~ a FE. Rushed PRNC 48 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 ---Page Break--- ---Page Break--- TABLE OF CONTENTS Foreword - General Background 1 Latin American Development Opportunities 8 Raw Materials 10 - Social Factors 11 Industry and Agriculture 12 - Latin America: Surplus to Deficit 13 Elements in the Advancement of Latin-American Agriculture 22 - Nuclear Energy in Latin American Development 24 - The PRC in Latin American Scientific Development 25 - Progress of PRNC in Relation to the Five Year Plan 26 - Conclusions and Recommendations 27 - Appendices Report of Advisory Committee for Biology and Medicine - to Chairman ABC, October 26, 1960 43 - B, Five Year Plan (Appendices omitted) 44 - Letter, John C. Bugher to General Manager, AEC, August 2, 1963 48 - 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 I should undertake a review of the objectives of PRIC with an analysis of the present status. In the main text and appendices, I 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. Brow. Foreign Agricultural Economic Report No. 12, U.S. Department of Agriculture, 1963. "Resources in America's Future," by Hans H. Landsberg, Teonant L. Fischman, and Joseph I. Fisher, The Johns Hopkins Press, 1953. U.S. 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 a 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-term continuity to educational and technological development that precludes any marked partisan political benefit. In this respect, technological development, both national and international, resembles the arenas of foreign policy and defense in the long lead time 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. Bag hu ron Du September 15, 1964. "An Examination of the Program Objectives of the Puerto Rico Nuclear Center" by John C. Eughner, M.D.

Director GENERAL BACKGROUND Among the various efforts to implement 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 (1) the nonmilitary applications of atomic energy could serve to

greatly accelerate the processes of development, and (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 considerations for both of these assumptions had not been clearly stated. Under the pressure of weapons requirements, the ABC itself had not pursued with conviction its own program of year-round applications. The ultimate necessity of switching to nuclear power on a wide scale was acknowledged 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 scale of their solution were generally underrated. The exploitation of radioisotopes in medicine, agriculture, and industry did not have the emotional impact to those developing foreign policy that costly and massive atomic power stations possessed. This factor, combined with a widespread misunderstanding of the ---Page Break--- ---Page Break--- 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

Bispano-America here the AEC could maintain both supervision and operational control, was in Puerto Rico. Since the reactor was to be the center of activity, operational control for the assurance of safety was indispensable. To follow 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 in the development of AD programs, the University of Puerto Rico did not begin on the basis of existing postgraduate studies. A few members of the faculty had personal experience in research in nuclear physics and radiation chemistry, but there was no well-established interest in nuclear science in the University. All available funds and resources had been sorely then absorbed by the exceedingly rapid growth of the student body at the undergraduate level. Notwithstanding the problems implicit in this academic situation, conversations were initiated with the authorities of the University in 1957 as a result of which a contract was established with the Puerto Rico Nuclear Center as a training center for Latin Americans. A training course in radioisotope techniques in Nuclear Studies modeled on that given at the Oak Ridge National Laboratory was initiated at once and building plans were formulated. Because the College of Engineering was located at the Mayaguez Campus at the western end of the island, the decision was made that the reactor and the main components of the Center should be constructed there. Medical activities were being centralized at Rio Piedras, near San Juan, in a large Medical Center. A second component was constructed as a part of that Center to house radiation therapy and 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 on the part of students in the University of Puerto Rico was ---Page Break--- ---Page Break--- the cultural climate of the University of Puerto Rico was still an advantage in permitting visitors from other countries to concentrate on their studies as a result of the reduced problems of adjustment. The rapid development of graduate studies in the Nuclear Center accelerated plans in the University, and Master of Science degree programs became established in chemistry, physics,

biology, engineering, and agriculture. While the number of students from other countries remained fairly constant until the present year, their qualifications and general preparation have steadily increased. During the current year, there has been an upturn in the number of students from other countries, largely as a reflection of the improvement in the level of educational effort. The impact on the University of Puerto Rico has been striking. The number of graduate students of Puerto Rican origin has increased sharply and gives indication of continuing to increase further. The new graduate program in Nuclear Engineering has been received with enthusiasm. Chemistry and physics attract increasing numbers 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 ---Page Break --- been possible to develop fruitful research in a short span of time. It was evident from the beginning that a project of the dimensions 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 successful completion. It was the consensus that FRIKC should undertake to emphasize work in those areas which are best attacked or an Aetand 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 small 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 will be set forth later in this discussion. The essential point is that PREC is no longer simply a 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 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. [LATIN AMERICAN DEVELOPMENTAL OPPORTUNITIES] During the past 15 years there has been much play on words in considering assistance to other countries. Terms such as "developing", “emerging”, "nations in transition", etc. have tended to obscure certain hard principles. National development is a continual process and is never ended. Growth falters when economic progress in some countries lags behind the rest. Amplified in the state of political and social

development of those areas and in the world at large. Whatever may be the degree to which outside stimulus may be applied, ultimately the economic and social development of a region must depend upon the efforts of the people of the region themselves. Without a dedication to the appropriate goals on the part of the peoples concerned 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. Integration, which is part of the spirit of the time, requires that modern technology be applied to the problems to be solved, even those of primitive societies. These technologies require an educational sophistication which does not exist locally. To talk of industrial development without emphasizing the requirements placed on education is to ensure the failure of any program so constituted. Education is a laborious process

which does not lend itself to great acceleration. The time scale is that of human development. Yet if the improvement of a society is to be achieved, the education and training of the youth are indispensable. Political stability is necessary, and to 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. Furthermore, even diverse technologies must be integrated and maintained in an overall balance. Electrical power production implies an industrial

structure to absorb it and employ it creatively. Transportation and communications are vital. Despite industrialization, an expanding and efficient agriculture, capable of freeing the country from importing foodstuffs that can well be produced locally, must be achieved if economic and social balance is to be attained. ---Page Break--- 10 [RAW MATERIALS, Technology involves the bringing of scientific knowledge and practical skills to operate upon the raw materials of a region to carry out specific 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 because 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 with vast regions which have either been explored very superficially 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 ---Page Break--- 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 found 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, aluminum, 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 uneconomic for energy purposes in comparison with nuclear energy by 2050. Agriculture in Latin America in 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.

Notwithstanding this, rainfall in the totality is 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 economic to move great quantities of water over mountain ranges by a combination of pumping followed

ty hydroelectric power generation on the descending side, using nuclear power to achieve energy balance. In summary, Latin America possesses all the raw materials needed for the future and has them in abundance and of types especially well suited to a nuclear power economy. Critical raw materials, in amount and feasibility, are more than adequate for the immediate future and modest exploration will undoubtedly bring to light additional resources as time progresses. SOCIAL FACTORS ‘The Spanish and Portuguese heritage in the New World was a society essentially feudal in outlook. Those in a favored position of wealth and political power could enjoy the best that Europe could afford in culture and education. The great mass of the people, ---Page Break--- 3 however, could anticipate little in the way of education save for ministrations of the Catholic church. There remained through a 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 a 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 exception 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 turned, by necessity rather than by choice, to the United States. Once suspicious of the "Colossus of the North," an attitude not discouraged 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 drawing 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 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 task 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 is an unresolved debate as to whether the National University of Mexico or San Marcos University of Lima, Peru is the oldest institution in the New World. San Marcos 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 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 unsatisfactory 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 past decade, there has been effective movement toward the reform of higher education, making great 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 intercommunication will become less formidable, 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 quick solution to such difficulties is the sending of large numbers of students to the United States or to other countries to study in their 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 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 leaders for the training of a new generation of teachers and educators. At the same time this 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 of 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 as a rule and share in the ---Page Break--- WESTERN HEMISPHERE POPULATION GROWTH IN THE 20TH CENTURY (MIL. PERSONS) 400 200 0 1 i! 1900 1920 1940 1960* 1980 2000 ---Page Break--- a general increase 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 is 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 dilemma 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 adumbrates a host of social problems upon whose acceptable solution

political and economic stability will depend. INDUSTRY AND AGRICULTURE, Purely agricultural countries are generally economically handicapped and from this arises the common belief that the remedy ---Page

Break--- is to achieve a rapid conversion to an industrial economy. Too often the results are a neglect of agriculture with the creation of new problems that may be even more difficult than the original set. Food, as an absolute necessity, and reliance on external supplies creates a situation of inherent instability. 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 U.S. and Canada have become, according to recent 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 complain would be rapidly eliminated if the needs of the free (or semi-free) 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 man-hour agricultural productivity is one of the greatest of world needs. With over one half of man’s calorie intake derived from the direct consumption of grains and most of the remainder indirectly ---Page Break--- 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 ---Page Break--- 2 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 ite standing in vorla grair trade comparable to that of Latin smerica. During the Late 1930s the region dominated the world grain market as a supplier. It exported more grain than North America and Oceania combined; it was an important supplier of wheat and corn exports accounted for almost three-fourths of those of all regions. By 1960/61 Latin America had relinquished its impressive advantage 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 1950s, to raise output by expending 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 ---Page Break--- 2 ‘the period do 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 production from 25 kilograms in 1936-38 to 21 kilograms in 1960/61, availability has risen from 180 to 216 kilograms per person. This has been achieved by sacrificing net exports, which amounted to 18 kilograms per person in 1953 to 2 kilograms per person in 1960/61. Of this 76 kilograms, and becoming a net importer to the extent of change in the per capita trade position, 40 kilograms were required to offset the decline in output per person. ‘The remaining 36 kilograms represent an improvement in per capita consumption. Thus while per capita output was declining 16 percent, per capita consumption was rising 20 percent, but at the expense of exports and the foreign exchange vitally needed for industrialization."

Part of the solution to the agricultural problem in Latin America lies in the additional methods of plant breeding and crop improvement along with the reduction of the losses from plant diseases and insect pests. Another large and highly important area is in the application of power to the agricultural process. As in industry, the worker must guide and control the application of power to his operations; he cannot be the primary mover himself in a prosperous economy. Even animal power is no longer economically viable in the most unusual circumstances. Rural electrification and the application of electrical power to farm operations, especially those with fixed machines, and the use of liquid fuels for mobile machine operations are now part of agricultural development. All these imply a well-developed system of roads, communication, and electric power distribution. A third essential element in the advancement of agriculture is 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 a large scale exist. If power is 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, all 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 minerals of the soil together with all 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 a part of industry, drawing upon mechanical and chemical manufacturing for its equipment and part of its raw materials, and in turn delivering to society a series of elaborately synthesized products, many of which can be consumed immediately while the remainder becomes the prime material for other manufacturing processes. The generation of power where needed makes it possible to disperse industrial manufacturing in the same way that agriculture may be dispersed without loss of efficiency. The growth of industrial volume becomes no longer inevitable nor even profitable, and a 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 in order to be profitable. The pattern of the industrial-agricultural complex will vary from country to country, depending upon local resources and needs. It should be reasonably obvious that the key to the development of the balanced economy is the availability of low-cost power at the sites where it is needed. In the long run, power is the only form which can meet all of the criteria. Although the time frame is 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 modifying biological systems, especially in the genetic sense. The radiation geneticist uses nuclear reactions as a means of altering.

compress: ‘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 somewhat embryonic in terms of its ultimate possibilities, as in

the case of generation of electric power. We have scarcely taken the first steps. NUCLEAR 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 future development of Latin American countries in much the same sense as in the United States. Cultural and socio-economic differences will modify the patterns, but the fundamental principles hold good for all. The benefits to be achieved in accelerated national 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 at 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 academic structure and functioning of universities throughout the region. It should be further apparent that 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 more ways of adapting the forces of nature to his own well-being. THE PROBLEM IN LATIN AMERICAN SCIENTIFIC DEVELOPMENT If one accepts the needs for socio-economic development of Latin America that have been sketched in this paper, then one may inquire as to what role, if any, should be assigned to Puerto Rico and especially to the Puerto Rico Nuclear Center. What advantages are attached to the location in Puerto Rico? To what extent are developmental programs and methods pertaining to Puerto Rico related?

ar applicable to the problems of geographically huge countries as Brazil. The main thesis of the entire discussion is that the great imperative in Latin American development is education, education that is pushed to a high level of excellence and competence in all phases of intellectual life, but especially in science and technology. The main job must be done by the citizens of the countries involved, but the first seed must come from without. There should be an opportunity for advanced students to observe at the operating level the advanced technology which they are studying; and the circumstances of that demonstration should be as closely related to those of their own countries as is possible. There is little doubt but that the recent history of Puerto Rico, after allowing for the important differences, exhibits many of the same perplexities that now are becoming crucial in South America. With its mixed racial origins, the Hispanic derived culture, its original reliance upon primitive agriculture, its insular character and tropical location, it is a microcosm which contains many of the most difficult problems that Latin countries have to face. In addition, it possesses 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. ---Page Break--- 28 While the solutions to problems of Puerto Rico may not be directly applicable to those of other regions, the situations are 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 Rico 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 practical 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 Nuclear Center, pointing the program to graduate and post-doctoral studies 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 scientific advancement rather than on numbers. A significant and vigorous research program was obligatory and this has been progressing rapidly in development with the research projects being pointed at problems of direct 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 together with all of the other factors that are the problem. Thus he learns about reactors, their design and operation and the economic and engineering problems that could be solved. Practical power production is to be gained. He conducts his studies in an environment where he can observe a power system which exhibits a high level of efficiency; hydroelectric, fossil fuel, and nuclear power plants are all subject to the same baselines and all feeding into the state power grid. He can observe, if he wishes, the interrelations of various electrifications, commodities, and agriculture, along with unsolved problems and in some instances continually with the same dilemmas that he faces in his own country. The Nuclear Center thus does not attempt to tell the visitor what the solutions to his country's problems are.

developmental problems here; rather he participates in a Puerto Rican effort to solve what are essentially U.S. problems. In special cases and where the circumstances are favorable, the visiting scientist may work on a scientific problem of primary importance to his own country, rather than the exception rather than the rule. The concept of “training” has been extended to a much higher level of performance than is usually meant by the term. Graduate education and its associated research become in themselves training at a mature level. In the process, the student is stimulated to think of 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 continuously for graduate students and will continue for a considerable period of time into the future. At the same time that the level of performance in training and education was raised, 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 that 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 training and education with the other portion being concerned with advanced research. A condensed progress description is given in Appendix 5. All of the research is directed to matters of concern to the United States and to the immediate Caribbean region. Among these activities are those devoted to developing knowledge concerning the lens.

term effects of radiation and fission products are similar questions pertaining to the cycling of radioactive elements in tropical forests, questions which are intimately 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 radiotherapists for the treatment of cancer opens up unusual opportunities for significant research in this area. Puerto Rico, for reasons unknown, has a very high death rate from carcinoma of the esophagus and the cervix uteri, with a strikingly low rate of malignancy of the testis. The organization of medical and health services permits ready access to the entire population for studies which, while important to Puerto Rico, would be relevant to the situation in other countries,

especially the United States. (See Appendix C). As the result of these program developments, the Nuclear Center is now in such a state of balance that it can readily respond to a change of emphasis as desired; that is, it can intensify the graduate education activities, or it can exert more drive in the area of primary research. The point is made here that policy choices need not be forced by the limitations of circumstances but rather should be made in terms of national and international needs and policies. PROGRESS OF PRI IN RELATION TO THE FIVE YEAR PLAN In February 1961, an analysis of the Latin American needs for training and education was made the basis of a five year plan for PRI. The text of this is attached as Appendix B. Program development has rather closely followed the plan and most of the specific projections have already been implemented and, in some instances, have already advanced beyond the level contemplated at the four year point. The scientific progress has generally advanced well save in Agriculture. There have been serious handicaps resulting from the inability to expand the physical plant in phase with the program. The lack of

Space has been partially offset by the generosity of the University of Puerto Rico in making available a number of laboratories for the several purposes. As graduate programs have come into operation, there has 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. ---Page Break--- AIMED AT FOC ---Page Break--- ---Page Break--- xB as PRC will develop as the institution of excellence and as it becomes a reputation for academic excellence. Personal betterment, along with the universities of the various countries, visited by staff members to leaders of departments of leading universities in Latin America, is indispensable for developing mutual understanding and cooperative interchange. It would result in a revision of the Five Year Plan, a 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 were 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 Biology. The fed schedule. Solid State Physics program is about on the antiquity. We now are moving toward a joint KIH-ABS cancer program which will be much more broadly based than that outlined in our original plan. Puerto Rico should become one of the major locations in the United States for cancer research. Although the Five Year Plan stressed the development of research, it was essentially a program for education and training. Table II shows the operations and equipment cost projections with which can be compared the actual costs for the respective fiscal years. Tt ---Page Break--- Oper. Equip. Total oper. Bui. Total Oper. Equip. Total TABLE II Comparison of PRNG Costs with Five Year Plan

Projections Program 07 Training and Bau 11998: Actual - 119,068 - 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 ---Page Break--- 37 ‘TABLE IIT Comparison of PRIC Total Costs with Five Year Plan Projections ‘ALL Programs: 05, 06, and 07 ‘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 (Est) 69 (Est) ---Page Break--- 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. On 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.

---Page Break--- It is suggested that Program O7 should hold at approximately this level until further experience has demonstrated a definite need for additional expansion. CONCLUSIONS AND RECOMMENDATIONS 1. The utilization of nuclear energy is an essential, and in some instances, a critical factor in Latin American development. To the extent that the United States participates in this development as a matter of national policy, the nuclear energy activities should be pursued at an appropriate level. 2. The necessary base for technological development in Latin America is a great acceleration in education at all levels with a rapid strengthening of the sciences 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, forms a complex with industry and both may be greatly benefited through the introduction of nuclear energy. 5. The Training and Education Program of the nuclear Center 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 forthcoming from the operation in the tropics. 6. Programmatic research should continue its orderly development to the extent dictated by the national interest. The investigations should be those unique to a tropical environment or those whose nature indicates that the tropical location of PRIC can confer a definite scientific advantage. 7.

the primary mission of the Puerto Rico Nuclear Center should continue to be in relation to Latin American development, but the doors should be opened to a greater extent to advanced students from the United States. To the extent that it is AEC policy, the same consideration should be extended to a small number of nationals of other countries. In conformity with the policy decisions, the physical plant should be amplified to achieve greater efficiency and coordination. The University of Puerto Rico should continue to serve as the operating contractor and be encouraged to maintain the pace of university development in the sciences that it has recently demonstrated.

The integrated medical services of Puerto Rico and the unusual frequencies of some forms of cancer establish an attractive opportunity for cancer research in cooperation with the USA. The Five Year Plan, written in 1961, still constitutes a reasonable statement of program objectives. The Training and Education activities have not reached the full level projected in the plan but generally now stand in reasonable harmony with that plan when special research is considered.

ADVISORY COMMITTEE FOR BIOLOGY AND MEDICINE to the UNITED STATES ATOMIC ENERGY COMMISSION Washington 25, D.C. Box 1823-U.P.R. Station Ro Piedras, Puerto Rico October 6, 1950 Memorandum To Mr. John Mstone, Chairman From: The Advisory Committee for Biology and Medicine Subject: The Role of Nuclear Energy in Inter-American Development The renewed crisis in Latin America demands a 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 human terms. Without a substantial augmentation in man-year output, there can be no real improvement to 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 it must be spent according to the gospel of the G.A.O. is stultifying and self-defeating. The idea of the Committee suggests that a new approach is needed. Clearly, the ABI cannot revise America ---Page Break--- a "heaven the loaf" 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 informed 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 genuinely powerful tools 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

anong the most crucial. ‘The contribution of nuclear energy has 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 at a much more desirable pace except in special areas where it can contribute economically to the prompt utilization of proven methods that 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. 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 university responsibility. In the meantime, however, certain aspects of existing outputs can be made better in the quality and effectiveness of educational systems. There has been sufficient experience in the U.S. to suggest that special training for high school science can be made highly

successful through collaboration with university science faculties. Such a collaboration with emphasis on nuclear science could be supported during the summer recess throughout Latin America. The course content and the pattern of organization have been established and but little alterations in national systems of education have been accomplished by providing access to programs. Much can be achieved for study within such a program, as a university could have one or two aspects of study in an outstanding department of education in this country. A program of nuclear education in Brazil for five years at the postgraduate level is needed for advanced studies.

Those who have taken advantage of the resources in their own countries should expand existing programs with their terms of reference. The program systemically lists, there should be proper relationships for cultivating U.S. graduate universities at the graduate level. Activities should bring about a program in university science faculties, and improvement will not take place unless significant changes take place in university structure. Adjusted salaries to permit investing in research, stability of tenure, 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 postgraduate studies. The encouragement of national research and educational councils could facilitate the organizational changes which are necessary.

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.

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 human 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 humans 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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B. Plant Breeding: Generally, the work of the plant breeder is directed to achieving the most satisfactory reassortment of existing genes and the pace is determined by the growth characteristics of the plants. Entirely new characters, or mutations, 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 gained, the second step could be the adaptation of plants with desirable features from other parts of the world and from different 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 is there 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. Radioisotopes are indispensable for these studies and may be the only means by which some of the problems may be resolved. ---Page Break--- 48 Of continuing activity in this field is activation analysis which enables the rapid estimation of extremely minute amounts of many elements. The technique requires a source of neutrons so that this must be carried out in those contexts possibly. Winter Resources. The study of the water resources of a country including underground storage and movement may be greatly facilitated by nuclear technology. The measurement of natural tritium is of great value and may directly indicate the degree of dependence of underground supplies upon local rainfall. Radioisotopes such as tritium may be added in small amounts at critical points to volume of underground flow. becomes an adjunct to other delineation of the water resources of a country, a study that is essential for intelligent planning of agricultural, industrial and urban development. Medicine: The greatest single contribution of nuclear energy to clinical medicine and public health in the next decade will probably be 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 nutritional in origin while the basis of others is completely obscure.

Procedures involving the use of Seis and tagged organic compounds must be moved from the research laboratories to clinical practice as 'rapidly as possible.' This requires the closest of collaboration between the nuclear centers and those of medicinal and clinical research. Areas of interest in which nuclear science may make significant contributions include, for example, radioisotope tagging of mosquitoes in their natural environment.

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. While one must be prepared to accept delayed returns in this field, 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 developmental plant was a particularly happy one as a first step in a sound Latin American program.

Method of Operation

A developmental program for Latin America should presuppose the active financial participation of all the associated countries. Inevitably, it would fall to the U.S. to carry a large share of the financial burden. It then becomes tempting for 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 American States in the long run leads to the greatest degree of real cooperative endeavor with the preservation of national dignity. 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 scientific development and for the improvement of education. The program operations of these agencies should be based upon common philosophy and should move along lines that are mutually reinforcing. Finally, we recognize that the scientific development of a country must take place within a sound sociologic and economic structure. Forward planning must take cognizance not only of the aspirations of people but also of the resources which nature has provided. With the studies of resources for the future must be coordinated those of population trends. The achievement of a favorable distribution of population is vital to intelligent planning. Human health and happiness may be vitiated by excessive population growth on the one hand and gross underpopulation 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: Recommendations: To advance the purposes of Inter-American development, we recommend to the Commission that it: recognize the potential contribution of nuclear energy to Latin American development in scientific fields vital to economic progress and human health; 2. tie the monitoring by the U.S.

Government of a strong developmental program along lines set forth in this memorandum; 3. Invite the consultation of experts under the aegis of the Inter-American Theelar Energy Commission to determine the specific objectives of a program of economic and scientific development and their order of priority; and consider the desirability of assigning the operating responsibility to the Organization of American States. Respectfully submitted, John C. Bugher, Chairman H. Bentley Gla Fred J. Hodges James H. Horsfell Robert Loeb Leonidas D. Marinelli Carl V. Moore James H. Sterner Herland G. Wood ---Page Break--- 1 APPENDIX B FIVE YEAR PLAN 1, Recoverton The Puerto Rico Nuclear Center, operated by the government of Puerto Rico under a contract with the U.S. Atomic Energy Commission, was established in October, 1957, as part of the Atomic for Peace program. It grew out of the proposal by President Eisenhower on July 22, 1956, at the Pan

American Conference, that work be initiated to “hasten the beneficial uses of nuclear forces throughout the hemisphere - both in industry and in combating disease.” The main objective of this Center is to serve as an effective teaching 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 Nuclear Center is bilingual with the courses predominantly 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 of Latin America today not only read English well but also possess reasonable skill in speaking the language. The Center operates on the three campuses of the University: Mayaguez, Río Piedras, and San Juan. At Mayaguez, near the campus of the College of Agriculture and Mechanic Arts, are located the reactors and

associated facilities for instruction at the Master of Science level in Molecular Science and Technology, Health Professions, and Agriculture ---Page Break--- Structural Biosciences. The expertise in plant physiology and radiation genetics. At the Rio de Janeiro and San Paulo campuses, the program is medically oriented in great part. However, training in biotechnology technology is also given here with increasing attention to radiochemistry and physical chemistry, in the medical field, the primary emphasis is upon new methods of diagnosis and treatment and 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 effort to widen there is a constant improvement in the quality of education in science and in research in the leading universities has been generally, so the T.B. Tosa | Uatia knvica has been extended towards Topes, and for Literature and the arts this is still true. In the way newer, the association with the U.S. has been much accepted especially in recent years. The progress in the quality of education in Latin American universities has a postal impact on those scientific centers and institutes that are stated - Mexican presume 10 of the ---Page Break--- improvement in proportion of their offerings so must leave the time and devote themselves to graduate education and research. This is voluntary organization is not a single reformation. As the chemist relinquishes the more elementary sort with more advance: Scientific Lexi in a number of the Persp? where in Brazil and Chile there is totally a significant group of young geneticists of high competence as robust strength across countries, at advances in public new the genetic outcomes have been achieved in South America. The worldwide context continues to concentrate largely based on technology developed in South. Substantial competence already had graduate chemistry in Brazil, Argentina, and Chile. Certain characteristics of Latin American universities operate to

retard scientific development, eop which are Amdacantaliy mlthisecig inary sional schools ndunte education malty Wave sine provision fer poe bat it fe the ant oriented prograa off grauusie otaline ---Page Break--- oh In order for Mull progeeas tn setence to be achieved, certain changes must take piace in the rusture of nost Eatin American universities, Alequate conditions to permit ‘ull tine teaching and research are essential. There must be fim standards of stufent selection and linitation of enrollment, with strong adnintstrative authority in mature ant responstble hands rather ‘than in those of an adolesseat etulent body. Most of the Latin American universities require sone degree of reorganization to provide the cultural and scientific basie for profesetonal eduestion and to establish the atmuetv of post-graduate studies. TET, INTER-«MERICAN COO=ERAN TM ADVANCING THE USES OP NUCLEAR ENERGY ‘A cingle center auch as the Puorto Rico Thxclear Center camot function properly without reference to the needs sud resources of Latin anerica and without close cooperation with other scientific centers in the various coustrice, Maclowr getence must find tte

proper place in the porspocttves of setence tf 15 1s to make tts full contribution to the goreral welfare. Tn a recent report to the U, 5. Atomic Energy Com its Mvisory Committee for Blology snd Medicine said: telear scterce can play a definite part 4m accelerating the pace of develeppant to a urate with tne development of che oa Of each 0 Mere on je uniguely yowrrtul tools thick in the Io cf the uygest nay dewmatioally compress ---Page Break--- $5 the tine seals o? mucus progress. In the ghovt Vine thet sickowr asengy nas oeen availarle for poaceftu develowwrt, only the mast euperticial application of thea mmatkable tools had teen atteeyied, uspactally In agrioulivze vhere latin Anexiear ieods arc mung thy moat orurial Ghe coutstbuttoy of suelews snangy be thus geen to te a vury tral une in a geweral upgrading OF sebecse an Slogy. ‘Teiing Tatin America as Bvnole, ty

azar af top priority for meeting is our signature and negligence with nuclear more elaborate care whom Itese sontribute utilization of proven approaches are 2 The event are: field of ‘progress have in the heretofore “wat Ps valve. As store Lvized ¢ Beane Toeaite east be and those are likely to show are different of education is the various countries,” Not only are there a carbe of stag certification centers to Latin news 12 of nuclear studies already extol, Containing acne the latter are the Institute at the Onby soxnat smaller program at the atv can Atonte Energy Vonatssicn, in asacotwiten ulin the Cavezesty at Bvenos Anes and ‘the Instat 2 substantial ‘A small reactor ped. At Swe Paulo, associated research Atvisiona pig, wd hulsgy. Mess Gerais hae a ---Page Break--- % pool reactor of 100 Kijevatts and is developing a graduate program around 11 with participation by 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 iaywel) are used in quantities in practically all of the universities south of the Ro Grande. A variety of accelerators are in use in Mexico, Bra, Argentina, and Chile. As the effort of its kind on the part of the U.S. outside the continental borders, the Puerto Rico Nuclear Center is neither the first nor the largest of such institutions in Latin America. At, theny © the long range mission? Clearly, a vast expansion to make it another regional laboratory would be advisable in a governmental unit as well as that of Puerto Rico. Neither work! 2 yoriticn of the 0, S. for the center in Puerto competitive competition with similar countries. 1st look for Somtues wherein the FIC may be distinctive and will 44 can git substantially to the total scientific resources of the As we to mind at once, Puerto Rico ea, the climatic zone where so many of the dere ere ave to ve found, With the exception of the axa: ‘civera!t? Lovantue in the

Congo, PRC, the Indies Institute in Venezuela are the only research centers in the tropics where neutrons are available in ---Page Break--- ST. Second, Puerto Rico is not only in the tropics, it is an island in the tropics, and it presents sharp ecological boundaries which greatly facilitate many phases of agricultural and medical research. This variety of fauna makes it possible to approximate the climatic conditions of much of tropical America. Third, Puerto Rico presents a model of rapid Latin American development. Health services and sanitation actually exceed in quality those of most of the states. The so-called "illnesses of the tropics" are either being eradicated or rapidly approaching termination. Social and industrial cooperation on a planned basis are world-famous. The standard of living exceeds by far that of any Latin American country, closely representative of those found in other Latin American areas that experimental results obtained in fields have direct application in other countries. From these considerations, it would appear that PRIC should function cooperatively rather than competitively with the other centers in Latin America. It should be an institution preoccupied with the problems of the tropics which, by their nature, must be solved in the tropics. However, it is unique in the Western Hemisphere that it shares only with the United States that possesses an enormous advantage over the latter in that it can call on the nation's laboratories and the universities of the U.S. for support. PRIC enjoys a depth of support unmatched by any

other national center in the former U.S. territory, the Puerto Rico Nuclear Center ---Page Break---38 may be regarded as a unit of a Pan American network of scientific development and research which should take a primary interest in those major problems which have special tropical reference. Similarly, the other centers and institutes should be expected to give their most active attention to issues distinctive of their regions. No 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 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 to 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 case, ‘The rapid progress of higher education in Latin America and the flow of graduate students to scientific 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 education is not needed in the current context; it would also increasingly attract less prepared graduates. Gradually the position of FRYC would be established as one of inferior quality, incapable of meeting the needs of students coming from the better universities, particularly these few South American. To maintain its effectiveness as a regional center, FRYC must achieve scientific and academic distinction in the fields in which it can operate to the greatest advantage. This inevitably means a sort of emphasis for purely technical instruction to a post-graduate curriculum associated with a strong research program. The goal is wide. FRYC shows potential in areas in which there is significant interest for the advancement of knowledge, medicine, and agriculture, oriented to the tropics, major areas of professional activity. However, graduate saturation and research in these fields can be prejudicial without strong provisions in the

physteel sciences, biotechnology prescient as a vadiostatary and indispensable to the effective development of this bioethical research. Consequently, an 5 of FRE activation on a core Front ho Initiation Le ts by achieved © ts now a large in relatively weak; certainly 90 of the Ha au they have been cot search activity has been in the Medical School.. + the physical sciences, the reasons here; but the fact is basic ---Page Break--- 60 to the forward planning of the PRC programs. ‘The UFR faculty cannot supply all of the scientists with the advanced academic qualifications which are needed. The development of strength through the training of young Puerto Ricans in U. S. institutions would require several years delay which would be fatal to the objectives of HRIC. ‘The path to follow by necessity appears to be that of strengthening the scientific staff by recruitment from outside Puerto Rico, chiefly from the U. S. universities but also from other countries where suitable candidates may be encountered. At the same time, advanced training of young Puerto Rican scientists is essential for the future. How many recruited from outside Puerto Rico will probably be temporary but some should be willing to identify themselves permanently with PRIC. Obviously, such individuals must be acceptable to the University as tenure faculty members if they are to be considered permanent members of the academic community. In any case, service on a leave of absence basis of less than two years would not be generally productive and there should be a reasonable prospect that the visiting scientist will continue their association as part of their activity in his own university. These requirements in the university framework apply equally to those

whose actual years are in the national laboratories or other special research institutions. There should be a special emphasis on the national laboratories because of their complete identification with the intended program. ---Page Break--- 8 on the Mayagüez campus, there is a building with approximately houses

the resource mately 39,009 square feet of floor (000 square feet for reactor and the laboratories. k groundhouse of 14 vita the necessary features for avon has been constructed by taoplen, ko wasidinry pallding of low-cost construction 1p Wied there stor und teaching activities for Station ta TY-62 or Sn tnadequate space fs plawas for early F-62. cre cossareh reactor. A ‘The Largest employ of squtpeen ob typi) this wanter is presently operating at one megawatt, but it ane 1) to raise the pumes Inter to flys mgawatta, Tt is 4 vas for saximar flexibility ant reas ali fe: The second reactor tH 4 JO-watt aguecas hencgensous Typs aad has proved Aevabias ouster operators and for teaching the principles fs eraphitesnataral usanfun subcritical phew the reactor physics ompion of may work with saterdals the Iatorstoctus ary wil app oth lew acd tlgh levels of vaifuactivity. Thene are fully equipped ey ant physics. 8 gw incorporation for math: Station Pyectie tidy of radiation effects fest for tetearch ---Page Break--- he fo Fletrae location, the various programs are to be housed in a building of approximately 22,200 square feet floor area vn tion. The new structure is part of the te now x ‘comp Puerto Rico Medical Center now unie~ development and is close to the Few Concer Hospital and also conven! University Hospital woe land other units of the growing Kidscat Center. A ual? amount of space will still co be at the Medical School in San Juan ane in the school of Natural Sciences on the main campus. Major AFT equipment available to the San Juan-Rio Piedras programs consist of a compists radiotectope training laboratory, an 6,000 carries 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 ne Radiotherapy and Cancer program utilizes equipment: In addition, the following equipment which the omel ty the Dr. T. Gonzalez Oncological Hospital: . Potattocat, of approximately koe curse erherspy obait-60

Two deep therapy X-ray units for superficial therapy X-ray treatment. Approximately 700 milligrams of radium in the form of needles and cells of various sizes and activities. The use of the above equipment by the Radiotherapy and Cancer Division is strictly dependent on the workload of these units as seen in the accompanying chart. The program functions under a Director and two Associate Directors, each of the latter being primarily responsible for one of the geographic sub-divisions of the Continent. The Director reports to the Chancellor of the university through the Dean of Medicine in matters pertaining to the Mayaguez-San Juan campuses and through the Vice Chancellor in matters concerning the Nayeque area. The major programs are represented by Divisions, each with its respective Head, which is responsible for the operations in the program area. To an increasing extent the programs will tend to involve the entire center and measures must be taken to offset the distance imposed by the separation of 100 miles between the two halves of the organization. Where communication is imperative, plans are underway to improve this part of the process. The existing telephone service is inadequate. Part of the communications lack can be remedied by a microwave beam installation covering telephonic teletype, along with a provision for data transfer but to that full advantage can only be taken which the University is piecemeal.

The present programs of the Nuclear Center at Mayaguez comprise a series of courses of instruction which lead to a Master of Science degree: The Delusles Goiense and Engineering Program: The PRG offers a full curriculum leading to the degree of Master of Science in Nuclear

Technology. The course of study starts with the summer session and

requires one r The curriculum: clear objectives and engineering follow- 2 bows approved by the Contestation for these fellowship holders. The current program 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 associated chemical with metallurgical processes. This program was first given in 1959-60 as a leading to the degree of Master of Science in Radiological studies. The curriculum is designed to provide the fundamental knowledge in radiometry, instrumentation, and the principles of permissible exposure and prevention of undesirable exposure. The students are also introduced to a great deal of the legal and public relation aspects of radiation protection. Now the Division has presently developed programs which the prospectuses have been formatted in close with Agriculture. It is expected to be an important channel ---Page Break--- as we move toward radiostore logical research activities of the Division have already been initiated with the equipment currently available. A preliminary study of the effects of neutrons and gamma radiation on a taker of tropical plants, both as seeds and in the vegetative form, are underway. Irradiated fuel assemblies being utilized as high intensity gamma sources. Other studies in plant physiology are being conducted in cooperation with the Federal Experiment Station at the University of Puerto Rico Experiment Station, Rio Piedras. The programs are directed mainly at utilization and training, and medical and biological. These programs are as follows: one program: This technical course patterned after a similar course offered by the Oak Ridge Institute of Nuclear Studies. Its course permits scientific and technical personnel to obtain training in the use of radioisotopes for clinical radioisotope applications. Fresca: Grants in a training program in training and research in the clinical applications of radioisotopes for diagnostic and therapeutic purposes. 40 kinds of programs are offered: a short term program.

Withe my last one of two comments and another long term program which was lagged from three months to 8 years. The alert ears take more common along. The stresses in the long course therapeutic and research aspects of radioisotopes in clinical medicine as well in the diagnostic procedures are addressed. After the Ceais radioisotopes techniques course has been successfully completed, two years are spent at the Clinical Radioisotope Laboratory in a formal program of lectures, seminars, and practical work. Radiotherapy and Cancer Training Programs aim to teach physicians the safe use of ionizing radiations in the treatment of cancer. Two types of procedures are particular to 3 years or longer, 43 three-year late tasks required. Treatments are to determine the mine the routine for tumor, plan care using radiation alone or in a Math therapy method, carry out and polling to determine how they are taught to, ole Sutnina: postlame associated is also broom votations. The pre-analytical processes and consultation are the essential chemical molecules. Involving particular reflections termed, a total yet creating. (Detailed fare chow: the tent, OL are Moon 36 countries in training in the Radiobiology Division has been limited to the use of facilities by nine (9) radio school students to do specialized experiments in biosynthesis of radioactive sulfur components by yeast and the incorporation of radioactive phosphorus into the phospholipids of different tissues of albino rats. These experiments were performed under FRUC supervision. Training by this division has been limited by the illness and eventual resignation of the division head. YL, FUTURE DEVELOPMENT AND EXPANSION 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 a ‘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 --- The Mayagues Program The Reactor Division is basically a service division in charge of the physical plant, running the reactors, hot cells, gamma sources, and irradiators according to the needs of the other divisions. Also, it provides technical advice, and the reactor supervisors must know how a reactor works, how its performance can be maintained and improved, and 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 Nuclear Science and Technology Division for maximum effectiveness. It is evident that there are many possibilities for suitable research, development, and testing programs 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 ---Page Break --- 70 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 7RIC, 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 circuit characteristics and operation, approach to criticality, control rod calibration, pile oscillation, void reactivity, etc., will be developed for 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. 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 facilities for these curricula; and the development of research programs. The nuclear sciences and nuclear engineering are presently in one division. Such a grouping becomes advantageous as the division expands into the various activities with which it is charged, although this is an acceptable expansion during the initial establishment of the Center.

3. Health Physics Division: It was recently determined under Nuclear Science and Technology that Health Physics has now been given divisional status. In its relevance, it reports to the Director and is responsible.

for health and safety of ‘the operations of the Center: reviewed for proper safety. We are and direct

assistance in operations are coming from the stage of the service Division. The previous practice of contracting out some of the health physics operations is being discontinued. The Health and Safety function may be completely seen within the organization of RIC. Otherwise, it would be impossible to maintain the ability to respond effectively to an emergency situation. In its teaching and research functions, the Health Physics Division will function as do the other divisions. The students part of the training of the 2 will be given at the Medical Center where the students WILL become more proficient with the applications wherein patients must be given appropriate radiation exposures. 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 Rincon region before operation of the Bonus reactor. Curricula: the Center at Bayamón has offered two curricula leading to the Master's degree: a Master of Science in Nuclear Science and Technology and a Master of Science in Radiological 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 looking to attend the Puerto Rico Nuclear Institute. It is proposed to substitute the following degree programs, all of which would require the same total number of semester credits for the master's degree - at least 30 and not more than 36. Each new education requirement appropriate to the field of specialization would require a portion of the total effort to be applied to a special project, thesis, or design problem, as appropriate. Moreover, in a manner similar to that of most proven graduate schools, the curricula would be about one-half specified and the other tailored to the individual needs of the students.

Joopaniize cur gathovlzstion to accept ABC special fellows in ved see ard Technology or in Radiological Inysles, but ts @ change in the same direction as recent changes to the requirements for these fellowships. The curriculum would start with the upcoming semester and would, for the normal student requires full-time work and education until the end of the fellowships. ---Page Break--- B preceding the regular fell admission would be available for the fulfillment of satisfied admission requirements, a Master of Science in Health Physics: This will be quite similar to and will replace the present M.S. in Radiological Physics. The change in title is in line with recent actions of both the Health Physics Society and the AEC Committee on Health Physics fellowships. Master of Science in Nuclear Engineering will be quite similar to the offerings in many U.S. university graduate schools; it will acknowledge the particular engineering bias of the candidates for admission and will allow the student to specialize in aspects of nuclear engineering related to their undergraduate training. For instance, the applicant with a Bachelor’s degree in Chemical Engineering would logically continue specializing in the chemistry and technology of nuclear fuels. The electrical engineering candidate would specialize in reactor instrumentation and control problems. Master of Science in Reactor Physics: This will be designed for students interested in the applications for the operation and application of research and training reactors; it offers from nuclear engineering in many significant ways. There will be some emphasis on reactor physics, the dynamic behavior of reactors, the electrostatic aspects of reactor instrumentation, and the instrumentation of problems associated with the use of reactors, teaching is becoming more important as reactors become numerous and varied. A course in Nuclear Science: Tailored to meet the broad spectrum of students interested in various aspects of the biological and physical sciences. The degree will carry a

specification of a major in a given topic, such as Advocacy, Nuclear Physics, Radiation Biology, Radiochemistry, etc. ‘The curriculum will particularly undercut that, but will require those common to all of these areas, such as Health will be designed to fit with the background of the student. Courses will be academic departments of the ---Page Break --- will include a 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 by any means a proportional increase in teaching load. Many of the courses will be common to several curricula. By means of these research, design problem, or special project, the students will in turn contribute to the research program of the Center. San Juan-Río Piedras Programs 1, Radiotope Techniques Program: In the Radiotope Applications, the needs for training in Latin America should increase due to the present trend and emphasis being placed on the use of radioisotopes in medicine, industry, and agriculture. Along with this increase there must be an increase in the number of persons trained in the uses of radioisotopes. It is evident, therefore, that for the Radioisotope Applications training Program we should a, 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 c, Introduce specialized courses in the basic techniques as applied to industry, agriculture, and clinical diagnosis. ---Page Break --- 5 4. Prelude research programs In support of the above training and services to the lines of interest of the staff. "Such research could very generally encompass the use of radiations for sterilization and

Chesca processes the explanation of radioactive isotopes in the teaching of basic principles in chemistry: and the application of particles accelerators in physical or chemical research. Radiotherapy and Cancer Programs: It is felt that the Radiotherapy and Cancer programs, more than any other FRIC programs at present, have been generally accepted in Latin America and have had the least difficulty in attracting trainees. The usefulness of this program for Latin America can be seen by the fact that to date there are no created training programs for radiotherapy in Latin America, yet those countries are facing a constant increase in the cancer problem. The Radiotherapy and Cancer program is based on the need for training individuals in cancer centers within their own countries. The Radiotherapy and Cancer programs are based on the training hospital for those facilities which are practical to duplicate. Such facilities include clinical laboratories, patient wards, the departments of medical imaging, pathology and surgery, and rehabilitation facilities. However, therapy units are necessary for training in the "RE" building. Trainees must be familiar with operating various types of equipment, including specialized apparatus such as accelerators. These units would provide the protection of several beams of radiation and cover the necessary energy electron beam therapy. Such a setup would enhance the training and research potential of the Center in radiation therapy, radiobiology, and radiological physics. The current research programs in the evaluation of radiation response of tumors to conventional and supervoltage modalities by cytological techniques will continue. New programs to be started include tumor and tissue culture studies, effects of pharmacological 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. Clinical Radiotracers Program: The increasing use of

Radioisotopes in clinical medicine also makes the Clinical Radioisotope 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 may have many more legitimate requests for training than can be accommodated. It is expected that there will be no major change in the training program of the Clinical Radioisotope Division in the near future except to introduce new

techniques as they are developed or proven. The research potential is good and the current research projects in vitamin B12 absorption in tropical sprue, fat absorption in dyspeptic patients, and iron metabolism in various anemias will be continued. The activities will also be expanded to include pediatrics, obstetrics, urology, and gynecology in addition to medicine. ---Page Break--- Additional equipment required for the instruction in new and existing techniques in clinical medicine will be procured as needed. The Radiology Program will be activated as rapidly as consistent with other program demands in view that it may be responsible for the teaching of the principles of radiobiology within medical programs. The interaction of various modalities of radiation with living systems, both acellular and multicellular, will be presented in considerable detail; 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 operations. Both the genetic and somatic effects of mutation at various stages of organization will be considered, and it will require a considerable amount of work to prepare to render a number of service functions to the other Divisions of the Center. Among these are: vital sign monitoring, ultraviolet and infrared spectrophotometry, tissue culture, statistical consultation, and microbiological pathology.

services. 5. Medical Sciences Division activated in the new structure aims to provide the broad coverage in the medical field not now covered by the existing organizations and units. The Clinical Radiotoxicology system is primarily concerned with the problems we face. There are four forms of clinical application of cotah!vehod proc ---Page Break--- 8 'the Division of Medical Sciences to conduct those special studies 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 Radiotoxicology operations Division. 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. First among the fields to be considered will be tropical nutrition. As infectious diseases are overcome, the more abstruse aspects of nutrition become progressively more important. Gross malnutrition is generally recognized as an outstanding problem among primitive tropical peoples but the structure of nutrition in the tropics is not at all well understood. Biochemistry, especially that of enzyme systems, must play a major role and must include an examination of the dynamics of trace elements, a more present-day knowledge in fragility. The Division should also concern itself with the tropical, parasitic diseases prevalent in Puerto Rico, and attempt to devise new attacks against those with the objective of eradicating them. Foremost in the list is schistosomiasis, which not only persists in Puerto Rico but elsewhere as well. It has stubbornly refused to yield to the existing public health and sanitation techniques. New approaches are needed to address this problem, and it is possible that useful answers will be found in the biotechnological approach. ---Page Break--- 9 'these are examples of problems of high priority which await the activation of the new program. Further study of

the radical patterns of Puerto Rico will doubtless disclose numerous other disease entities that now suspect 14. Among them, one can anticipate, will be a 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, certain 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 emphasize 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 biological 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 medical 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--- 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% follow-up of cancer patients, and through the Regionalization Program the quality of this activity may be substantially improved from the standpoint of medical records and investigation. ---Page Break--- 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, essentially 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 that there are unusual frequencies of some types of cancer, make a program of clinical cancer research especially attractive described in some detail. In addition to the research program detailed in the proposals of the Division of Radiotherapy and Cancer, there is the opportunity for an advanced study of chemotherapeutic compounds as adjuncts to radiation therapy and surgery. This would involve the synthesis of such compounds tagged with

O-I4 and tritium, found in some instances with Pa32 and S935. Tissue distribution and the metabolic pathways of the compounds in human beings would be compared with that in tissue cultures of neoplastic and non-neoplastic cells and to a limited extent of laboratory animals. If the in PANG and the Medical School, then these studies should be extended to the steady flow of leukemia in children's ants would sum to the Medical Center and the Ganser Hospital if there were a 2 Le encouragement. Still another line of investigation which I already incorporated in the progress plan is the experimental study of the use of ---Page Break--- 83 neutron capture reactions in neoplasms. It is not presently contemplated to use the reactor for man therapy but rather to confine the study to transplanted neoplasms in small laboratory animals. This part of the program would function in close collaboration with the Medical Department of Brookhaven National Laboratory. Agriculture is an area wherein the Nuclear Center 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 attention 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 character. Photosynthesis, enzymatic conversions, electrolyte and water movements, cell respiration, and the physical chemistry of inorganic systems of low solubility are just 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 consequence 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 science title problem. ---Page Break--- 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. This would presume cooperative operations with the various experiment stations, 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 is abysmal. 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 in the present absence 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--- Because of inadequate staffing 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 may be made. While 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 prospects 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. ---Page Break--- 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

engineering 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. The 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°, 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 development of activation analysis, especially in connection with the agricultural and medical programs. The reactor is admirably designed for these traditions. 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 quantities. This will be essential for the program in nutrition mentioned earlier. Some of the research programs would adequately arise simply because of great personal interest on the part of members of the staff. Research of this kind should be encouraged even though it could be conducted as well elsewhere, as long as such research is related to an energy 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 applied technology cannot attract good students nor hold superior teachers. Without a founded student dynamic, students' structure and character, the Puerto Rico Nuclear Center would not only fail to enhance the reputation of Goaters, it would fail more profoundly in its inability to meet the urgent needs of the region it should serve. In summary, the advanced research programs which have been discussed in this section may be listed as follows, together with the operating divisions of PRI that would be involved: Program Divisions of PRIC concerned: Human nutrition, Medical Bio-Sciences, Radiobiology, Reactor, Agricultural BioSciences, Chemotherapy and Radiotherapy of Cancer.

Radiotherapy and Cancer Medical Biosciences Radiobiology Clinical Applications of Radiotropes Structural Biosciences Nuclear Science and Technology Radiation Physics, Neutron Nuclear Science and Technology Distraction Molecular Reactor Structure Heat Transfer under Irradiation Science and Technology CATIONS In Table T (page 36) are presented 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 through FY-65. In the table, which begins with the date of assumption of duty by the present Director, the total variables are on the following pages. ---Page Break--- TABLE FRNC CSERAT: 58 THROUGH FY-60 956+ 5.1959 operations $119,068 $283,180 $467,500 Equipment $10,552 $206,193 $225,500 Total $259,620 $509,273 $692,500 Man Years per calendar year operations 7,079 $6,973. + 10/yr ---Page Break--- 000g 00st 00g 00g, and Obn'd. o9"¢e ouste2 wu'te — yeeter one oe oze st ave ox ot st 3 rE 5 B oo w $6 06 % a 9 we s f o 9 % im s00%oz0'z on006g*T o00%0S).4t 00%o0TT o00%O0L"T Deproar—auTaE——_caUTOOT —_eaNFEOT 068 COCR 00%026*T 000'064"T 900'0S9‘T 00000'T oF 00652 000g str TSHR] postaou ponyTants tou poeTase — poremaeg po agri 99-4 HONOMID 19" SNOTIWNGEO Old SEMVIEISE GESTAD! AIMERIND GhY GEIVATISS ATSAOTAMIL 11 weve ---Page Break--- a manyear 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 a much greater proportion of the staff to 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 is 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 sometimes 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 consistently. 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 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 II, 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 reasonably 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 as a guide. One major piece of construction is shown to be budgeted in FY-63. This is an addition to the biomedical 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 available for the purpose and since site development has been largely accomplished in the construction of the present.

In laboratory, the cost of the additions is estimated at somewhat less than for the existing structure. Pending the availability of the addition, a temporary animal house is a necessity, there being no animal quarters in the present Nuclear 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 entities is the minimum for effective operation in as many scientific disciplines as PRIC is committed to serve. A very much larger institution would overbalance the University and tend toward isolation from the academic community. It seems reasonable to say, therefore, that growth beyond that projected for FL-66 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.

---Page Break---

% ATTEND PURSUED RICO NUCLEAR CENTER operated by University of Puerto Rico for U.S. Atomic Energy Commission August 2, 1963 Gen. Alvin R. Luedecks, General Manager U.S. Atomic Energy Commission Washington 25, D.C. Dear AL: Your letter of July 27 presents difficulties in defending the finance of the difficulty. The motivation for the original establishment of the program

in Puerto Rico 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, to a focus the essential aim of the Nuclear Center. Part of the issue 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 reason but not a

sufficient reason for the notion of a center such as this, I am more concerned with the problems and needs of the U.S in this context. I believe that there is a pretty good case which I will try to state. With the exception of Brookhaven National Laboratory, our major centers of research in the non-military aspects of atomic energy grew on the structure of the wartime and postwar weapons development operations. This was inevitable for economic and staffing reasons primarily. But one result has been that the greatest impact on science and industry of the atomic energy program has been in the northern portion of the United States. The scientific potential of the country, however, has no such geographic emphasis. We have a good number of research centers working on the agricultural, medical, and engineering problems of the northern parts of the country, but 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 the end toward which I have been striving to direct its activities. ---Page Break--- A few examples from the present program may serve to illustrate the point: 1. One of the causes of serious loss in sugar production, especially in Alabama, is the cane borer (Diatrea saccharalis). An appreciable portion of the crop is lost each year throughout the cane-growing regions, a loss that amounts to many millions of dollars annually. This 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, through radiation sterilization of the larvae, this moth whose larvae do so much damage, while I 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 government reactors and nuclear rocket propulsion on food cycles of the tropical seas. These cycles are quite complex, and the investigations of those in the sargassum zone do not substantiate. These operations are also yielding significant new findings concerning the geology of Puerto Rico and the adjacent areas. Of substantial, although incidental value, are the measurements being made of the total productivity of the ocean at various depths and areas. These figures, which indicate the ultimate potential of fisheries, etc., can only be obtained by the use of radiochemical techniques and radioisotopes since the basic measurement of the total photosynthesis per unit volume of the sea. The research reactor has made these measurements possible.

Biodiversity, Radiobiology of Tropical Forests marine studies, the new year is moving rapidly in quantitative evaluation of the effects of nuclear radiation on the growth and survival of forests in the tropics when subjected to nuclear radiation. This is the first step of a process: the Division of Biology and Medicine plans to extend to forests of higher latitudes. It is a study which is vital to predicting the ultimate damage of any ways program in Terrestrial Ecology.

The 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 intere. program, both NIH and the Controllable Disease Center of Firm! are cooperating with us in this work. 5. cancer and the Gnipies There are some minor differences in the frequency of certain types of cancer in Puerto Rico as compared with the contiguous United States. These special characteristics plus some resources make Puerto Rico a natural location for major research. A copy of a letter I have written to Dr. Badicott below for further information on this phase of the area; It is not generally realized that PRIC in its training and research activities in cancer carries 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 Medical Hospital, Colorado Springs. 6. Solid State Physics With timely support of the Division of Research, it's vigorously active in re-search dosing with molecular organization in the solid state, the program utilizes neutron and X-ray facilities at Mayaguez; and in (of Plotras, involves studies of activity as a measure of radiation damage in pure crystals of organic semiconductors. These programs are being developed in close cooperation with Brookhaven National Laboratory and, especially in the case of the neutron diffraction work, the establishment of a sound program in short time was made possible by the active participation of the Department of Physics of PM. This research is not related to problems of the tropics but the necessary resources and the 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, thus affecting both medicine and agriculture. 7. Radiation Effects in Schistosoma The parasitic infestation of man which causes so 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 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 seems to be becoming 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 weeks. 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 nore satisfactory position to discuss than one in which no

activity is present. Although not expressed in specific project terms, the location and the special mention 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 drawn 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 confidence that the best interests of all will have been served. Many thanks for your interest and help, and best regards to all of the family. Sincerely yours, Joba 2. Bagher, M.D. Director Encls: 1 Endicott ---Page Break--- 200 PUERTO RICO NUCLEAR CENTER Operated by UNIVERSITY OF PUERTO RICO for the ATOMIC ENERGY Commission Slo-Medical Building 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 Rio Piedras where the Biomedical 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 auspices 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 significant 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 the medical care of cancer patients; potentially they are also all research beds. Under the existing agreement between the Cancer Hospital and the Nuclear Center, patients who remain in the 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. ---Page Break--- a0 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 organization 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 subteam 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 Ill. 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 firsthand knowledge of the

Advantages as well as the difficulties in the evolution of a 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 a proposal may 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, as will 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 background information concerning the Medical Center, the Cancer Hospital, and the Nuclear Center. Sincerely yours, John C. Eugher, M.D. Director ---Page Break--- ---Page Break--- 3 ApPauDL: D cry LOWTNG NABRATIVE MAS THCLIDED ui Ia PR! PY-1g RIDGET semaissrom: ‘he budget proposal for FY-1966 for Program 7 is essentially identical to that originally submitted for FY-1965 and which in turn was the level previously planned for FY-1963. In the interim, appropriation actions have forced progressive cutbacks in educational activities, resulting in the drastic reduction of the program in FY-1965. All activities of the Program 07 are reduced but that devoted to agriculture will be practically suspended. The Division Agricultural Business is my well during the 2 fiscal year and a very proactive program has been in operation, especially in graduate education where it has attracted more candidates than before. The chief in this part of the grant dramatically is that it is the only division from which the grant can be moved into current special resource pivots. Since the divisional personnel are also members of the university, they are entitled to the same considerations as those pertaining exclusively to the University of Austin. The limitation of appointments for purely budgetary reasons could well...

encourage the components of the contract between the University and AR Tre, inevitably seen against the effectiveness of PRNC in its Latin American operations. 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 Biology 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 growing 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 addressed 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 addressed 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. 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 a 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 research programs are essential of the

scientific stature of PRNC is to 2+ of consequence; however, they do not substitute for the types of research activity which is vital to Program 07. Among the outstanding achievements of the current year are: 1. The successful isolation of the virus of dengue fever in the first outbreak in Puerto Rico since 1918. The virus appears to be a new type and one that 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 submarine 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. ---Page Break--- 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 García 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 borer (Diatraea 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 hand of losing the pool water in a reactor of the fuel type with U-235-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 and many other respects: The laboratory space which has been made available by other agencies in many scattered locations is approximately as follows: University Hospital 950 Sq. Ft. Cancer Hospital 800 Medical School, San Juan 1,900 Physics Dept., Río Piedras Campus 450 Chemistry Dept., Río Piedras Campus 1,800 Biology Department, Río Piedras Campus 500 Agricultural Experiment Station (U.PR.) oo Forestry Dept., (U.S. Forest Service) 2,000 Physics Dept., Mayaguez Campus 1,000 Chemistry Dept, Mayaguez Campus 500 College of Engineering, Mayagüez 2,000 Total 1,000 To this we can add Temporary animal quarters, Río Piedras 1,500 Temporary chemistry laboratory, Río Piedras 1,500 Grand Total 14,000, Total results in a fragmented and widely scattered operation but without this temporary space it would be necessary to suspend large blocks of programs. Director's office The Director's Office operates at both Río Piedras and Mayaguez with most of the staff being at the former location, Accounting and ---Page Break --- 108 procurement are based at Mayaguez. The separation of program and administrative activities results in a considerable burden of communication costs. During 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 Rfo Pledras and Mayaguez as an established activity. These will continue indefinitely and have added substantially to the scientific background of the stage. 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 the Summer Institute of Radiology 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 tone of the administrative activities as well as the cost of the various services rose in FY-1953 and is expected 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-1964 the Hi ris 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 procedures were completed, approved, and adopted for all important operations of the Reactor Division. Two 6 inch beam tubes are occupied by the neutron spectrometry program, and one 8 inch beam tube is occupied by an experiment in thermal sensitivity of graphite. Open pool side irradiations are continuously increasing in demand. The I-77 homogenous 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 occupancy 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. ---Page Break--- 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 crystals. 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 damage. 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 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 convenient as the commonly used Fricke (ferrous) system.

Further work will investigate the effect of other cations on the ceramic dosimeter and the mechanism of the ceramic stabilization. The present studies on Szilard-Chalmers reactions in antimony oxides will be continued to cover the effects of thermal and gate smearing on the distribution of radioactive antimony between the three and five valence states. A new program on the host 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 bis alert 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 photochemically. 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. ---Page Break--- 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 coursework 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 is that 15 applicants.

have been accepted as candidates for the M.S. in Nuclear Engineering in addition to the 11 already enrolled, making a total of 19 for FY-1965 already assured. Health Physics: The Health Physics Division has continued rendering its services concerning personnel and area monitoring, environmental surveillance, waste management, instrumental calibration, decontamination and handling of radioactive material. In addition, it has continued participating in teaching and training of students in Radiological Physics as well as training of PRNG personnel in general safety. All these services have been extended also to the divisions of PRIC at Rio Piedras where we have now a Health Physics Section under the direction of a health physicist. As a result of the reorientation of PRIC policy, the division is now vested with the responsibility for supervision of all safety: radiation, industrial and fire, while each division is responsible for safe operation of all facilities under its control. For fiscal year 1965 some increase in services and a moderate increase in supervision is expected. Because of budgetary limitations, the Division has reduced its training activities and is largely concerned with health physics operations. Agricultural Sciences, 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 detections and recombinations was planned. The initial experiments were conducted with cuttings from the best variety of sugarcane now in use. Lethality occurred at about 2,000 rads (subject to later revision) indicating a high relative biological effect of the neutrons, which means more irradiation 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 shade and ability to resist drought. Ultimately the final screening requires...

quantitative estimation of sucrose in each plant without significant damage to the plant. The necessary methods have been developed and have been automated so that one technician can perform from 20 to 40 quantitative analyses per hour on microtamples. Both sucrose and invertase are being determined on each sample. The sugarcane borer (Diatrea 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 the dose which is lethal. In the larval and pupal stages, the sterilizing dose is also the lethal dose. Molecular volumes of many of the tropical plants (including sugarcane) have been determined to test the formulas 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. ---Page Break--- Out 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 07 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, though the effort which has been expended has been woefully inadequate, especially 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 indefinitely continuing demand for this training, especially for students of the University of Puerto Rico. The basic course ---Page Break--- is offered five times a year and it will probably not be necessary to expand it. With time, a larger proportion of students coming from Latin America will have already had the equivalent in their own universities. The expansion of graduate work in chemistry related to radiation and nuclear reactions has been well established. The research program, all of which is built around the graduate activity, is being developed under four sections: 1. Organic Chemistry a. Synthesis of compounds of interest to the nuclear field, especially medicine and radiobiology. b. Quantitative study of organic reactions utilizing radioisotopes. 2. Radiation Chemistry (sponsored by ABC Division of Biology and Medicine, and National Institutes of Health). This section has two major fields of activity, which became 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 microproteins and the constituent molecules. Emphasis will be laid on the study of cross-linking reactions and the role of excited states in the reactions of the heterocyclic bases. ---Page Break--- 3. Solution Chemistry Deferred until FY-1966. 4. Solid State Physics of Organic Crystals (Sponsored by ARC Division of Physical Research) This section studies the effect of neutron and 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 Biomedical Building which can house 8 graduate students. Clinical Radioisotope Applications in the Clinical Applications Division is currently offering two types of sources for training physicians at an introductory level. It provides diagnostic services at the Puerto Rico Nuclear Center to support its coaching programs, operates the Radioisotope Laboratory at the University Hospital for the Medical Staff of this Hospital, supports with diagnostic supplies the San Juan City Hospital Radiotope 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 clinical nature on problems of local and general interest. ---Page Break--- The 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 a program of research activities conducted with the purpose of improving our knowledge in the cancer and radiation fields. The following functions are carried out to accomplish these goals for those who want to become qualified residency. It lasts three years and includes practice in the specialty. This is also often offered to experienced physicians in radiation therapy who have been engaged in this field for a considerable length of time, which permits them to conduct specific research in their field and participate in all teaching activities for students to familiarize them with cancer and various

therapeutic techniques. Training for nurses, technicians, and radiological technologists is provided in the joint program between the Puerto Rico Department of Health and the University of Puerto Rico Medical School. ---Page Break--- It has been discontinued in the Nuclear Center due to budget.

restrictions. Medical Sciences and Radiobiology ‘Tala, the youngest of the Rfo Piedras Divisions, was formed in July 1962 by amalgamation of the Division of Medical Sciences with the older Division of Radiobiology. The actual content of the field of radiobiology has been divided in a natural manner between Agricultural BioSciences, Health Physics, Medical Sciences, and Radiotherapy and Cancer. It can be said that radiobiology is a science in Mo Piedras. In the latter location, the small program which existed in the Division of Radiobiology is being continued. J. Mesue Culture Program ‘The first phase in the program was the development of a central 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-1961 and extending through FY-1965 several radiobiological studies will be instituted with tissue culture cell ---Page Break--- 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 desorbed in the associated Form 189 and their Radiation Induced Genetic II. Indigenous Virus variability III. The use of gamma radiation to modify Schistosoma mansoni cercariae so that they induce immunity to attack instead of causing disease. 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 a two-year period, by which time it will be possible to decide along what lines any further research might best be pursued, the hoped-for end result being a contribution to knowledge which may eventually help in combating the disease. Technical Services (Mayaguez) This operation, which originally was part of Reactor Division, has 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 blowing shop. With the exception of buildings and grounds, the Mayaguez Technical Services, through its shops, serve the entire PRC and must be prepared to meet a considerable variety of demands. 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 the construction of Ionization Chambers, Crystal String Saws, High-Frequency Microphones, or X-ray Spectrometers. The Technical Services (Rio Piedras) section has charge of building maintenance at Rio Piedras, the operation of a small electronic shop and general instrumental repair. Shop services in general and engineering supervision are supplied by the Mayaguez branch. 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. The biological systems chosen for study are those which are composed primarily of light elements with but traces of medium atomic weight elements. Inhibited inactivation of the 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.

bacterium Z, coli. Biological studies have been supplemented by investigation into the underlying physical phenomena of the radiation 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. 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 modes of decomposition of the various excited states of anions, and will uncover evidence indicating the participation of excited states in the radiation-induced decomposition. Work is underway on solutions of nitrate ion. Photochemical 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 determination. Genetics regulatory systems which control gene mutation are being investigated with emphasis being given to the parameterization 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. Terrestrial Ecology Program I; Biodiversity of a Tropical Rain Forest The rain forest irradiation project was started in the Spring, 1963, with the objectives of determining effects of gamma irradiation on the lower montane rainforest near El Yunque and the movement of chemical elements of fallout in the normal biogeochemical cycles. An area in the Luquillo Forest Reserve provided by the U.S. Forestry 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 identified 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. Fallout 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 of nutrient holding ability of the vegetation. Terrestrial Ecology Program II; Radiation Induced Variability in Indigenous Arthropod-Borne Animal 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 an "engineer-like” agent was accomplished in this laboratory on August 30, 1963. This represented a significant scientific contribution to our knowledge of viruses in the Caribbean area. ---Page Break--- 125 Field work on the regular study areas continues with successful mosquito 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. Fp giectanlans of Antinen Antibody Reactions Following the Inoculation of Mice with Irradiated and Normal Schistosoma mansoni Cercariae Approval for this program was received in December 1963, and the first preliminary experiment designed to determine the number of semantically paired cercariae necessary to induce a standard infection is 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 mansoni 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 all detectable reactions occurring between the challenging parasite and the "immune” host. Neutron Diffraction Program The first long-range research commitment, using the reactor, is in the field of neutron diffraction, in close cooperation with the Brookhaven National Laboratory. Two beam tubes of the PANG Reactor have been assigned to this work, and an advanced design ---Page Break--- 16 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 activation 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 ---Page Break--- 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. ---Page Break--- ---Page Break---