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ATOMIC ENERGY APPLICATIONS TO AGRICULTURE

John H. Rust

(A synopsis of talks to be presented at the University of Puerto Rico, Rio Piedras Campus on January 24, 1957, and on the Mayaguez Campus on January 28, 1957.)

The application of atomic energy to agricultural problems holds great promise though one must confess that there does not appear to be any spectacular changes in this field. All the gains that can be anticipated will be through the ingenious and intelligent application of this new tool plus unremitting work. It is likely that the advances will be small and repeated but when summed up mean a significant contribution. At present the applications of atomic energy to agricultural problems seem to be confined principally to increasing crop yields through the development of disease resistant or heavier yielding food plants by applied genetics, the control of plant parasites, the improvement of the quality of fertilizers and their utilization, insect control, the control of plant and animal diseases, improvement in the preservation of foods, and in some special agricultural-industrial applications. One should be warned that it does not seem necessary to confine investigations to these fields alone for other fields may well be more important if looked at closely.

The applications of atomic energy to agriculture can be broken down into two broad categories which are based upon physical considerations. The first is the utilization of tracers or isotope techniques. The second is concerned with the effects of large amounts of radiation upon genetic or schematic cell materials. In order to understand some of the many ways in which atomic energy has been applied to agriculture, it will be well to review some of the successful uses which have been reported.

Fertilizer studies are among those which have been conducted for the longest period of time and yet new information is being constantly yielded for as everyone can see, and there are endless combinations of plants and soil types which need to be studied. There are many elegant techniques which can be presented here but for illustration one can mention such a simple study as the comparative uptake of fertilizers labeled with radiophosphorous by the leaves and by the roots. It is rather surprising to the conventional minded that the leaves were more effective (isotopes Division slide No. 277A) in absorbing the fertilizer. A practice derived from this fact has developed particularly on the West Coast where orchardist spray dormant fruit trees with fertilizers. This method of fertilization has turned out to be a particularly successful innovation. Urea, an inexpensive by-product of the chemical industry, is being used extensively as a foliar fertilizer by orchardist and vegetable gardeners. The urea molecule when attacked by the naturally occurring plant urease yields ammonia which can be used in nitrogen metabolism by many plants. By labeling the carbon in the urea molecule the ability of the various plants to use urea has been determined by the formation of radioactive CO_2. These new techniques of foliar fertilization in combination with urea have given a cheap effective fertilizer for several crops. It is interesting to note that foliar fertilizers are not effective for all plants nor for all nutritional needs - for example calcium is not satisfactorily utilized.

An interesting application of radiosulfur with the problem of orange storage was concerned with sulfur containing spray residues. A break-down of the spray residue into some substances which were inimicable to storage of oranges. Using a radiosulfur laber in the sprays, the depth of penetration under various conditions and the nature of the toxic substances were determined. It was then found that the sun light and heat would promote the formation of the toxic substance in question. Proper steps were taken to correct the trouble and the removal of a vexing problem for orange growers was made (Isotopes Division slide No. 413).

Soil scientists have been pressed for many years for a technique to measure soil moisture without disturbance to the soil structure or the associated plants. A probe system was developed in which a fact neutron source was inserted into the soil at one point and at another foil, a metal foil, for capturing slow neutrons was placed. The resulting radio-activity in the foil was then measured. Advantage was taken of the fact that most of the slowing of fast neutrons was by the light hydrogen atoms of water. The resulting radioativity was therefore a direct measure of the water content of the soil.

Forest trees are an important natural resource. For a good number of years now there has been concern about the depletion of our forest resources through diseases of trees. Thus anything that can be done to give some aid in silviculture has economic import. Rather interestingly there occurs natural root grafting among the trees in the forest which plan an important part in the movement of water and nutrients and most particularly in the transport of disease inducing organisms from one tree to another. The extent of this was not realized until labeled nutrients were used. The use of radioisotopes has clarified some special problems in this respect. In a representative experiment where trees were some ten feet apart the treatment of one tree with a radioactive substance disclosed that five nearby trees were grafted to it by the roots. When these additional five were treated twenty more trees were proved to be joined. When these twenty-one trees were treated ten more trees were found to be involved. Thus with only three successive radioactive treatments thirty-six trees were found to be grafted directly or indirectly with one another. It is easy to see that by means of its sap a disease could be spread quite rapidly through a forest. The basic information developed proved of value in developing control measures for tree diseases. For example, in lawns and park areas where individual trees have a rather large value severing all root connections to a depth of about 36 inches around the diseased tree was adequate to prevent the spread of the disease by means of root system. Wooded areas where individual trees are of low value the poisoning of healthy trees within 25 feet of the diseased tree usually could control the infection. Using these methods it was possible to control the spread of some diseases of trees that were becoming a serious economic problem.

One of the most interesting of all recent developments in which radioactive isotopes were used has been that of the role of certain substances in the milk, in promoting the absorption of radiocalcium. In a series of studies, calves were being observed for their ability to absorb calcium from the diet. It was noticed that there was a marked difference between calves at two months of age and those at six months of age in the total calcium absorbed from dietary sources. This age difference was investigated more closely and it was found that the difference was related to weaning time. The weaned animals, on standard commerical diets of good quality, were not able to absorb nearly as much calcium as those that were still nursing their mothers. It was then established that it was substances in milk that promoted the absorption and these are principally lysine, arginine, and lactose. This is even true in old animals, for even when an aged cow given milk solids with calcium, was able to absorb a considerably greater amount of calcium from her diet. Thus a new system of feeding was established, one in which the milk solids were incorporated with calcium where it was desired to get good calcium absorption in growing animals.

Another interesting aspect of the radiocalcium studies came about through the study of the fetal transfer or fetal utilization of calcium from the maternal blood stream. The fetus draws heavily upon the mother's store of calcium so much so that it has been suggested that the irritability pregnant mothers often show it related to the hypocalcemia. Hypocalcemia or low calcium in the blood has been known for many years to produce such a condition in man and animals. Studies with radiocalcium have shown that the fetus will draw calcium from the dietary calcium first if it is available and if it is not it will draw from the skeletal calcium the reserve stores of the mother. The ordinary three meals daily permitted skeletal stores to be drawn upon to a large extent. Therefore, in order to protect the mother from excessive drains upon her calcium stores it has been a policy to advise frequent feedings with an adequate calcium diet for pregnant mothers. This in turn has a tendency, in the eyes of some authorities, to reduce the irritability of pregnant mothers by preventing the low blood calcium levels which develop when skeletal calcium is being mobilized.

Please pardon me for including a personal incident involved with tracers. It will serve to let you know that there are pit-falls that befall the investigators using radioactive tracers. For some years it has been noticed that form animals fed phenothiazine, and anthelmintic, would gain weight and this was attributed in many cases to the removal of the parasite from the intestinal tract. It has also been observed by the more astute observers that animals without parasites would also gain weight. A troubling paradox indeed. These facts were known to me and to some of my colleagues. In some prior work by a colleague rats were fed phenothiazine and the uptake of radioactive iodine measured. Animals treated with phenothiazine did not concentrate radioactive iodine to any extent at all. This work was repeated with burros and sheep with similar results. This led us to believe that because the thyroid activity was depressed we had uncovered the cause for the weight gains noted. Some very exhaustive studies were done in exploring this possibility and no evidence that the phenothiazine was responsible for the failure to pick up radioactive iodine was uncovered. Instead it was found that the iodine that was used as a catalyst in the preparation of the phenothiazine competed with radioiodine. This still left unanswered the main question as to why animals gain weight when given phenothiazine. Some time later I noticed that the nucleus of the phenothiazine molecule was very similar to that of the nucleus of the chloroppronazine molecule. If you will recall, chloropromazine is a drug that is quite widely used in human medicine for its tranquilizing effect. It then occurred to me that phenothiazine itself might be a tranquilizing agent and that the animals that were being given phenothiazine were in effect getting a tranquilizing drug as well as an anthelmintic. This year in a report in a scientific journal it came to my attention that some investigators had studied phenothiazine in respect to its tranquilizing ability and sure enough it does have some effect of that type. Now I believe that the weight gain noted was at least in part due to this. Incidentally some very highly respected race horse owners think that phenothiazine will cause a horse to run slower.

Another aspect of the use of radioactive substances is in the sterilization of foods. This requires large sources of radiation and is dependent upon destruction of enzymes or bacteria. I have a number of slides showing various foods which have been treated with radioactivity in large amounts and their keeping quality has been improved (Isotopes Division slide No.). Recent methods by which various meats can be effectively pasteurized have involved destruction of proteolytic enzymes before irradiation. The results are quite effective.

A use of large exposures of germ plasma has been where corn and other grains have been irradiated and to hasten the mutation processes. This slide (Isotepes Division slide No.) shows the relative number of grains of corn that one has to inspect to see under various circumstances a sizeable increase in the number of mutations; somatic mutations as indicated by this slide (Isotopes Division slide No.) of the carnation plant. The plant in the center is red compared with its mates which are white. This is considered to be a somatic mutation. Similar reports have been made which indicate that early maturing, disease resistance, and various other things can be induced by radiation.

Another, and very interesting, use of large doses of radiation has been to expose the larva of the screw worm fly to sterilizing doses of radiation and releasing the males. The irradiated sterile males mate with the females in competition with fertile males. So many sterile matings, with sterile eggs, are made in such large a number that the total population of the screw worm flies in an isolated area can be reduced to essentially none. This was done by the Department of Agriculture on the Island of Curacao and a very serious economic hazard was removed from animal population.

These illustrations are meant to stimulate more of your thoughts along the line of what can be done and what has been done in the field of agriculture. They are certainly not all that are possible and as I said earlier that possible uses of atomic energy in agriculture are limited entirely by one's ingenuity and intelligent approach to problems. It seems to me that the benefits from the use of atomic energy in agriculture are well on the way to surpass the disadvantages.

I thank you.

UNIVERSITY OF PUERTO RICO
Río Piedras, Puerto Rico

ATOMIC ENERGY AND THE WORLD TODAY

By: A.M. Weinberg, Director
Oak Ridge National Laboratory

It is a great pleasure to be in Puerto Rico to talk to you about atomic energy. Many of you may be puzzled about this atomic energy "Chatauqua" which we bring to you. I should explain that this is one of a series of Regional Atomic Energy Symposia sponsored by the ORNL[1], the ORINS[2], and the Atomic Energy Commission. Our purpose is to present first an overall view of the current status of the nuclear energy arts, and second, to indicate, in each of the regions where we put on our show, how nuclear energy, in its many ramifications, can have important implication for that region.

You will therefore hear, during this symposium, talks on economics and education, talks on cancer and agriculture, talks on radioisotopes and power.-- In short, you will be told that nuclear energy bears, in some way or another, on a remarkably wide gamut of human activities. Our medicine show, so to speak, is selling very strong medicine indeed; yet, at the outset I should make clear that we do not seek to represent our product-nuclear energy- as a panacea. If we should sound too enthusiastic remember always that no single technical achievement, no matter how magnificent, can solve all of mankind's problems-- that the release of nuclear energy, by itself, has certainly not "Set the World Free", as H. G. Wells predicted in 1913.

My talk will be concerned mainly with the present state of nuclear power, and its implications for Puerto Rico. The possible interest of Puerto Rico in nuclear power

1 Oak Ridge National Laboratory
2 Oak Ridge Institute of Nuclear Studies

was well stated in a paper presented at the International Conference on the Peaceful uses of Atomic Energy at Geneva by A. Mayne of the Puerto Rico Planning Board and P. Mullenbach of the National Planning Association. The economy of Puerto Rico is expanding very rapidly. Fundamental to any such expansion is adequate power. In Puerto Rico most of whose energy comes from burning important oil, this means that two questions must be faced-- can one count on oil at, the present price of about $2.10 one barrel over the indefinite future; and can one see any alternate energy source which would be available either at lower cost than oil, or should oil become scarce, in greater abundance than oil. It is my belief that nuclear power might very well be such an alternate source for Puerto Rico should oil become scarce for any reason in the future.

As measured by U.S.A. standards, the cost of electricity in Puerto Rico is at first sight not very high. Mayne and Mullenbach in their article quote a price of about 7.5 to 8 mills per kwh. Of this about 4 mills per kwh is the cost of fuel, about 1/2 mill per kwh goes for operation and maintenance, and 3.5 to 4 mills per kwh goes for depreciation and other fixed costs. The fraction of the total cost of electricity which goes for fixed costs is very low by U.S.A. standards-- 6.75% compared to 13.5%, the major difference being in taxes. If fixed costs were as high as on the mainland, the cost of conventional electric power in Puerto Rico would be nearer 10 to 12 mills per kwh rather than 7.5 to 8 mills per kwh.

It is very important in discussing the economics of nuclear power that one reduce all such discussions to a common base of computing costs. Thus by mainland cost accounting, the target which nuclear power must meet is not the very low figure of 7.5 mills per kwh but rather the much higher figure of 10-12 mills per kwh. Moreover, again because of accounting, fixed costs are much less important in assessing electrical costs in Puerto Rico than on the mainland. Insofar as we can judge the future of nuclear energy technology, it appears that nuclear reactors will be expensive devices. Low fixed costs would therefore be extremely important in making it possible for nuclear energy to be competitive with conventional power. To summarize then, the quoted conventional electrical costs in Puerto Rico-- 7-8 mills per kwh is unusually low because the fixed charges are computed at such a low rate. If the fixed charges are computed by U.S.A. standards, Puerto Rico becomes one of the moderately high electric cost areas of the world; or conversely, if the fixed charges on a nuclear plant are computed at the low Puerto Rican rate, the possibility of nuclear power competing with conventional power in the relatively near future is good- at any rate much better than in the states where the fuel costs are often less than half what they are in Puerto Rico.

Present Status of Nuclear Power

Just where does the Nuclear Power Enterprise of the world stand today-- how close are we to achieving 7.5 mills per kwh (at 6.75% fixed charges).(?) To give an idea of the current state of the technology, I shall describe in some detail three of the currently operating or nearly built nuclear power plants-- The British gas cooled Colder Hall Reactors, the American Pressurized Water Reactor (pwp) and the American Homogeneous Reactor Test (HRT). As you will see, the British Reactor, built in a country which faces a drastic energy shortage right now, represents a relatively conservative technology. The American HRT, built in a country for which nuclear power can make little immediate contribution because fuel is so abundant and so cheap, is a very advanced device. In between, perhaps in the PWR.

Two major lines of development of nuclear power have emerged during the past decade-- one based on the exploitation of natural, unenriched uranium, the other based on the exploitation of uranium which has been enriched in Uranium^{235}. The first line of development is followed largely by countries such as England and France which possess only limited facilities for separating Uranium^{235} from Uranium, the second line of development strongly dominates the United States atomic energy program.

Broadly speaking, reactors based on natural uranium tend to be larger than reactors based on enriched uranium. In consequence, one has the impression, though this is not proved, that natural uranium reactors may be more expensive to build than are enriched reactors. On the other hand they will probably be cheaper to operate than at least some enriched machines. Thus in situations where operating costs are more important than capital costs-- as in Puerto Rico-- unenriched types may be very attractive; in places like the U.S. where capital costs are more important than operating costs, enriched types are advantageous. Thus this division in emphasis between the European and American programs corresponds rather well to the technical and economic needs of the two areas.

It is well to point out that even the enriched non-regenerative systems will have fairly low operating costs if the reprocessing of the fuel can be done cheaply enough. Consider U^{235} at $17 per gram, then at 35% overall thermal efficiency, and complete burn up, the fuel cost is about 3 mills per kwh. Such economics is often unappealing to countries outside the United States since it implies that the country's fuel would always depend on U. S. diffusion plants. Such an argument loses its force when one speaks of Puerto Rico which is closely tied to the United States.-- In other words, burning of U^{235}, even without regeneration ought to be an economic possibility in Puerto Rico relatively soon; and such a possibility would not resolve the same problem of power self-sufficiency which seems to trouble many other countries.

I turn now to a short description of the three nuclear power plants which represent the major developmental lines-- Calder Hall, a natural Uranium gas cooled system, PWR, a water cooled enriched U system, and HRT, a liquid fuel, enriched and possibly regenerative reactor. I shall describe each of these reactions by means of a number of slides.

Broader Aspects of Nuclear Energy

While the possible utilization of nuclear fuel as an energy source in Puerto Rico is in itself sufficient reason for the interest in nuclear development here, I believe there are other, possibly more persuasive or immediate reasons for this interest. I refer first to the possibility of using nuclear energy technology as a jumping off point for the expansion of technological activity of all kinds-- not only nuclear energy-- here in Puerto Rico; and I refer secondly to the significance of nuclear energy as a symbol of the newly arrived Scientific Era.

The breadth of nuclear technology-- the fact that on the one hand it makes demands on all the fields of science and that on the other hand it can give impetus to a wide variety of scientific activity of great variety-- means that institutions which are established firstly as atomic-energy institutes in fact require the capability of pursuing every phase of scientific and technical investigation. For example, Oak Ridge National Laboratory-- the largest of the American national laboratories-- has on its staff representatives from every branch of science and technology. We are an atomic-energy laboratory, yet we are competent in computers, in biology, in geology, in ecology. Thus, the trend towards establishment of national scientific laboratories, even in smaller countries, around prices of atomic-energy hardware, I view as a trend which will, in the long run, have implications beyond atomic energy per se. It has been argued that nuclear-energy laboratories give to a special segment of technology-- nuclear science-- too large a fraction of available scientific talent; to this, I rejoin that scientific activity is infectious. A science tradition having its roots in nuclear energy can well be used as a base for expansion into other fields of science. This view is, for example, exemplified by the Boris Kidric Institute in Jugoslavia; this laboratory, of moderate size, serves not only as a national nuclear-energy laboratory, but also as a national physical laboratory for Jugoslavia. With the rapid industrialization of Puerto Rico, an educationally oriented laboratory whose original mission lies in the field of nuclear energy, but which has the flexibility necessary to expand into other fields of science and technology significant to the Puerto Rican economy, strikes me as making good sense.

I turn now to nuclear energy as a symbol of the new Scientific Era which mankind is now entering. I trust that this symposium, and perhaps even my remarks, will give you some idea of the ultimate significance of nuclear energy to science and technology. Great though this significance is, I cannot help but feel that the incredible public reaction to the possibilities of peaceful nuclear energy is not justified by the actual possibilities of nuclear energy. Rather, it seems to me that nuclear energy has been seized upon by mankind to symbolize what mankind has suddenly realized: that our science and our technology generally-- not only nuclear energy-- have become so successful as to open the possibility of dealing with all of our human wants in a drastically more effective manner than in the past. In short, the real fuss about peaceful nuclear energy has to do with nuclear energy as symbol and harbinger of what has been called the Scientific Era.

The first-order achievement of nuclear science has been the imposition on mankind of the Thermonuclear Peace. I am one of those who believe that mankind can hardly be reasoned, or cajoled, or subverted into peace-- mankind can much more effectively be deterred and frightened into peace. It is this belief which basically has sustained each scientist who has been concerned with nuclear weapon development.

But, as the current events have shown, a Thermonuclear Peace is not a stable thing. It is true that the activation energy required for war has been raised by the existence of thermonuclear weapons; yet, without a basic amelioration of mankind's lot, it is hard to believe that the Thermonuclear Peace will last forever.

It is this most worthwhile accomplishment-- the amelioration of the condition of life, and the consequent stabilization of the Thermonuclear Peace-- that we optimists believe is possible through our science.

Is it wishful thinking to believe that a world which has solved, by science, its shortage-- food, water, energy, materials-- will, under the threat of thermonuclear war, in fact become a world without war? If we look at the trouble spots in today's world-- if we look at history's trouble spots-- it is almost no exaggeration to say that major trouble has always been the result of a lack of abundance.

We scientists have strong hope that this lack of abundance is amenable to solution by the techniques of modern science-- that the traditional causes of war, insofar as they lie in poverty and want can be eliminated by science; that even extreme political doctrines such as Communism, which were based on the assumption that there was not enough to go around for everyone, will be seen to be irrelevant in the new age of abundance which modern science is making possible.

In the achievement of this era, nuclear energy development will certainly play an important role. But other branches of science will be no less important. We shall require new methods of agriculture; we shall require new methods of collecting and computing data; we shall require new methods of extracting minerals from rocks. We shall require new techniques for dealing with human relations; we shall need to learn how to maintain our population below the explosion point; we shall require better ways to deal with the new leisure at our disposal; we shall need achievements in psychological science of the same order as our achievements in physical science.

And finally, we shall need people trained in the new techniques-- people who see the possibilities in the new era of science and who are in position to give advice concerning the impact of these developments on society. Such people have come and will come from your great university here; we trust that, in a small way, our symposium will help give further impetus and encouragement to you here in Puerto Rico who have started the expansion of your scientific base, and who are prepared to use nuclear energy as the vehicle for furthering this expansion.

Remarks Prepared by Lewis L. Strauss, Chairman,

U. S. Atomic Energy Commission,

for delivery to

Regional Symposium on Peaceful Uses of Atomic Energy

University of Puerto Rico, Rio Piedras Campus

San Juan, January 25, 1957

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It is a great pleasure to return to Puerto Rico for your delightful island has, for many years, had a very secure spot in my affections. On this occasion that pleasure is enriched because of the opportunity which is afforded me to participate in this Symposium on the Peaceful Uses of Atomic Energy.

As a small boy with an almost passionate interest in the story of Christopher Columbus and his voyages, I, of course, came to know about Puerto Rico, and determined that it was one of the romantic spots which I would visit at the earliest opportunity. But I was perplexed by something of a contradiction about the place. Columbus -- according to my school books -- when he stepped ashore here 463 years ago named the island San Juan -- San Juan Bautista. And fifteen years later, when Ponce de Leon came back to explore and colonize, he sailed into this beautiful bay and established a settlement which he called Puerto Rico. I never could understand the strange inversion of names -- why the island which Columbus christened San Juan came to be called Puerto Rico, and why the city -- christened Puerto Rico -- came to be known as San Juan. Perhaps there is some simple explanation, which has escaped my notice, but I must confess that I am still perplexed; it is an historiaal mystery which I hope someone will olarify for me before I leave fcr home.

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During the past two days you have, in your various seminars and panel programs, discussed in considerable detail the rapidly expanding progress and prospects in the field of atomic energy -- in medicine, biology, basic research, agriculture and industry. Such outstanding authorities as Mr. Hall, Mr. Sapirie, Dr. Pollard, Dr. Weinburg, Dr. Goodman, Dr. Grigorieff, Dr. Rust, Dr. Andrews and others have outlined for you various aspects of the United States program. I shall not, therefore, engage in any repetitious account of these activities. Instead, I shall endeavor to describe the broad basic purposes and policies which underlie President Eisenhower's program of Atoms for Peace.

As preface to my remarks I should like to recall to you an unusual message which was telephoned from Chicago on the afternoon of December 2, 1942. I believe that message bears a relevant historical association with this delightful island, as well as with the topic of our interest.

You will no doubt recall that Columbus, when he stepped ashore on the west coast of this island one November day in 1493, was very apprehensive as to what kind of a greeting he and his men would receive from the Borinqueno natives. The natives fortunately turned out to be very friendly.

But to return to the date of December 2, 1942, and the telephone message from Chicago:

The call was placed by Dr. Arthur H. Compton, a Nobel laureate then in charge of the highly-secret laboratory operated by the U.S. Government at the University of Chicago. On the other end of the line -- at Harvard University, in Cambridge, Massachusetts -- was Dr. James B. Conant, at that time associated with the wartime Office of Scientific Research and Development.

The conversation of the two men was brief and cryptic. There were no wasted words of greeting when Dr. Compton spoke into the telephone and announced.

"The Italian navigator has reached the new world."

"And how did he find the natives?" asked Conant anxiously.

"Very friendly," answered Compton.

All of you, I am sure, must be familiar with that episode. The "Italian Navigator" was Enrico Fermi, illustrous son of Italy. The "natives" in this instance were not the Indians of San Salvador, nor the Borinquenos of San Juan; they were the neutrons liberated in countless billions that December afternoon -- "friendly" natives because they had submitted to Fermi's design as they penetrated and split apart the heart of uranium atoms. In controlling and sustaining nuclear fission, man, for the first time, had tapped what appeared to be the basic energy of the Universe.

The new world of the atom -- still only in its fifteenth year, and not yet of the full stature of its growth -- presents to man the most fateful choice of his entire civilized existence; For the power of the atom can be used to create a new world, rich in abundance and limitless blessings, or it can be perverted to fashion a barren and primitive world. The choice between these alternatives still remains to be made by the peoples of the world -- in their combined enlightenment or their mass blindness, as they may decide.

On that wintry afternoon in Chicago a little over fourteen years ago, and in that moment of eternity when Fermi and his associates cautiously inched the control rods out of their pile of uranium and graphite to start the world's first atomic reactor, they had little time to speculate on the future and the alternatives it would pose. Dreams of atomic power for man's peaceful pursuits, and of radiation to combat the diseases which beset him and enrich the harvests of his fields, had to be put aside, for we were then at war. Freedom, not alone of our Western Hemisphere but of vast areas of the world, was in deadly peril and would be lost were we to lose the deadly serious race to produce an atomic weapon before it might become the ultimate means of world enslavement in the hands of the aggressors. Yet Fermi and his colleagues foresaw, even then, a time when the "friendly natives" of his discovery would show us the way to richer existence.

We Americans are furtunate that our land became the refuge of so many scientists and scholars of other countries -- such men as Einstein, Fermi, Wigner, Teller, von Neumann and many others. We do not regard the great progress made in nuclear science in the United States as an achievement peculiar to our American culture. On the contrary, it is a vivid example of international teamwork -- and proof that scientific excellence and achievement is not associated with any particular birthright. This teamwork among men of different nations is not less essential today than it was during the grim wartime race to develop the atomic bomb, for the peaceful, productive potentialities

It was obvious, however, that any comprehensive system of disarmament could be realized only through the most serious and conscientious effort. Man, in all his recorded existence, has never been able to achieve voluntary disarmament. Something new and bold was called for if the dead weight of the world's fears was to be lifted and the atom put to work for peace on a truly international scale.

In 1953 the President's thoughts were running in this vein:

Perhaps if the peoples of the earth could be brought to realize and comprehend the many ways in which the atom stood ready to serve them and improve their lives, they would reject even the suggestion of atomic war as unrelieved idiocy.

The President was eager to strike out into the new world and to enlist its "friendly natives" in the cause of peaceful progress.

He decided, therefore, that, just as we had offered as far back as 1946 to give up our nuclear weapons in the interest of peace, we would -- in the same spirit -- share with the rest of the world all we had learned about the beneficent atom.

His inspiration was translated into a sincere, concrete proposal when he went before the United Nations General Assembly on December 8, 1953, and, in an historic message, rejected the thesis of "atomic colossi doomed malevolently to eye each other across a trembling world." He said that to resign one's self to that kind of thinking would be to accept helplessly the probability of civilization destroyed and the annihilation of the irreplaceable heritage of mankind handed down to us from generations.

He went on to say:

"The United States knows that if the fearful trend of atomic military building can be reversed, this greatest of destructive forces can be developed into a great boon, for the benefit of all mankind. The United States knows that peaceful power from atomic energy is no dream of the future. That capability, already proved, is here -- now -- today."

He then proposed that the atomic powers of the world establish, and contribute to, an international "pool" of fissionable materials, to be devoted to the pursuits of peace, and administered under prudent safeguards by an International Atomic Energy Agency. This, as the President explained, would be an effective start toward diminishing the potential destructive power of the world's stockpiles of nuclear material. Accordingly, a little later, the United States Government allocated 200 kilograms of fissionable material to serve as fuel for experimental research reactors in foreign countries.

We have not been content to pay mere lip-service to peace and nuclear progress. It has been our aim to carry out President Eisenhower's objectives by promoting the fullest measure of international cooperation in exploiting the benign atom while -- at the same time -- we strive with steady purpose to establish a basis for disarmament. We mean to continue these efforts.

In translating the President's words into action and substance, we have negotiated agreements of cooperation with 42 nations and discussions have been undertaken with seven others. These 49 countries represent almost every area of the free world and eleven of them are with our sister republics of the Americas. The agreements facilitate an immediate exchange of information and nuclear materials as well as technical assistance for the development of atomic energy programs in those countries.

The state of atomic art varies widely among the countries with which we have negotiated such Agreements of Cooperation, ranging from countries with a minimum of people trained in basic science to those with a real capacity for advancing nuclear technology. Therefore, the assistance contemplated under the agreements likewise encompasses wide scope.

Some provide for assistance in research and training programs in order that those countries may establish the necessary basis for an atomic industry of their own. Other agreements, known as "power bilaterals" provide for cooperation in the design, construction and operation of nuclear power plants.

The program of Agreements of Cooperation has been underway now only about two years -- since early 1955 -- yet there is substantial and gratifying progress to report.

For example, eight American research reactors have been contracted for by friendly countries with whom we have agreements, and several other countries are discussing similar contracts. We anticipate that a number of these research reactors will be built in American Republics with U. S. financial and technical assistance.

Also, seven power reactor projects abroad are currently being discussed by American and foreign interests.

I feel that much emphasis should be placed upon the programs provided for in the "research bilaterals" -- that is to say, the construction and use of research reactors. There is no better means to create a sound basis for nuclear development and progress.

Even one research reactor will, in itself, permit a wide range of activity in the field of nuclear energy. It will produce many of the radioactive isotopes of various kinds which can be of benefit to medical science, agriculture, industry and basic research -- radioactive iodine for use in the treatment of cancer, or radioactive gold to treat other malignancies. It will produce Carbon 14 with its many applications in biological research, and other isotopes capable of performing the most delicate measurements and of testing materials in countless industrial applications. These same radioisotopes, applied to agricultural research, will show the way to improving fertilizers, increasing crop yields through mutations, and combatting plant diseases and pests.

And most important of all, such research reactors serve as a magnificent device for training young nuclear scientists, engineers and technicians, who represent the prime requirement for any sound and productive atomic energy program. Until a reservoir of such scientific and technological skills has been established, no country can reasonably expect that it will have atomic power to light its homes and operate its factories and transportation facilities. Skilled manpower is a component of an effective atomic program not less essential than nuclear materials or money.

The system of bilateral agreements of cooperation, covering both research and power development, is but one facet of the U. S.

program of international cooperation for the development of the peaceful atom.

It was the United States which originated the International Conference on the Peaceful Uses of Atomic Energy in Geneva, in August 1955, when 14-hundred delegates from 73 countries broke the seals of silence on scientific communication that had lasted for many years.

It was the United States also which cut through the international deadlock and, in President Eisenhower's inspired address to the United Nations -- to which I have already referred -- called for the creation of an International Atomic Energy Agency and a world "pooling" of nuclear materials to extend and accelerate the peaceful uses of the atom. The President's bold and imaginative proposal had its dramatic fulfillment last October 26 at the United Nations in New York when some 80 nations of the world adopted his plan and signed a statute creating such a world agency dedicated to serving man's welfare. This represents a great stride forward in international cooperation to promote the peaceful atom and to draw away from weapons production, here and in other countries, the atomic materials required for the development of the peacetime uses of nuclear energy.

In our desire to encourage, to the fullest extent possible, the building and operation of research reactors in other countries the United States is not only supplying enriched uranium fuel for such reactors, but we stand ready to grant up to $350,000 in each case toward the building of such a reactor. One of these American research reactors is already in Switzerland and grants for similar reactors have either been made or ear-marked for a number of other countries, including, of course, Latin America.

Furthermore, to encourage activity by our friends abroad under the so-called "power bilaterals," President Eisenhower on February 22 of last year approved the Atomic Energy Commission's recommendation and designated 40 metric tons of enriched uranium for civilian uses in our country and overseas, and primarily as fuel for nuclear power plants. This allocation -- which will be increased as may become necessary -- was evenly divided between the United States and our foreign friends, 20-thousand kilograms for each. Thus far, the commitments of special nuclear material which the United States has made to other nations amounts to nearly two-thousand kilograms of Uranium-235. Sales of heavy water to other countries exceed 250 tons.

We have sought to eliminate, wherever possible, the roadblocks which hamper our friends abroad in efforts to determine the economic factors in the atomic energy programs on which they hope to embark. We have helped to solve many of these problems by means of a two-way approach. First, we have released from all classification large amounts of technical information, and secondly, we have established price schedules for special nuclear material -- applying not only to prices to be charged for such materials, but also the prices we will pay for by-product materials generated in reactors using fuel from the United States. These policies, which were announced in mid-November, will assist importantly in arranging investment and financing for nuclear projects.

In the matter of technical information, which we are sharing in large volume with our friends of the free world, there has been underway for some two years now a greatly accelerated effort to declassify such data, within the limits of prudent regard for military security. The Commission has reviewed all the thousands of secret and top secret reports accumulated over the past 15 years with the result that last year over two-thirds of them were widely available and over one-third of them were declassified completely. Recently -- in agreement with the United Kingdom and Canada -- our wartime partners in atomic energy development -- we proceeded to make public essentially all the information on reactors designed for research and commercial power. This information is freely available to our friends abroad with whom we are cooperating and continues to be added to the atomic energy libraries which we are happy to have sent thus far to 48 countries.

Since 1947, we have been supplying radioisotopes -- those miracle-working by-products of atomic reactors -- to our friends abroad for use in medical research and therapy, in agriculture and in industry. To date, we have made more than 5,000 shipments to a total of 54 countries.

I have spoken of the dominant need for projects and facilities to train larger numbers of our young people in the nuclear arts, if we are to take advantage of the promises of the peaceful atom. The lack of trained talent stands as the only limiting factor, of any serious proportions, in nuclear development -- in the United States and in all the nations of the free world.

In the United States, for example, it is estimated that during the 1955-56 academic year there were about 200 college students majoring in nuclear engineering, and that in the current year there are about 600 such students. Next year the number may be doubled -- to nearer 12-hundred. However, this increase -- encouraging though it is -- is considerably short of our requirements. Based on the best estimates of anticipated nuclear growth and expansion we will need a much larger crop of post-graduate scientists and engineers qualified to take their place in the ranks of nuclear specialists.

The existing and future shortage poses difficulties not only for our own domestic nuclear program -- particularly in reaching the goal of plentiful, economic and safe nuclear power; it also serves as a limiting factor to the amount of skilled manpower which we can assign to our program of international cooperation. We are determined to continue to extend, to the fullest extent possible, our technical assistance to other friendly countries in helping them to obtain the required talents. The ultimate answer and solution, of course, becomes one of helping those nations to train their own nationals that they may become skilled in the nuclear arts and qualified to guide the creation and operation of their own atomic enterprises.

The Atomic Energy Commission has been aware for some years of this urgent need and has attached great importance to its solution, both as regards our own requirements in the United States and those of other friendly countries.

We have established and operated a number of schools such as the Oak Ridge Institute of Nuclear Studies and the International School of Nuclear Science and Engineering at the Commission's Argonne Laboratory near Chicago, to which are welcomed students from our own and many other countries for training in the production and applications of radioisotopes and in reactor technology. I am happy to say that students from Puerto Rico and from a number of the American Republics are among the enrollees.

However, our authority and our facilities for these educational activities must necessarily have their limitations. There also is the language difficulty, as well as the additional expense of bringing students to the United States rather than affording such training opportunities to them nearer to their homes.

It was for this reason that the Commission last year extended its program of international cooperation by helping to establish a nuclear training center in Puerto Rico, at the University of Puerto Rico.

We are extremely gratified at the response, and the extent of the enthusiastic collaboration which has been evidenced by the administration of Governor Muñoz and by the officials and faculty of the University of Puerto Rico.

There is a sound and promising basis for this decision to expand the Spanish language training facilities here in Puerto Rico, to serve as a bridge of scientific and technological cooperation among the American Republics.

As far back as 1950 your University, under auspices of the Atomic Energy Commission, was engaged in important research in the field of electronic radiation of cosmic rays. In the years since then, the University has carried on still other major studies for the Commission, as for example, the researches in radioactive iron contents in soils and crops, which are presently being conducted for the Commission by the University's Agricultural Experiment Station. This work is now to be extended through the opportunities afforded by the new research center which will include U. S. assistance to the University's School of Medicine, School of Science, College of Agriculture, Mechanical Arts and, of course, the Agricultural Experimental Station.

This program will provide the University of Puerto Rico with unique training and research facilities. Because these facilities will be truly outstanding -- and the most up-to-date in concept and design -- and because instruction will be in Spanish, the University of Puerto Rico may well become a training center of interest to many countries of the hemisphere.

I am told that about 300 students from Central and South America are now attending the University, some of them under the Technical Assistance Program of the United States International Cooperation Administration. It may soon develop, with the nuclear center in operation here, that Puerto Rico will be attracting steadily larger numbers of Spanish-speaking students from other countries. We will cooperate enthusiastically and support that expansion.

Under this training program, a broad horizon of rewarding opportunity will be unfolded for the youth of Puerto Rico. The skills and knowledge which they will acquire -- working with the peaceful atom here -- will qualify them to assume important roles in the development of this exciting new art which stands in urgent need of such trained minds. There will be a steadily increasing demand for their talents, here at home, in the United States and in the nations of Central and South America.

As another component of the United States desire to promote -- in a spirit of friendly and neighborly cooperation -- the atomic development of the Western Hemisphere, the Commission is, as you know, presently arranging for an Inter-American Symposium on Nuclear Energy to be held this year at its Brookhaven National Laboratory on Long Island, New York. It is our plan that this symposium will embrace both the scientific and economic aspects of nuclear energy and that it will be attended by appropriate representatives of the 21 American Republics. We hope to be able to announce more detailed plans in the near future. Not only will the delegates discuss such topics as the uses of radioisotopes in industry, agriculture and medicine, the various types and uses of reactors and the economic factors involved, but also the feasible courses to be followed in the establishing and operation of effective nuclear energy programs.

In conclusion, I should like to refer again to that prime requirement of atomic growth and progress -- that is to say, the training of scientists and engineers.

We have given much thought to ways and means by which all of the American Republics might accelerate the use of this new force to bring greater health and happiness and abundance into the lives of our people. We are convinced that the surest and soundest approach to that goal is through educational projects such as the one being established here.

President Eisenhower at the signing of the Declaration of Principles at the Meeting of Panama last July spoke of steps which might be taken ". . . . to hasten the beneficial use of nuclear forces throughout the hemisphere, both in industry and in combatting disease."

On that occasion he said:

"The coming years will bring to mankind limitless ways in which this nuclear science can advance human welfare. Let us progress together, as one family, in achieving for our peoples these results."

That, Ladies and Gentlemen, is the very essence of the program of international cooperation to which we are pledged.

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NUCLEAR REACTORS FOR UNIVERSITIES

Excerpts from the address of Dr. Robert A. Charpie, Assistant Director, Oak Ridge National Laboratory, at the afternoon session of the Symposium on Atomic Energy, University of Puerto Rico, January 25, 1957.

Nuclear energy is the most powerful force to appear on the world scene during the past two decades. The dramatic story of the military conquest of the nucleus which has led to our present uneasy "thermonuclear peace" is now common knowledge. It is my belief, however, that the taming of nuclear energy has brought us to the threshhold of even more dramatic changes in our way of life. A new dimension is being added to human experience--which dimension has been variously designated as the Scientific Era or the Era of Science.

Last evening, January 24, Dr. Alvin M. Weinberg characterized nuclear energy as the harbinger of this Era of Science. In keeping with the changes which nuclear energy has already wrought in international affairs, we must anticipate that virtually every aspect of our way of life will be affected by the rapid application of scientific methodology to vast new areas of our living experience.

It follows quite directly that as we gain increased understanding of the details of nature, of the origin of life and our universe, and of the psyche of man that both our individual and collective living patterns must respond with changes. So we see, as Dr. Weinberg has pointed out, that our society must be increasingly sensitive, as time goes on, to the most recent discoveries at the very frontiers of science.

It is my belief that the proper degree of scientific sensitivity can best be achieved in a growth society such as Puerto Rico through the organization of a strong central scientific laboratory to which both the universities and industry contribute as full partners.

To be most effective, such an establishment must acquire the academic tradition and breadth of inquiry characteristic of the university--while at the same time retaining the organizational flexibility and dedication of purpose typically found in industrial research.

I believe that the effect of such a central establishment on the university and industrial interests in Puerto Rico would serve the people of Puerto Rico well in paving the way for them to achieve the greatest possible beneficial impact from the Era of Science.

I should like now, within this very broad framework, to investigate a single aspect of such a central scientific establishment. Specifically, I shall try to answer two questions:

UNITED STATES
ATOMIC ENERGY COMMISSION
Washington 25, D. C.

FOR RELEASE AT 10:00 A.M. (EST)
FRIDAY, JANUARY 25, 1957

REMARKS PREPARED BY CLARK D. GOODMAN
ASSISTANT DIRECTOR, DIVISION OF REACTOR DEVELOPMENT,
U. S. ATOMIC ENERGY COMMISSION
FOR PRESENTATION AT
TENTH OAK RIDGE REGIONAL SYMPOSIUM,
UNIVERSITY OF PUERTO RICO,
SAN JUAN, PUERTO RICO
JANUARY 25, 1957

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ATOMIC ENERGY AND THE EDUCATIONAL PROBLEMS OF OUR AGE

Dean Bueso, members of the faculty, and students of the atomic age -- my colleagues, in the Atomic Energy Commission and in the Oak Ridge National Laboratory, and I are pleased and honored to participate in this symposium, the first of its kind to be held on this lovely island of Puerto Rico.

The title of this talk is far more imposing than I would have chosen. However, I accept it as a challenge.

As students you may have some unpleasant associations with "educational problems." You may be thinking of these as problems that must be solved to complete an assignment or to pass a final examination. On the other hand, as viewed by your professors, such problems are mainly necessary evils which may serve the questionable functions of making students study and of forming the basis for final grades.

The "educational problems" to which I wish to direct your attention are of quite a different sort. You have been living with them most of your life. You may have even become unaware of their existence. These educational problems are the obstacles you have met and will continue to meet in your preparation for life. For education is surely the preparation for life as well as for professional accomplishment.

In this sense, I believe the number one educational problem of our age is the increasing complexity of our culture. Science continues to shrink distance, to increase leisure and comfort, to reduce manual labor, to widen communications among mankind and to open new vistas of the mind. But to partake of this expanding existence you must pay for it. You must know and understand more. As students of the atomic age you must learn more and learn it faster.

What is more as adults you must keep on learning in order to stay abreast of the times. Dr. Mortimer Graves, executive director of the American Council of Learned Societies, in an address last spring put it aptly when he said "to keep pace with this new age the American must learn as long as he lives; terminal education and the undertaker will arrive on the same day."

In its first interim report the President's Committee on Education emphasizes the need for every individual "to develop his or her talent to the fullest" to meet national needs and the increasing complexity of civilization. Furthermore, as my good friend Admiral H. G. Rickover recently stated before the Thomas A. Edison Foundation, "the more complex a society becomes, the larger proportionately is the number of intelligent, highly trained men needed for its proper functioning."

He pointed out "that a 3 per cent annual increase in our gross national product will require 4 1/2 to 5 1/2 per cent annual increase in scientific and engineering manpower. Or, to put it differently, in the last 20 years our population has increased by 35 per cent, but the number of scientists has increased by 450 per cent, and engineers by 225 per cent. Yet even this tremendous increase leaves us seriously short." With the rapid industrialization and population growth which you are experiencing in Puerto Rico, it will be necessary to increase your production of scientists and engineers at an even greater rate since many of your technically trained men and women migrate to the States or to South America.

The purpose of this symposium is to assist you and your leaders in the effort that faces all of us to work out practical means of meeting these educational needs. In particular we feel that the peaceful applications of atomic energy provide a new and stimulating area in which to develop this expanded educational program.

In order to carry out such a program you will need more teachers, particularly those trained in nuclear science and technology. This brings us face to face with the second big educational problem of today.

At a time when good technical teaching is most urgently needed, both in our colleges and in our high schools, the number of trained teachers in the United States is decreasing at an alarming rate. The number of qualified teachers of high school science and mathematics has fallen off about 53 per cent in the past five years while the high school student body has increased 16 per cent and continues to rise. The U. S. Atomic Energy Commission is keenly aware of this and is doing a great deal to help solve the problem. Chairman L. L. Strauss and Commissioner W. F. Libby have made numerous appeals to industrial, academic, government and philanthropic groups to awaken to this national need and to assist in bold, new educational programs designed to fill this need.

They have sparkplugged vigorous training and education assistance programs by the Commission of which this symposium is but one example. Since your new nuclear curriculum will want to follow much the same pattern as the Commission's activities in some areas, I will sumarize briefly our educational and training programs. At the advanced level the Commission has established three special graduate schools, The Oak Ridge School of Reactor Technology which has graduated 469 students sponsored by American industries and government agencies, the International School of Nuclear Science and Engineering which has 100 alumni from 29 countries and The Oak Ridge Institute of Nuclear Studies which has provided training and specialized research facilities for 4800 students and visiting faculty. As American universities take over the reponsibility, these schools, which were established to meet emergency needs, are gradually being converted to advanced laboratory training centers. AEC Fellowships in Nuclear Energy Technology (150 per year) in Radiological Physics (69 for 1956-57), and in Industrial Medicine (7 in 1956-57) are attracting talented scientists, engineers and physicians to these fields in which the need is especially acute. Graduate student research training (about 1180 per year) is provided through approximately 300 research contracts with about 100 colleges and universities.

Summer courses have been conducted in nuclear reactor technology for engineering faculty (90 in 1956). Likewise an additional 285 university faculty members participated in research programs at AEC laboratories during the summer of 1956.

As you know, the Commission is providing assistance to educational institutions to acquire training reactors, teaching aids, demonstration apparatus, laboratory equipment, and certain nuclear materials to be used primarily for educational and training purposes in nuclear technology courses. The University of Puerto Rico has applied for this assistance. We now come to the third major educational problem of our age. This is the language barrier. Even if we had an adequate number of qualified teachers and students adjusted to the complexities of modern civilization, there must be easy communication in the classroom. Language serves this purpose -- but it must be native, or nearly so, to both the teacher and the student.

I recently spent a year in Japan as a Fulbright Professor at Osaka University. Fortunately the students in my nuclear physics course could all read English. Despite this advantage it was very difficult to communicate orally any but the simplest concepts -- in a subject in which I feel concepts are the real keys to understanding. Needless to say, had it been necessary to communicate in written Japanese the barrier between us would have been almost impenetrable. You are indeed fortunate in having an essentially bilingual university. Spanish and English have common roots and hence are very similar both in the written and in the spoken language. The University of Puerto Rico is, therefore, ideally suited geographically, culturally and academically to serve as an educational bridge between the Americans.

There is a veritable flood of technical information in English but this needs to be reduced to Latin America's needs and presented in Spanish in order to be of greatest usefulness in most of the Central and South American countries. Next we come to the fourth big educational problem which is particularly close to my heart but which is difficult to express simply and clearly. It is what I alluded to a moment ago. You might call it conceptual teaching as contrasted to factual teaching. This approach is applicable to nearly all fields of knowledge but is essential in the physical sciences.

In brief the student should be presented with the true educational essence of mathematics, physics and chemistry. This does mean that practical applications are ignored. Quite the opposite; for in the ultimate all knowledge is first derived from experience. The relevance of fundamental knowledge to real situations must be understood and put to practical use.

However, in learning applied science the basic principles are often lost in a plethora of practical details. As a result the student finds it not only difficult to know where to hang his intellectual hat, but he is also likely to forget where he hung it. It is truly amazing how little we really need to remember and how much we can forget and still retain the real nourishment of a subject.

I submit that there must be something wrong with our teaching for this to be the case. Clearly we can no longer afford the luxury of gorging our minds in much the same manner as we so often gorge our stomachs. We must work out ways to make our teaching more effective, to increase our educational efficiency, as it were. Reasoning must replace rote learning. The accumulation of facts about science and technology is secondary to the mastery of a scientific method of thinking. The attainment of professional stature in science and engineering is best achieved through an orientation of mind and habit which begin in early childhood and follow continuously through high school and college. The education of future teachers in these fields is an objective of equal importance to that of training scientists and engineers. We must improve the instruction by reduction of detailed content and by increased emphasis upon fundamental principles and upon the development of powers of judgment and discrimination in the formulation and application of these principles. I will illustrate what I have in mind with only two of the numerous examples which could be cited. In classical mechanics as well as in the more modern wave mechanics, the principle of conservation of momentum is applicable without known exception. The basic principle is certainly simple. It hardly seems necessary to defer acquaintance with this concept until the senior year in high school. Yet that was my experience, and I believe such is still the case in general.

On the other hand, valuable elementary school time is spent in teaching the child about temperature, presumably because he meets this so frequently in everyday life and hence should surely know about it. Actually the concept of temperature, at least its true physical meaning, is much more difficult than momentum. Furthermore, because of its commonplace nature, temperature in the everyday sense is something the child will pick up easily outside of school. Why do we teach children about temperature but not about momentum?

I believe the answer to this question lies at the root of the problem. Our elementary science teachers have not been trained to appreciate what are the truly significant physical concepts. This is no reflection on them. Rather it is part of the broad problem of the gulf between our professional scientists and engineers and those who have the responsibility of teaching our children. We need a thorough updating of our textbooks. They contain too much scientific stuffing and not enough scientific meat. Furthermore, there should be continuity in content from grade to grade. In addition, for each group of textbooks there should be a teacher's companion reference book giving background information and perspective. Otherwise how can we expect our teachers to keep abreast authoritatively on the many new discoveries and developments of the atomic age? Textbook publishers should take more responsibility for providing the teachers with such backup information. Continuing with the momentum example, this concept would flow into the minds of our students in an unbroken sequence which might go something like this:

Grades 3 - 5.....First introduction of idea

Grades 6 - 8.....Simple numerical examples of conservation of linear momentum in collisions with marbles and bouncing balls as examples.

Grades 9 - 10....Two dimensional motion with numerical examples and problems. Extension to angular momentum with spinning tops and the momentum of the earth and of the planets as classical examples.

Grades 11 - 12...Linear and angular momentum as numerical examples in algebra and trigonometry. The momentum of fluids, gyroscopes, atoms, nuclei and light waves would be among the examples.

College 1 - 2....Waves, quanta, relativistic motion, space quantization, atomic and nuclear selection rules. Classical mechanics lead naturally into modern mechanics at this level with the proper preparation.

College 3 - 4....Wave mechanics, quantum electrodynamics, mesic fields, advanced mechanics and general relativity.

In this way we have been able to cover in college much of what is usually reserved for graduate school. However, we have actually expanded rather than telescoped the learning period largely by an early introduction followed by a slow soaking in which is so gradual that the student accepts the concept as one of nature's laws and not as an esoteric educational hurdle. If his technical education ceases at the end of the freshman or sophomore year, he would have a much better understanding of the world around him than is now the case. Likewise, the conservation of energy could follow a similar pattern. Here we probably would begin with the general principle that like momentum the conservation of energy is applicable without known exception. Then as the understanding of the student gradually increases we would broaden the definition of energy to include the various forms such as heat, chemical, electromagnetic, and mass (nuclear). The introduction to kinetic and potential energy would be a natural part of this subdivision.

Likewise, the means of transforming from one kind of energy to another would serve as familiar practical examples. By the time the student had reached the freshman year in college he would be able to understand and appreciate the significance of experiments such as that of Dr. Frederick Reines and Dr. Clyde Cowan, Jr. who recently established experimentally the existence of the neutrino, a particle without electrical charge and with vanishingly small mass. We have known for 20 years that such particles must exist -- otherwise our laws of the conservation of momentum and of energy would be violated. But until nuclear reactors were available as a source of neutrines, it was not possible to measure these elusive little beasties. This brillant work was supported by the U. S. Atomic Energy Commission. It is only one of many examples of fundamental discoveries which have been made under the sponsorship of the AEC. Needless to say, such discoveries are not made by more than a very small proportion of the scientists needed in this rapidly expanding field. Likewise, not every engineer can come up with a revolutionary development in reactor technology. Still there is a wealth of satisfaction in being a member of a scientific group that is carrying out fundamental research or in being a member of an engineering team that develops, constructs and places in operation a nuclear power plant.

Talented people are needed and needed in large numbers for these jobs. We are not productng nearly enough to fill the demand. This is the fifth and final educational problem which I will mention today.

The speech of Admiral Rickover, from which I quoted earlier, was devoted to this problem, "The Education of our Talented Children." He has pointed out that "one half of our children who are endowed with the ability to enter college and university do not do so. For every high school graduate who eventually earns a doctoral degree there are 25 others who have the mental capability to achieve that degree, but do not."

Rickover lays much of the blame for this "waste of our most precious national asset" to the fact that with few exeptions the talented children, the top 15 to 20 per cent who are capable of more intensive and more extensive training, "are being taught with the 80 per cent of average and below average mentality." Because the above average child is kept from advancing at the speed appropriate to his ability, he often loses interest in learning and may become a poor student from sheer boredom. I certainly agree with the Admiral's proposals:

a. "We shall not do justice to our talented youth until we seek them out at an early age -- no later than 10 or 11 -- and educate them separately", not necessarily in a separate school but in a college preparatory section of the school;

b. "The schooling must be purely academic, and the teachers must have professional competence in the subjects they teach";

c. "Admission as well as advancement into each higher grade should be by examination";

d. "If possible, the school year should be extended to 210 days", and

e. Industry, together with our educational foundations should set up model secondary schools (5th grade and above) which would be free but which would require passing entrance examinations designed to select only the talented for specialized training and preparation for entry in college at age 16 or earlier.

In summary, I consider the five major educational problems to be:

1. The complexity of our culture is increasing faster than the efficiency of our education,
2. The number of trained teachers is decreasing at an alarming rate,
3. Language barriers impede our international communication of ideas,
4. There is too much emphasis on factual knowledge and not enough educational effort on conceptual understanding, and
5. Our educational system neglects the talented in favor of the average.

There are undoubtedly other big educational problems, but these five seem foremost to me. In formulating plans for the future of technical education at the University of Puerto Rico, I am sure your leaders in government, industry and education are aware of these problems. The U. S. Atomic Energy Commission and its laboratories stand ready to help them and you in every way that we can to build a Spanish speaking technical education center which will be a model for all the world to admire and to emulate.

Miguel Wiewall
January 28, 1957

UNIVERSITY OF PUERTO RICO
Río Piedras, Puerto Rico

"A NUCLEAR PROGRAM FOR THE COLLEGES AT MAYAGUEZ"

I. Background.

Active interest in nuclear education began on this campus of the University of Puerto Rico about eight years ago with the visit of D. R. T. Overman, Head of the Special Training Division and Dr. R. S. Poor, then Head of the University Relations Division of the Oak Ridge Institute of Nuclear Studies. They made clear to us the possibilities in this field and the growing need of trained personnel for the various uses of the peaceful atom. As a result one member of our Physics Department went, in the summer of 1950, to Oak Ridge and took the short course in Isotope-handling Techniques. The following year a member of our Faculty of Agriculture took the same course, and since then two others, both from our Chemistry Department have taken it. These men have kept up their interest in the nuclear field. One of them, Dr. F. Saltero is now using a radio isotope in his current research. A recent activity of another, Dr. E. Ortiz, is mentioned further on. We also were visited by Dr. Ralph Lapp in connection with the Traveling Lecture Program of the Oak Ridge Institute and by Dr. W. G. Pollard its Executive Director.

II. Selection of the Type of Program.

As a result of this activity, the idea soon developed that we should offer to our own students some kind of course in nuclear science, and we were debating the question of the type of course or courses to be offered, when two years ago the Puerto Rico Water Resources Authority announced its interest in nuclear energy and the possibility of establishing a nuclear power plant on the Island. This helped us in making a decision, and we settled on four elective courses of advanced undergraduate level: a course in nuclear engineering in the Faculty of Engineering and courses in Atomic, Nuclear and Reactor Physics in the Faculty of Science. This brings us up to last summer, when Drs. J. L. García de Quevedo of the Engineering Faculty and E. Ortiz, of Science were sent to the Brookhaven National Laboratory, where they took an accelerated course in Nuclear Engineering which was offered under the auspices of the National Science Foundation. It was these professors who were to offer two of the subjects mentioned above during the fall semester. But things happened differently. On August 20, there was a meeting in Río Piedras with representatives of all sectors of the University attending, at which Admiral P. F. Foster, of the International Relations Division of the Atomic Energy Commission described the new assistance programs of the Commission. Shortly before this we had received an invitation to the Conference on Engineering Education and Nuclear Energy at Gatlinburg, Tennessee held under the joint auspices of the Oak Ridge Institute of Nuclear Studies, the Oak Ridge National Laboratory and the American Society for Engineering Education. Dean F. González-Mandry of our Faculty of Engineering and I attended this conference where the new programs of the Atomic Energy Commission were described in detail. We were also impressed with the amount and variety of activity already existing in the nuclear field and with its growing need of personnel of various types. It became apparent that the minimum type of offering we had planned would soon become inadequate and upon our return started planning a more ambitious program. Two other meetings in Río Piedras followed at which ideas were clarified and overall planning for the University was initiated. At the second of these, the Chancellor, Dr. Benítez described the results of the talk he and Dr. Marston Bates, Director of Research for the University had had with representatives of the A. E. C. in Washington. It was then decided that the offering on the Mayaguez campus should be a one-year graduate program in Nuclear Science and Technology.

Dean González-Mandry prepared the first draft of this program and after consultation and discussion with members of the Faculty of Science and with representatives of both the Atomic Energy Commission and the Oak Ridge

Institute of Nuclear Studies it assumed its present form.

TABLE I

SUGGESTED SPECIAL PROGRAM OF INSTRUCTION

IN

NUCLEAR SCIENCE AND TECHNOLOGY

Course Number	Course Name	Hours Lect. Weekly	Hours Lab. Weekly	Credit Hours
SUMMER (6 weeks)				
Math. 475	Math. of Modern Science I	9	0	3
Phys. 410	Atomic Physics	9	0	3
Phys. 415	Atomic Physics Laboratory	0	9	1
		18	9	7
FIRST SEMESTER (18 Weeks)				
Math. 476	Math. of Modern Science II	3	0	3
Phys. 503	Nuclear Physics	3	0	3
Chem. 501	Radiochemistry	2	3	3
Biol. 501	Health Physics	2	3	3
Nu. E. 501	Nuclear Reactor Technology I	3	0	3
Nu. E. 511	Reactor Instrumentation and Controls	1	3	2
		14	9	17
SECOND SEMESTER (18 Weeks)				
Phys. 504	Reactor Physics	3	0	3
Phys. 506	Nuclear & Reactor Phys. Lab.	0	3	1
Chem. 502	Chem. Processing of Nuclear Fuels	2	0	2
Nu. E. 502	Nuclear Reactor Technology II	3	3	4
Nu. E. 512	Reactor Metallurgy	2	3	3
Nu. E. 592	Seminar	3	3	4
		13	12	17

III. Proposed Graduate Program in Nuclear Science and Technology.

As can be seen this program, which is to lead to a Master's degree in the field consists of three sessions, one during the summer followed by two semester sessions during the regular academic year. A total of 41 credit hours of work are required of which 31 are in graduate level courses and the other 10 are in advanced undergraduate courses. The summer session is frankly preparatory and was put in because we realized that many of the possible candidates for this course would not have the required training in mathematics or physics. During the first semester the emphasis is on the basic sciences related to reactor operation, and during the second semester the applied science and technology of reactors is given greater consideration. It is clear that the main objective of the program is to give the student an adequate command of reactor theory and operation. Most of the individual courses included are quite standard, and require no further comment, but it is perhaps advisable to state what is to be included in four of them. The first of these is Nuclear Reactor Technology I. This is a course intended to introduce the student to the nuclear reactor and its engineering problems. Terminology, types of reactors and their component parts are to be considered. Towards the latter half, considerable time is to be given to the production of heat in reactors and its transfer and utilization elsewhere.

The next is Reactor Instrumentation and Controls. This course, besides its obvious sections includes one on the measurement of quantities important in reactor operation, such as neutron flux, gamma intensity and power levels.

Then there is the second course in Nuclear Reactor Technology. Here we propose to include consideration of the more important problems related to reactor design and operation. Typical section are: thermal convection in heat exchanger design; circulating fuel system; time behavior of reactor systems and an introduction to reactor economics. Last of the four courses to be described is Reactor Metallurgy. This course is intended to acquaint the student with the metallurgical problems inherent in reactor technology. However, due to the possibility that many of the students may not have any previous knowledge of the field, there will be an introductory section on elementary physical metallurgy. This will be followed by the metallurgy of the principal reactor elements, such as uranium, aluminum, zirconium and others. Besides mechanical properties of these metals and their fabrication problems, consideration will also be given to the damage which may be produced by radiation on reactor components.

Two other things need be said about the program itself. First it is intended for Spanishi- speaking students with a reading knowledge of English. Instruction is to be in Spanish but the textbooks will be in English due to the scarcity or total absence of suitable material of this type in Spanish. We, therefore, expect to get most of our students from Puerto Rico and Latin America. The other thing is that, although at the completion of the second semester the successful student will have completed his requirements and will obtain his degree, he will nevertheless be advised to take one or another of the intensive summer programs given at one of the national laboratories in order to round out his education in this field. It is our intention to cooperate with such students by making the necessary arrangements for them wherever possible.

IV. Problems Related with the Establishment of this Program.

Let us now consider the principal problems related with the establishment of this graduate program. The first of them concerns personnel. Although at present we have or shortly expect to have the personnel necessary for handling the program the first year, we realise that it will soon be necessary to expand the student capacity at the program. This will require more personnel, and it will be necessary to send some of our professors to one of the National Laboratories or to an American University with a well -

established graduate course in Nuclear Engineering in order to acquire further training or experience. In some cases an intensive summer course should be sufficient. In others it will be better to send them for the whole year. Preparation for this eventuality should start right away, and a faculty subcommittee has been appointed to handle this problem.

The next important problem is the procurement and installation of the laboratory equipment. Even with the generous aid of the A. E. C. this is still quite a problem due to the shortness of the time available between now and the date on which the proposed program is to start. Delivery periods are sometimes long, and it takes time and effort to install and test the equipment once it has arrived. Fortunately only one laboratory need be ready on the starting date, and that is the one in Atomic Physics, for the preliminary summer session. Three others, in Health Physics, Reactor Instrumentation and Controls and Radiochemistry must be ready by the start of the first semester towards the end of August. Of these, the last one presents the greatest difficulty, as it requires more installations than the others. The second semester laboratories present a lesser problem, as more time is available. Related to the above problems is that of securing space and other facilites for the laboratories. Space has already been assigned, but it must be made ready for the purpose it is to serve. Partitions must be moved or set up, laboratory tables must be obtained and installed, gas, water and electrical facilities must be secured, and so on. A second faculty subcommittee is already working on these problems. The remaining administrative problems constitute the province of a third subcommittee. They have to deal with such matters as securing and screening the candidates, public relations, and others. Administration of the program is handled by a nine-man committee composed of the three subcommittees mentioned, and the Chairman of which is Dean F. González-Mandry.

V. Plans for the Future.

In conclusion, let us consider briefly some of our plans for the future. The first and most important is securing a critical reactor, as during the first year of operation none will be available, its educational functions being substituted by a subcritical assembly and a reactor simulator. Final selection of the type to be obtained has not been made yet, but it will probably be one of the materials-testing types which have proved useful for training purposes. The power level should be between 10 Kw and 50 Kw. A building will be required to house this reactor as well as the other laboratories of the program, as the space now assigned for the latter is temporary.

Additional equipment must be obtained for all the laboratories, as the initial installations will contain only the minimum required. And it is also intended to add a laboratory to the subject dealing with Chemical Processing of Nuclear Fuels. This laboratory was not included in the first-year installations due to the expense involved.

Another of our plans is that of expanding facilities and personnel to accomodate more students, if the demand proves to exceed the proposed first year capacity of 15 students per laboratory session.

We have also given some consideration to the possibility of adding other types of offerings to our nuclear curriculum, such as an undergraduate option in one of the conventional engineering fields, in Physics or in Chemistry. Another possibility is a short training course in isotope techniques similar to those proposed for the Río Piedras campus, but with emphasis on industrial uses.

Finally, we have been giving some thought to research possibilities. We recognize that research is a necessary adjunct to graduate instruction, especially if good teachers and students are to be attracted. On the other hand it has already been agreed that basic research in the nuclear field is to be the province of the Rio Piedras campus. This leaves applied research for the Mayaguez faculties, which is quite suitable to the type of instruction we are to offer and can be readily handled by our new Engineering Experiment Station.

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