposed site will be developed but it does not seem to me that we have yet arrived at the point of its proper formulation.

The administration of the Cancer Hospital would welcome such a visit as I have suggested at the Medical School. As to dates, whatever is possible for yourself and Dr. Denham will be agreeable.

to us. In many respects, the earlier the conference the better for
events are moving quite rapidly here.

For general orientation, I am including a background infor-
mation concerning the Medical Center, the Cancer Hospital and the
Nuclear Center.

Sincerely yours,

John C. Eugher, M.D.

Director

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PY-1g RIDGET

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?he budget proposal for FY-1966 for Prosrn

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An PY-1965. ALL otviofone of the Program 07 aro reduced bat that

Sevoted to agriculture will be practically suspemtel, The Divtston

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of PRNC in its Latin Aneefoun,

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104

some reduction in participation must be anticipated, particularly in the category of those who will form the future scientific strength of the Latin American universities.

A substantial change has occurred as the result of the introduction of research support on a project basis by the Divisions of Botany and Medicine and the Division of Research. The financial assistance of course has been of great value but the most important aspect is that research at a high

level of competence has been

established and that the United States now has a going nuclear

research capability located in the tropics in an environment that is entirely propitious for those investigations that pertain to problems either tropical in nature or which may be most favorably

attacked in a tropical setting. An example of research which can

only be done in the tropics is the program of radioecology of a

tropical rain forest which is now fully operative. Among the

problems most favorably attacked in the tropics is the genetic work

on paramutation in corn where the fact that two crops may be harvested a year doubles the rate of progress over doing the same work

in the northern states.

in the northern states.

in the northern states.

in the northern states.

The special research projects are oriented to the interests of the United States and only incidentally to the concerns of Latin American countries, Many of them are entirely concerned with ABC programmatic requirements. The development of this part of the total program thus implies a substantial change of objective. To

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105

4 Limited extent, the special research programs can absorb a few advanced degree candidates but in general these Projects are not designed for graduate thesis research which requires problems of Limited time demand and the adjustment of the research to the needs and capabilities of the student. These resea

programs are es

essential. As the scientific stature of PRNC rises to 2+ of consequence;

however, they do not substitute for the type of research activity

which is vital to Program 07,

Among the outstanding achievements of the current year are:

2. The successful isolation of the virus of dengue fever

in the first outbreak in Puerto Rico since 1918. The virus appeared

to be a new type and one which can be studied only with the most

sophisticated of virological techniques. Over 20,000 persons are

known to have been affected in this outbreak.

2. A substantial increase in interest in radiological

health at the graduate level.

3. By refinement of the techniques of neutron activation

analysis and atomic absorption spectrography and their application

to the quantitative measurement of stable isotopes of trace elements,

new light has been thrown on the geological history of the continental

shelf (analogous to the continental shelf) about Puerto Rico and on

the chemical mechanisms of bottom sediment formation.

4. A new class of organic compounds of boron which are

resistant to hydrolysis.

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106

5. The participation in a movement sponsored by the Organization of Catholic Universities of Latin America to accelerate the development of science programs at the graduate level in the universities of Latin America with special reference to nuclear science.

6. The establishment by the University of Puerto Rico of a new Department of Nuclear Engineering, the first graduate department in the University. A corresponding Division of Nuclear Engineering was formed in PRIC and Dr. José Luis Garcés de Quevedo resigned his position as Associate Director in order to head both

of these new activities. The new Department, although still in the formative stage, is already attracting a gratifying number of graduate students. The new program, while small in financial demands, is the most significant educational development of the year.

7. The colonization in the laboratory of the sugarcane

wormer (*Distrexa saccharalis*) and the demonstration that the males

may be sterilized by irradiation as adults,

8. The determination of the structure of compounds,

copper sulfate, iron orthosilicate, barium nickelate, and copper

formate, by the use of neutron and X-ray diffraction.

9. A study of the ha

zard of losing the pool water in a

reactor of the type

type with U₃O₈-Al fuel clad in aluminum

at power levels of 1, 2 and 5 megawatts taking into consideration

---Page Break---

107

the rise of the exothermic reaction of the fuel alloy.

The University of Puerto Rico has continued to make available considerable amount of laboratory space to help relieve the serious overcrowding of facilities. The U.S. Forestry Service has also been very helpful in this end many other respect:

The laboratory space which has been made available by other

agencies in many scattered locations is approximately as follows:

University Hospital 950 Sq. Pe.

Cancer Hospital 800

Medical School, San Juan 1,900

Physics Dept., Rio Piedras Campus 450

Chemistry Dept., Rio Piedras Campus 1,800

Biology Department, Rio Piedras Campus 500

Agricultural Experiment Station (U.S.R.) 00

Forestry Dept., (U.S. Forest Service) 2,000

Physics Dept., Mayaguez Campus 1,000

Chemistry Dept, Nayaquez Campus 500

College of Engineering, Hayamze2 2,000

Total 1,000

{fo this we ean add

Tenporary animal quarters, Rfo Piedras 1,500

Tenporary chenistzy laboratory, Mo Piedras 1,500

Grand Total 14, 000,

Tots results ina fraguented and widely scattered operation

bat without this temporary space

would be necessary to suspend

large blocks of progran.

Director's orice

Tae Divector's Office operates at both Ro Piedras and Mayaguez

with most of the staff being at the former location, Accounting and

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108

procurement are based at Mayaguez. The separation of program and administrative activities results in a considerable burden of communication costs. During the FY-1953 a microwave telephone link was established between the two parts of the Nuclear Center at an estimated annual cost of \$31,000. Staff travel between the two locations requires \$25,000 per year for proper program integration.

Weekly staff seminars have been held at both Rio Piedras and Mayaguez as an established activity. These will continue indefinitely and have added substantially to the scientific background of the staff.

Special training for staff members has been emphasized so that an increasingly large fraction of the staff has had basic training in radioisotope techniques, statistical analysis, experimental design, etc.

The staff of the Director's Office, in addition to its administrative duties, participates in the teaching and research of

several Divisions, and organizes and directs several special, conferences and courses such as at the Sumner Institute of RadioLiology for science teachers, It is responsible for the production of special reports concerning the activities of the Center and generally serves, as the focus of internal communication.

Administration and General Services

As expected, the tempo of the administrative activities as well as the cost of the various services rose in FY-1953 and is expected

---Page Break---

109

to continue at the present level through FY-1955 and FY-1966. Beginning with FY-1964, separate accounting is being kept of what is purely administration and what represents

its services to the

Individual divisions and programs.

Reactor

In FY-164 the Hi

Annual Summary Report for the Research Reactor

has been completely revised and updated, Changes have been made

where the characteristics of the reactor, as calculated by the

fabricator, differed from those experimentally determined by PRNC

staff, Written process

Fe were complete

1) Approved and adopted for

All important operations of the Reactor Division.

Two 6 inch beam tubes are occupied by the neutron spectrometry

Free

ran, and one 8 inch beam tube is occupied by an experiment in

thermal intensity of graphite. Open pool side irradiations are

continuously increasing in demand,

The I-77 homogeneous Reactor has been in frequent operation.

Most of its use is for training, but there is substantial use for

research not requiring higher flux.

The trend in FY-1965 and FY-1966 will be towards the complete

overcapacity of the reactor facilities, the increase in operation time

from one shift to two shifts and the increase in power from one to

two megawatts.

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Nuclear Science and Technology

The Division is responsible for graduate teaching and research in the programs for the Masters Degree in Nuclear Technology, Health Physics and Radiochemistry offered through the University. The M.S. degree in Physics has been established by the University authorities and the Division cooperates in this program. Many of the graduate students at present doing research in fields of applied physics within the Nuclear Technology program are now accommodated in this new program in Physics.

An increase in the research activities of the Division is,

anticipated, while still maintaining the present level of teaching.

The principal fields of research will be in Neutron Diffraction (covered in a following section), in Solid State Physics and in

Hot-atom Chemistry.

A solid state Physics program was initiated in FY-1963 dealing with the effect of X-ray, gamma and neutron radiation on ferroelectric exystals, It will include measurements over a range of temperatures to detect transition points, and at frequencies up to the microwave region, Ferroelectric hysteresis measurements afford a sensitive method of detecting crystal phase.

The study of the neutron flux in the thermal column has led to

a proposed design for an addition to this facility, The present configuration provides a satisfactory distribution in the vertical,

access hole, but a badly skewed distribution at the horizontal beam

---Page Break---

an

outlet. A movable extension of the column, about 5 feet long has been designed, which will produce a more uniform flux over a larger volume.

The studies on the cerium dosimeter have led to the important

Discovery that the addition of cupric ion stabilizes this system,

making it as

venient as the commonly used Fricke (ferrous) system,

Further work will investigate the effect of other cations on the ceric dosimeter and the mechanism of the cupric stabilization.

The present studies on Szilard-Chalmers reactions in antimony oxides will be continued to cover the effects of temperature and gas smelting on the distribution of radioactive antimony between the three and five valence states,

4 new program on the history

on chemistry of organic sulfur and

Phosphorus compounds is planned contingent upon outside support.

The object of this work is to provide information on the mechanism

of the

altered reactions in large molecules and the nature of the

Radioactive organic and inorganic products formed will be determined.

The mechanism of reactions following gamma radiation of organic

compounds will also be studied in relation to reactions produced

Photo-chemically, At present the germ:

induced hydroxylation of

estrogenic steroids is being investigated and the results will be

compared to those found in chemical hydroxylation (Fenton's reagent)

and Biochemical (in vivo) hydroxylations.

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Nuclear Engineering

?the youngest of the divisions is the counterpart in the Nuclear Center of the Department of Nuclear Engineering in the University.

?The latter is the first graduate department of the University and candidates must possess a degree in engineering to qualify for consideration.

?This division is concerned with the engineering applications of nuclear energy and research and development that may be related to its objectives. Emphasis is placed on reactor design, effects of radiation upon materials of construction, metallurgy, heat, transfer, chemical processing of nuclear materials and power

production. Students will take part of their course work on the campus but much of it in the Nuclear Center where all of their thesis work will be conducted.

Some programs, such as that dealing with heat transfer by radiation, are to be shifted from Nuclear Science and Technology to the new Division of Nuclear Engineering.

?The latest information shows that 15 applicants have been accepted as candidates for the M.S. in Nuclear Engineering in addition to

?tne lb already enrolled, naking @ total of 19 for FY-1965 already

assured.

Health Physics

?the Health Physics Divieion has continued rendering its services

con personnel and area monitoring, enviorrental surveillance, waste

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13

Asapoonl, instrumental calibration, decontamination ant handling of radioactive material. In addition it has continued participating in teaching and training of students in Radiological Physics as vel as training of PRNG personnel in general safety. All these services have been extended also te the divisions of PRIC at Rlo Piedras where we have now a Health Physics Section under the direction of 4 health physicist.

As a remutt of the reorientation of PRIC policy, the division 48 now vested with the responsibility for supervision of all safety; radiation, industrial and fire, while each division 4s responsible for safe operation of all facilities under .ts control.

For fiscal year 1965 some increase in services and a moderate

An increase in supervision is expected. Because of budgetary limitations, the Division has reduced its training activities and is

Largely concerned with health physics operations.

Agriculture) Biosciences,

1964, substantial progress has been made in developing a program devoted to the increase of sucrose production by sugarcane. The use of fast neutrons in producing a maximal variety of chromosomal deletions and recombinations was planned. The initial experiments were conducted with cuttings from the best variety of

sugarcane now

use. Lethality occurred at about 2,000 rads (subject

to lat

vevislon) indicating @ high rela

biological effect of

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a4

?the neutrons. thich more {rradiation in the vegetative phase will
be necessary. The second phase would be to irradiate seeds by the
millions and apply mass screening procedures. The two screening
measures of most interest are growth in shale and ability to resist
drought

Ultimately the final screening requires « quantitative estima-
tion of sucrose in cach plant without significant damage to the plant.

The nece

sary methods have been developed and have been automated so that one technician can perform from 10 to 40 quantitative analyses per hour on microsamples. Both sucrose and invertase are being determined on each sample.

The sugarcane borer (*Diatraea saccharalis*) has been intensively studied to determine the possibility of control or eradication by radiation sterilization. A laboratory colony has been successfully established and it is felt that a satisfactory method for mass rearing is possible. A fair margin was found between the sterilizing dose of radiation for adult males and that which is lethal. In the larval and pupal stages, the sterilizing dose is also the lethal dose.

Nuclear volumes of many of the tropical plants (including sugarcane) have been determined to test the formulae for prediction of the lethal dose of radiation for each species. At the same time, chromosome volumes have been measured and DNA per chromosome also estimated.

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us

OF eight graduate students at the beginning of the year, one transferred to another university and several will graduate this next June. For these students, work has been very active with

courses in advanced genetics, radiobiology, seminars and thesis research.

The progressive reduction of Program O7 support forces the suspension of the Training and Education activities of this Division for FY-1965 after being severely reduced in the current year. Only the teaching required for the existing graduate students is provided. Further applicants will be encouraged to apply to other institutions.

Provision is made in the FY-1966 budget submission for the reactivation of the program. Whether this move is made, however, will be dependent upon the determination of ABC interest in the role of nuclear energy in agriculture in general and in particular in Latin America. The potentials for the improvement of agriculture and human nutrition through atomic energy are almost unlimited but,

the effort which has been expended has been woefully inadequate,

specially in the tropics.

Radioisotope Applications

This Division continues to offer training in the use of

radioisotopes in the physical and biological sciences. There will,

be an increasing

and continuing demand for this training, especially

for students of the University of Puerto Rico. The basic course

---Page Break---

is

now offered five times a year and it will probably not be necessary

to expand it. With time, a larger proportion of students coming

from Tatin Anerice wil have already bad the equivalent in their

om universities.

Te expansion of graduate work in chonistry related to radiation
sod miclear reactions has been well established. The research program,
all of which is built around the graduate activity, ie being developed
under four sections:

1. Organic Cheatstry

a. Synthesis of conpouns of interest to the mclear fiela,
especially medicine ant radiobiology.

b, Quntitative study of organic reactions utilizing radio-
isotopes.

2, Radiation Chenistry (sponsored by ABC Division of Biology

and Medicine, and National Institutes of Health).

Mie section has two major fields of activity, which
ecane fully operative in FY-1963.

a. Radiation chemistry and photochemistry of oxyanions.

Study of free radicals, The radiation chemistry of water in the alkaline region will be studied,

b, Radiation chemistry and photochemistry of nucleoproteins and the constituent nucleic acids, Buphais will be laid on the study of cross Linking reactions and the role of excited states in the

reactions of the heterocyclic bases.

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aq

3- Solution Chemistry

Deferred until #Y-1966.

4, Solta State Physics of Organic Crystals (Sponsored by ARC Division of Physical Research)

This section studies the effect of neutron and of gamma and X-ray irradiation on the photoconductivity of organic crystals, Measurements have been limited to anthracene crystals; plans are being made to extend the work to other organic crystals.

The indications are that the program of this Division will attract all of the graduate students for which laboratory space can be provided. A temporary structure has been erected outside the Bloch Medical Building which can house 8 graduate students.

Clinical Radioisotope Applications

The Clinical Applications Division is currently offering two

types of sources for training physicians at an introductory level

is diagnostic services at the Puerto Rico Nuclear Center to

support its coaching programs open:

operates the Radioisotope Laboratory at

the University Hospital for the Medical Staff of this Hospital; supports

with diagnostic supplies the San Juan City Hospital Radioisotope

laboratory on a reciprocal relationship of mutual interest; collaborates

in investigative work with other institutions according to the general policies of PREC and conducts its own research program characterized

by work of elite national

for problems of local and general interest.

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us

Radiotherapy and Cancer

in purpose of this program is the training of physicians and allied personnel in all aspects of the application of nuclear energy to cancer, Another purpose is the development and carrying out of » program of research activities conducted with the purpose

of improving our knowledge in the cancer and radiation fields.

Following functions are carried out to accomplish these

who want to become qualified

Residency lasts

12 months three years

Residency practice in the specialty.

?tion ta also often

to experienced physicians

in radiation therapy who have been engaged in this field for a

considerable portion of time, which permits them to conduct specific
research in their field and participate in all teaching
activities

so students to familiarize

team with conser and vadiots

srapetic techniques.

reining for mirees, techniotane, and radiological

?techadedans and

cy School and operated in the

ster ara Joint pre,

ho Puerto Rico Department

of Boulsh and hw University of Plerte Aico Medical School, mas been

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Aiscontinied in the Miclear Center due to budget restrictions.

Medical Setences and Aadiobiology

?Tala, the youngest of the Rfo Piedras Divisions, ws formed on July, 1962 by analganation of the Division of Medical Sciences with the older Division of Ratisbiology. The actual content of the field of raiobiology has been divided in a natural manner between Agricultural BioSciences, Health Physics, Medical Sefences and Radiotherapy ant Cancer. It can ve said that radiobiology is

sctence in

Mo Piedras, In the latter location the snall prograx which existed tn the Division of Radiobiology is being continued.

J. Mesue Culture Program

?The first phase in the program was the developaent of «

tral tissue culture facility, It has been evident for some time that several divisional programs have a requirement for the employment of tissue culture techniques, It was also obvious that the size of this project would not permit the successful development of several tissue culture laboratories. The most logical solution to the problem seemed to be the establishment of a single tissue culture laboratory to serve the needs of all programs but in which the various members of the staff might have affiliations with other divisions and be directly interested in their special problems.

Beginning in FY-1964 and extending through FY-1965 several radiobiological studies will be instituted with tissue culture cell

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Lines. Chief among these will be the studies of the intracellular capture of neutrons by organic compounds containing B-10, The organic chemistry section of the Radioisotope Applications Division has been preparing a series of new boron compounds which are described in the attached Form 189.

and their Radiation Induced Genetic

II. Indigenous Virus

variability

TIT, The use of gamma radiation to notify *Schistosoma Mansoni*?

cercariae so that they induce immunity to attack instead of causing

At ease.

The procedures outlined in the proposal are, at this stage,

directed towards: (1) defining useful parameters for assessing the

effects produced and (2) comparing the effectiveness of different

approaches to the problem, This program is scheduled over @ to year

period, by which time it will be possible to decide along wh

Lines

?any further research might best be pursued, the hoped for end result
veing « contritution to knowledge which may eventually help tn
combating the disease.

Technical Services (Mavagucz)

This operation, which originally was part of Reactor Division,
As now separated in the new organizational structure of PRC.
Technical Services carries the responsibility for: buildings

?and grounds maintenance, machine shop, electronic shop; and the glass

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qa

Plowing shop. With the exception of buildings and grounds, the
Mayaguez Technical Services, through its shops, serve the entire

PRC and mist te prepared to meet a considerable variety of denands,

The variety of jobs performed by these shops range anywhere from general maintenance and construction work up to the most specialized precision jobs such as: construction of Ionization Chambers, Crystal

String Saws, High Frequency Microphones, or X-ray Spectrometers,

Technical Services (Mo Piedras)

section has charge of building maintenance at Rfo Piedras,

The operation of @ an all electronic shop and general instrumental repair, Shop services in general and engineering supervision are

supplied by the Mayaguez branch.

caumice in Radiation Effects

Experiments utilizing monochromatic X-ray irradiation in the 5-20 Kev range on biological systems have been carried out. This energy region is of considerable importance since it contains the K-absorption edges of the constituent atoms of most living systems.

Pielogio

IL systems chosen for study are those which are composed primarily of Light elements with but traces of medium atomic weight

elements, Inevitable inactivation of

1 @ metalloenzyme catalase,

which contains four atoms of iron per molecule of weight 250,000,

Was demonstrated near the K-absorption edge of iron, Biological

systems under study include the zinc metalloenzyme carboxypeptidase A

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and the bacterium *Z. coli*. Biological studies have been supplemented by investigation into the underlying physical phenomena of the ra-

Asation effect.

Marine Biology Program

Research in Marine Biology at PANG was started in January, 1962, and includes the following: Measurements of marine productivity, determination of selected stable elements, measurement of the concentration factors of selected marine organisms for given radioisotopes, measurement of radioactivity and radioisotopes now present, in the marine organisms, waters, and bottom sediments off Puerto Rico, and background observations in physical and chemical oceanography for use in the interpretation of the first four programs.

Survey work near the new BONUS reactor site was given priority, and

has been accomplished. Activation analysis techniques developed

in conjunction with this program have reached an advanced state of

sophistication. This program is fully operative in all phases

of Chemistry and Photochemistry

The objective of this program is to investigate the Kinetics

and mechanisms of (a) radiation induced chemical decomposition and (b) photo-dissociation of oxyanions. It is hoped that this work will quantitatively determine the reactivity of oxyanions to radical attack, will characterize the rates of decomposition of the various excited states of anions, and will uncover evidence indicating the

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23

participation of excited states in the radiation induced decomposition. Work is underway on solutions of nitrate ion.

Photochem:

ical decomposition to form nitrite has been demonstrated at wavelengths above 3040 Angstroms, Data are being interpreted in terms of various primary dissociation steps of the excited state

and diffusion kinetic

Batemanion

Genetics regulatory systems which control gene mutation are being investigated with emphasis being given to the paramutation system as it occurs in maize, Radiation treatments of the components of the system have indicated that the type of change which occurs is an inactivation process rather than a true mutational event, Radio-sensitivity curves of the regulator responsible for paramutation change are being obtained, The efficiency of densely ionizing radiation from neutrons is being compared with sparsely ionizing gamma rays as an aid in determining the nature of the mechanism of

the system,

Torrey) Ecology Program L; Biodiversity of a Tropical Rain Forest

The rain forest irradiation project was started in the Spring,

1963, 4

the objectives of determining effects of gamma irradiation

for the lover mon

vane rainforest: near Bl Yunque and the movement of
mechanical alteration of fall-out in the normal biogeochemical cycles.

Aa area in the thquillo Forest Reserve provided by the U.S, Forestry

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Service has been developed with trails, towers, instrumentation,
electric power, and work facilities, A group of 12 participating
investigators from other universities began a year of measurements,
preceding irradiation. The project now involves 65 phases with 15

ident scientists and student assistants. The effect of irradiation
will be assayed by measurement of animal noises, vegetation density
to Light, plant and animal populations, changes in microclimate,

localized effects, cytogenetic effects, and changes in chemistry and fallout. A 10,000 curie Cesium 137 source is scheduled to be placed in the study area in December, 1964, and post-irradiation studies will follow the exposure period. Fall-out elements are traceable with existing levels of activity and with tracer experiments. The

Level of fallout held in the vegetation is relatively high indicating the effect matrix holding ability of the vegetation.

Terrestrial Ecosystems; Radiation Induced Variability in
Indigenous Arthropod-Borne Arthropod Viruses of Puerto Rico

In August, 1963 an outbreak of "Dengue-like" illness reaching epidemic proportions occurred in Puerto Rico. The Arbovirus unit joined the local Department of Health and members of the Communicable Disease Center from Atlanta in an attempt to isolate and identify the virus. Successful isolation of a

Dengue-like agent was accomplished

Completed in this laboratory on August 30, 1963, This represented

significant scientific contribution to our knowledge of viruses in

the Caribbean area.

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125

Field work on the regular study areas continues with successful
snail and rat trapping and bleeding taking place at regular
intervals. It is hoped to have a clear picture of the arboviruses
present in El Verde before the radiation source is added. No

viruses have as yet been encountered in the El Verde material,

Experiments of Antigen Antibody Reactions Following the Inoculation
of Mice with Irradiated and Non-irradiated *Schistosoma mansoni* Cercariae

Approval for this program was received in December, 1963, and

the first preliminary experiment designed to determine the number

of cercariae necessary to induce a standard infection

4s underway. A modest mouse colony is available and cultivation of host snails for the program has also been started. Previous work indicated an acquired resistance to challenge with virulent *Schistosoma* cercariae after infection by cercariae which had been damaged

by exposure:

to gamma irradiation. When the optimal experimental

procedures have been established, it is intended to make a detailed study of detectable mutations occurring between the challenging parasite and the immune host.

Neutron Diffraction Program

The first long range research commitment, using the reactor,

4s in the field of neutron diffraction, in close cooperation with

at the Brookhaven National Laboratory. Two beam tubes of the PANG

reactor have been assigned to this work, and an advanced design

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neutron spectrometer is now in research operation at each of these. One spectrometer was being built by BNL to the same specifications as the newest Brookhaven spectrometers and provides PRNC with a highly accurate and versatile instrument. A spectrometer of somewhat similar design and of comparable quality was donated to the University of Puerto Rico by the Westinghouse Research Laboratories and occupies the second beam tube.

In addition to the PRIC staff members working on this program, there have been three guest scientists who have helped considerably in getting the program off to a fine start. One of these was a senior staff member from Brookhaven, who stayed for one year and continues to give guidance to the program. Another is an excellent X-ray crystallographer who was sent to PRIC by the German Government, for two years to gain experience in the planning, installation, and

use of neutron diffractometer

equipment. The third man is a physicist

from Kyoto, Japan, who is spending two years at PRNC.

?Study of Radiation Damage in Organic Crystals using Electrical

Conductivity

Effects of neutron irradiation on the electrical conductivity

of anthracene crystals are under study. Initial phases of the study

were limited to changes in dark and photoconductivity produced by

neutron bombardment which apparently knocks out a hydrogen atom from

the crystal, Electrical conductivity:

was selected because evidence

indicates this parameter is most sensitive to the presence

of

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Zr

impurities or defects. Gamma and X-ray irradiation effects will also be

studied in the future. Another phase of this investigation will include a more precise and direct technique for determining trap densities and depths by measuring mobility and conductivity

as a function of temperature.

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