ORAU

ORAU: From the Beginning

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by

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Oak Ridge Associated Universities is a private, not-for-profit association of 46 colleges and universities. Established in 1946, it was one of the first university-based, science-related corporate management groups. It conducts programs of research, education, information, and training for the U.S. Department of Energy and a variety of private and governmental organizations. ORAU is noted for its cooperative programs and for its contributions to the development of science and human resources in the South.

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Foreword

The history of Oak Ridge Associated Universities is woven of numerous strands: World War II, the Manhattan Project, the creation of the secret city of Oak Ridge and its sophisticated scientific facilities, the desire of universities in the South to develop quality graduate programs in the sciences—and the extraordinary career of ORAU's principal creator and first executive director, Dr. William Pollard.

Dr. Pollard is a man of contrasts. He was trained as a physicist and came to maturity as a scientist in secret work on the gaseous-diffusion method of extracting uranium-235 during World War II. In his middle years, however, he was ordained an Episcopal priest. As a religious leader and a scientist, he explores in his books, sermons, and lectures those perplexing regions where faith and reason seem to collide, searching for commonalities and certainties in areas more noted for polarity and uncertainty.

Dr. Pollard is a builder. From its modest beginning in 1946, he led ORAU to a position of influence in science and education and in their interactions with the federal government. Dr. Pollard is also unmistakably an academic, clearly reflecting the years he spent as a teacher.

The institution that Dr. Pollard built is a complex one. It began—as the Oak Ridge Institute for Nuclear Studies (ORINS)—with clear mandates: to train university researchers in the use of radioisotopes and to act as liaison between the universities and what has become the Oak Ridge National Laboratory.

But that was more than three decades ago. Along the way, ORAU has become a leader in the development of nuclear medicine, administered an enormous, highly successful national fellowship program, created a national museum, developed a program of national and international traveling exhibits in science and energy, established an outstanding industrial training program, organized a new consortium (UNISOR) for basic research in nuclear physics, and, most recently, established an important energy analysis institute.

Some things have remained constant, however. ORAU is still an organization governed by universities. The guiding principle was stated by David Lilienthal, first chairman of the Atomic Energy Commission, who was director of the Tennessee Valley Authority at the time he played a role in the creation of ORAU. Lilienthal argued then that a sharp distinction should be drawn between management and participation: Participation . . . should be open to everyone without any element of regional bias, but the sponsorship . . . should draw upon the strength and coherence represented by the common aspirations and endeavors of the southern universities."

That principle has endured—only the number of governing universities has changed. From 14 founding universities, ORAU's membership has grown to 46, including the major research universities in the South. Their scientific resources include biological and marine-science field stations, phytotrons, regional computer centers, nuclear research reactors and laboratories, primate centers, vast medical research facilities, extensive agricultural research enterprises, a wide variety of energy-related centers and institutes, and much more. Clearly, the desire to develop quality graduate programs in the sciences has been realized.

At the same time, ORAU itself has grown into a substantial organization. It now employs some 500 persons to carry out a wide variety of programs in research, education, public information, and human resource development for the Department of Energy, other government agencies, and private organizations. Its cooperative research programs at DOE research facilities, as well as its other activities, attract outstanding scientists from throughout the United States and abroad.

Oak Ridge Associated Universities is an unusual organization. It has assumed responsibilities far beyond the original objectives of its creators. It has proven remarkably capable of adapting to a changing world and to shifting priorities. The story of the founding and development of this unusual organization is told by Dr. Pollard and others in the pages that follow. It is a chronicle of accomplishments of which he is justifiably proud and for which we honor him.

We can expect a continuing contribution from ORAU to the understanding of energy, health, and environmental problems through research, training, and public service. We should also expect that ORAU will catalyze interuniversity efforts to apply our best minds to the scientific and technological challenges of our nation.

Philip L. Johnson
Executive Director

1

The Beginning in the University of Tennessee

In the late 1930s and early 1940s before World War II, the great scientific research centers in the United States were confined to the Northeast, the Midwest, and California. With few exceptions, universities in the South were undergraduate institutions. The rest of the country looked upon them, and mostly they looked upon themselves, primarily as educators of students for the distinguished graduate research institutions in other regions. The southern universities became in this immediate prewar period, however, increasingly discontented with this subsidiary status. Younger professors, who had joined their faculties after exciting doctoral and postdoctoral research experiences elsewhere, chafed at the lack of facilities and opportunity for research. They were becoming actively involved with their administrations in efforts to initiate research and graduate programs in their institutions. Throughout the region there was a climate of hope and aspiration which the war both interrupted and, when it ended, intensified.

During the war, the Manhattan District of the Army Corps of Engineers under General Leslie R. Groves had been established to develop an atomic bomb.[1] The major laboratories for the research support of this project were at Columbia University, the University of Chicago (with later extension to the Clinton Laboratories in Tennessee), and the University of California (with extensions to the Y-12 plant in Tennesssee and the Los Alamos Scientific Laboratory in New Mexico). Numerous southern university faculty members in

[1] A fascinating account of this extraordinary project has been given in a book by a Hungarian journalist, Stephane Groueff; see *Manhattan Project* (Boston: Little, Brown and Co., 1967).

physics, chemistry, and engineering were recruited on leaves of absence for these large, government-supported research laboratories. The scientists returned to their universities after the war with renewed determination and enthusiasm for building their own research and graduate programs.

The potential for developing scientific research in the region was greatly enhanced by the location in the hills of East Tennessee of the major plants for isotope separation and the pilot plant for plutonium production, in what was then called Clinton Laboratories, together with the central administration of the entire Manhattan District. A complete city, Oak Ridge, had been hastily built in the early 1940s to house those involved in these activities; even larger temporary construction camps were built around Oak Ridge to house the construction crews building the various plants and facilities. A steady stream of the nation's most distinguished scientists passed through Oak Ridge, which they called "Dogpatch." For both these visitors and the resident scientific staff, the entire operation echoed the spartan frontier life of an earlier America.

Thus, an accident of the Second World War had placed a major scientific research laboratory in the backyard of the University of Tennessee in Knoxville and in proximity to many other universities in the South. At Clinton Laboratories a distinguished research staff was making important contributions in the new and exciting field of atomic energy. The air-cooled uranium-graphite nuclear reactor, or "pile" as it was called, running at a steady high power level, was an object of scientific wonder and excitement, as were the associated research programs in neutron physics, plutonium chemistry, and radioisotope production.[2]

This was the context within which interest in Oak Ridge grew, beginning at the University of Tennessee and spreading soon to other universities in the region. The first steps in this development were taken by Martin D. Whitaker, director of Clinton Laboratories, and Warren C. Johnson, director of its Chemistry Division. They were concerned about the large number of young, capable staff members who wished to return to their universities to complete their doctorates now that the war was over. A meeting was arranged in September 1945 with Dean Fred C. Smith and

[2] The Graphite Reactor is now an official United States historical monument open to the public.

Professor Kenneth L. Hertel, head of the physics department, of the University of Tennessee. Agreement was reached to establish a branch of the University of Tennessee Graduate School at Clinton Laboratories in which young scientists could start a graduate program in physics or chemistry without interrupting their employment. This program began operating in October 1945 and was the forerunner of what became the Resident Graduate Program described in chapter 8.

A spur to action at the University of Tennessee came with the announcement that the University of Chicago and the Argonne Laboratory were jointly establishing an institute of nuclear studies with a distinguished staff. With this development as a model, several faculty members at the University of Tennessee began to discuss seriously the possibility of establishing an institute of nuclear studies in Knoxville in conjunction with the Clinton Laboratories. These discussions led to the preparation of two draft proposals, one by William G. Pollard, who had just recently returned from a war research leave of absence at Columbia University for the Manhattan District, and the other by Robert M. Boarts of the University of Tennessee's chemical engineering department. University President James D. Hoskins was briefed on these proposals and was persuaded that the project was both important and promising. He appointed Hertel to chair a special university committee including Pollard and Boarts to continue work on the project.

Before continuing with an account of the work of this committee, it will be helpful to describe briefly the confused state of atomic energy legislation in Congress; confusion was to persist for another year and would affect all planning in this area throughout the nation. The Manhattan District of the Army Corps of Engineers had successfully completed its task and had no legislative authority for the postwar, peacetime development of atomic energy and nuclear science. Scientists were leaving Manhattan District laboratories in droves to return to academia, and several industrial contractors were anxious to be relieved of their wartime responsibilities. The need for congressional action was urgent. A bill ensuring continued military control under a commission, with a structure similar to the Manhattan District, had been drafted for the War Department. With some modifications it cleared both the War and State Departments and in October 1945 was introduced in the House by Andrew J. May, chairman of the House Armed Services Committee, and in the Senate by Edwin C. Johnson of Colorado. Brief committee hearings were scheduled and speedy passage by Congress was anticipated, but this was not to be.

Major opposition to the May-Johnson bill was spearheaded from Chicago and Oak Ridge by scientists who were or had been involved in Manhattan District work. Opposition later spread to other scientists, universities, and various public interest and citizens groups. In the course of the debate, Senator Brien McMahon introduced quite a different civilian control bill early in 1946. With several modifications relating mainly to military liaison and security, this bill was passed by the Senate on June 1, 1946. The House debate was also intense, and House passage came only after a number of crippling amendments, many of which were removed in the conference committee. The Atomic Energy Act of 1946 was finally passed by Congress on July 26 and signed into law by President Truman on August 1. Nominations for the five members of the United States Atomic Energy Commission established by this act were not announced until October 28, and the actual transfer of the Manhattan District to the AEC did not occur until January 1, 1947. The 1946 timetable is important in understanding the difficulties that every group in the nation faced in planning its future in atomic energy.[3]

In this atmosphere of uncertainty, the Hertel committee's task of creating an institute of nuclear studies at the University of Tennessee seemed formidable and no substantive steps emerged from its first meetings.

In an attempt to develop momentum as well as ideas, the committee members spent time in Washington, D.C., discussing the proposed institute with Tennessee congressmen and others. For the most part, these discussions were fruitless at the time, and left the committee feeling no closer to its goal. Two of these contacts, however, later proved to have been important. One was with General Leslie R. Groves, who headed the Manhattan District, and the other with Vannevar Bush, the director of the wartime

[3] A fuller account of the complex legislative history only briefly sketched here is given in the official history of the Atomic Energy Commission: Richard G. Hewlett and Oscar E. Anderson, Jr., *The New World: 1939-1946* (University Park: Pennsylvania State University Press, 1962).

Office of Scientific Research and Development, who later wrote the influential report *Science, the Endless Frontier*. Bush was also the chief architect of the National Science Foundation established by Congress in 1950.

Two developments in late October and early November 1945 proved crucial in redirecting the committee's thinking regarding its goal. University of Tennessee President Hoskins requested that the committee arrange to meet October 24, 1945, in Chattanooga with Paul J. Kruesi, an influential member of the executive committee of the University Board of Trustees and chairman of its finance committee. After a discussion of plans and opportunities, Kruesi made several observations, the most important being that the project was too big for the University of Tennessee to undertake alone. The proposal would be much stronger and have a far greater chance of success if it involved a number of universities in the South. He qualified this recommendation by observing that it had always proved difficult for a group of universities to work together effectively on anything. By following this course, the committee might wear itself out in fruitless attempts to create a workable situation. Nevertheless, Kruesi urged that this was the best course, and he authorized the University of Tennessee to relieve Pollard of all teaching duties so he could devote his time to the project. Kruesi also suggested that the committee discuss its plans with David E. Lilienthal, chairman of the board of the Tennessee Valley Authority. He believed Lilienthal would take an interest in the project and give valuable assistance and advice.

The second development, which reinforced Kruesi's recommendation, came in a letter dated November 3, 1945, to Hertel from Bush. This letter reads in part:

> *It seems to me quite clear that many of the facilities developed by the Manhattan District can at the proper time be made available to physicists under such conditions that scientific research will be greatly furthered. Since the facilities will, of course, be highly expensive and also expensive to operate, I judge that this will have to occur in only a few places, and hence it will probably occur by reason of arrangements with groups of universities rather than with individual universities. All of this, of course, is simply preliminary reasoning on my part, for the policy will have to be determined and the procedures worked out later. In fact, one of the reasons I have hoped that*

> *Congress would soon enact a bill for control in this country of atomic energy matters is that I feel only when this is done can such matters be worked out. When a commission is formed, the Manhattan District will go out of existence, all the properties will be transferred to the Commission, and the job of making all such arrangements as I am here discussing will then devolve on the Commission itself.*
>
> *Accordingly, I believe at the present time that the best steps to be taken by those interested are in the direction of planning. In particular, I hope that groups of universities will join together and make their plans in consort, for I believe this is most likely to lead to end results in the most effective manner.*

With this redirection in its thinking, the committee met with Lilienthal. At the least he was made aware of the project with its new multiuniversity emphasis, but at the time he did not take it very seriously. Most of the conversation centered on the May-Johnson bill and the problem of the international control of nuclear weapons, a topic with which Lilienthal was at the time heavily involved. (President Truman had appointed him to chair a committee to recommend a plan for nuclear control that could form the basis of United States policy in the United Nations.)

Of more immediate importance, Dean Smith agreed to have the University of Tennessee host a dinner at which the Hertel committee could share with a group of scientists from Clinton Laboratories the new direction the project had taken as a result of the meeting with Kruesi and the letter from Bush. The dinner meeting was held at the Andrew Johnson Hotel in Knoxville on November 8, 1945. Those attending from Clinton Laboratories were Ernest O. Wollan, Lothar W. Nordheim, Norman Elliott, George E. Boyd, Karl Z. Morgan, and Richard N. Lyon. Both groups became more enthusiastic throughout the evening. The outcome of the discussion was agreement that the University of Tennessee would host an exploratory conference of representatives from universities in the South. The planners hoped the conference would stimulate a multiuniversity cooperative effort. Faculty in physics, chemistry, biology and medicine, and engineering were invited. The Clinton Laboratories group agreed to provide speakers from Oak Ridge, and the Hertel committee invited the university representatives.

Hoskins agreed that the University of Tennessee would sponsor the "Conference on Research Opportunities in the Southeast" on December 5, 1945, at the Andrew Johnson Hotel in Knoxville.

Hertel went to the University of Kentucky while Pollard visited the Universities of Virginia and North Carolina and Duke University to explain the purpose of the conference. Vanderbilt University had been visited earlier. Formal letters of invitation were sent by Dean Smith to university presidents on November 22. The conference was convened with 38 representatives from the Universities of Chattanooga, Kentucky, North Carolina, Tennessee, and Virginia; Duke, Emory, and Vanderbilt Universities; and the Alabama and Virginia Polytechnic Institutes. In addition, there were 26 representatives from the Manhattan District, Clinton Laboratories, the Y-12 and K-25 plants in Oak Ridge, and the Tennessee Valley Authority. Hertel presided over the morning session, which was addressed by President Hoskins; Colonel Kenneth D. Nichols, district engineer of the Manhattan District; Charles A. Thomas, vice president of Monsanto Chemical Company, the contract operator of Clinton Laboratories; Martin D. Whitaker, director of Clinton Laboratories; and Hartselle D. Kinsey, general superintendent of the K-25 Gaseous Diffusion Plant. Francis G. Slack of the Vanderbilt physics department presided over the afternoon session, which consisted of addresses and discussion by Nordheim (physics), Elliott (chemistry), and Howard J. Curtis (biology and medicine), covering research opportunities at Clinton Laboratories.

Following the afternoon presentations, Pollard led a discussion of the desirability and feasibility of a cooperative university program at Oak Ridge and of ways to implement it. The discussion was positive and enthusiastic, resulting in the formation of an interim committee that included one person from each of the 10 universities represented. This committee was empowered to work out the details of a cooperative graduate program at Oak Ridge. The committee members were as follows:

William G. Pollard, chairman, University of Tennessee
Reuben A. Day, Jr., Emory University
Llewellyn G. Hoxton, University of Virginia
Paul W. McDaniel, Alabama Polytechnic Institute
Walter M. Nielsen, Duke University
Louis A. Pardue, University of Kentucky
Raymond B. Seymour, University of Chattanooga
Paul E. Shearin, University of North Carolina

Francis G. Slack, Vanderbilt University

Frank C. Vilbrandt, Virginia Polytechnic Institute

With the establishment of this committee, the central role of the University of Tennessee, with two exceptions, came to an end. The Hertel committee also completed its work and disbanded. The two exceptions were the already established graduate program at Clinton Laboratories and Pollard's full-time assignment to this project as authorized by Kruesi and supported by the university through the following calendar year of 1946. Although the leadership role of the University of Tennessee was confined to the brief, three months from September to December 1945, in retrospect it was crucial to the subsequent history of Oak Ridge Associated Universities.

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The Executive Committee

The first and, as it turned out, only task which the interim committee set itself was to convene a broadly representative conference of southern universities empowered to take action on behalf of those universities. Committee discussions centered around the date and objectives of the proposed conference and the selection of universities to be invited to send representatives. On the first question the committee learned that its member from Alabama Polytechnic Institute, Paul W. McDaniel, had taken a leave of absence to accept a staff appointment in the Research Division of the Manhattan District and would be moving to Oak Ridge as soon as the institute closed for Christmas vacation. McDaniel agreed to handle all local arrangements for a conference in Oak Ridge December 27-29, 1945. It would open with a plenary session at 7:30 P.M. on December 27 at which all participants would be assigned to working committees which would meet the following day and prepare reports. Saturday morning, December 29, would be set aside for a final plenary session during which definitive decisions would be reached on organization, name, and objectives of the institution to be formed and a mechanism adopted for the execution of these decisions.

Various approaches to the problem of selecting universities to be invited to participate in the conference were discussed. At the time there existed an organization known as the Conference of Deans of Southern Graduate Schools. It was decided that all 28 universities holding membership in this organization would be invited to send representatives to the Oak Ridge conference. A mailing list of the presidents of these institutions was drawn up and letters of invitation were mailed on December 10 by Pollard in his capacity as chairman of the interim committee.

The conference was attended by 41 representatives of 24 universities and medical schools. In addition, there were 19 participants from the Manhattan District and the three Oak Ridge plants. Everyone was assigned to one of eight committees which met all day Friday and prepared reports to be made to the full conference the following day. These committees were organization, administration, staff, credits and standards, financial support, immediate needs, engineering, and medicine.

In the final plenary session an executive committee was established and its university members elected from nominations submitted by the committee on administration. (After the conference, a member from the Tennessee Valley Authority was added.) The executive committee, charged with the responsibility of implementing the decisions reached by the conference, included the following:

William G. Pollard, chairman, University of Tennessee
John P. Ferris, Tennessee Valley Authority
Paul M. Gross, Duke University
Donald E. Hull, Carbide and Carbon Chemicals Company
Harvard L. Hull, Tennessee Eastman Corp.
Paul W. McDaniel, Manhattan District
Francis G. Slack, Vanderbilt University
Ernest O. Wollan, Clinton Laboratories

Participants in the final plenary session also decided that the name of the organization would be Oak Ridge Institute of Nuclear Studies (ORINS). In this decision the conference reflected some of the thinking of the initial stages of the Hertel committee and possibly was influenced by the example set by the University of Chicago. The specific activities outlined in the committee reports would certainly not constitute what would normally be meant by an "institute of nuclear studies." On the other hand, an unexpressed long-range aspiration within the conference was that the institution they proposed to create might someday actually become an institute of nuclear studies.

Finally, the conference authorized the executive committee to solicit funds from the represented universities to cover office and commissioned by the Argonne Universities Association, the corporate body to which the original plan has since led.)[3]

In the fall of 1945, there were no models for multiuniversity corporations established to manage research facilities or any other enterprise. It is of special interest, therefore, to note that in December 1945 steps to form just such organizations arose independently in three regions in different ways. Although the three university associations which finally emerged from these initial efforts—Associated Universities, Inc. (AUI), Argonne Universities Association (AUA), and Oak Ridge Associated Universities (ORAU)—are different in structure, function, and operating mode, they share their intimate connection with the three general nuclear energy laboratories—Brookhaven, Argonne, and Oak Ridge National Laboratories, respectively. More recently similar organizations have been formed: Associated Western Universities, Universities Research Association for the operation of the Fermi National Accelerator Laboratory, University Corporation for Atmospheric Research for the operation of the National Center for Atmospheric Research, and the Association of Universities for Research in Astronomy for the operation of the Kitt Peak Astronomical Observatory. What in 1945 was a vague idea has become the standard pattern in the United States for large, specialized research facilities.

The Argonne bylaws became both an important stimulus and a pattern for the draft proposals for ORINS: They moved the committee to undertake the difficult but necessary task of describing in detail the kind of institution the committee proposed to create and its relationship to Clinton Laboratories. The relationship would necessarily be different from that proposed for Argonne National Laboratory, since it was obviously not possible to superimpose a board of governors elected by a group of universities upon Monsanto Chemical Company management. Thus, the differences between the ORINS and Argonne bylaws increased significantly as more definitive drafts were written. The process of developing a concrete proposal was aided significantly by Ferris of TVA and Nordheim and Andrew Longacre of Clinton Laboratories.

[3] Leonard Greenbaum, *A Special Interest* (Ann Arbor: University of Michigan Press, 1971).

Another important development, partially suggested by the Argonne bylaws, was given shape by Lilienthal and Joseph C. Swidler, TVA general counsel. The executive committee had represented many diverse elements, including both universities and industries. Lilienthal and Swidler successfully urged a change of focus to only the universities of the region. Harvard L. Hull had at the time already left Tennessee Eastman to become associate director of Argonne National Laboratory, and Donald E. Hull (Carbide) and Ernest O. Wollan (Clinton Laboratories) readily agreed to withdraw. In their places, Frank P. Graham, president of the University of North Carolina, and John L. Newcomb, president of the University of Virginia, agreed to serve on the committee. Lilienthal agreed to serve as the TVA representative, and a seventh position was reserved for a representative from the Conference of Deans of Southern Graduate Schools, a position later filled by Dean William D. Funkhouser of the University of Kentucky. McDaniel remained on the committee as a representative from Alabama Polytechnic Institute (from which he was on leave of absence) rather than from the Manhattan District.

An important element in the development of the final ORINS proposal came at the urging of Swidler. He suggested that the executive committee form the Oak Ridge Institute of Nuclear Studies as a nonprofit corporation in which only regional universities could hold membership, with each university paying an annual membership fee of several thousand dollars. He also agreed that the TVA legal department would assist the committee in drawing up a charter of incorporation, bylaws, and procedures for incorporation.

The reorganized executive committee met in Knoxville on July 25, 1946, and elected Frank P. Graham as chairman, William G. Pollard as secretary, and Paul W. McDaniel as treasurer. Two earlier drafts of the proposal were considered in detail and agreement was reached on their consolidation into a final version for submission to Charles A. Thomas of Monsanto, the onsite managing company of Clinton Laboratories, and to Colonel Nichols of the Manhattan District. Pollard was authorized to transmit the proposal on behalf of the committee.

The first section of the three-part proposal was entitled "Basic Considerations and General Requirements." It consisted of a general statement of the need for and value of a close working relationship between Clinton Laboratories and regional universities to provide maximum scientific manpower for the nation. The second section, entitled "Structure and Operating Plan," was devoted to organization and structure. It called for the incorporation of the Oak Ridge Institute of Nuclear Studies as a nonprofit corporation organized to use Oak Ridge facilites for graduate and postdoctoral research and to develop the scientific potential of the region and its universities. The university members of the corporation would be represented on a Council of Sponsoring Institutions, with one representative for each member. The council would elect a board of directors that would, in turn, appoint a full-time salaried executive director. The board would negotiate a contract with the national atomic agency, after it was established by Congress. The nature and duties of the council, board, and executive director were described in detail.

The third section, "Contractual Relations and Division of Responsibilities," proposed that the Manhattan District, and later the national atomic agency, would contract with the institute to fund its operations. Other contractors in the Oak Ridge area would keep the institute informed of provisions in their contracts for educational programs for which the institute was responsible and would seek advice from the board of directors.

Although the Argonne bylaws dominated the efforts at proposal writing, important differences existed. The ORINS council was a body representing corporate membership, rather than participants in the national laboratory. The board of directors was not a board of governors of the laboratory but a board of directors of a separate university corporation. In the Argonne plan, the council and board would simply be added to the laboratory structure as an umbrella while ORINS would have contracts independent of the laboratory. The idea of the ORINS board's advising laboratory management persisted from its Argonne model in this proposal. Fortunately, in subsequent developments this advisory function was never exercised or even requested, so the frictions and misunderstandings that beset the midwestern universities were avoided by the southern universities.

The final proposal was then formally submitted to the Manhattan District and Monsanto Chemical Company on August 7, 1946, just after the Atomic Energy Act of 1946 was signed by Truman. On September 12 and 13, a meeting was held in St. Louis with Thomas of Monsanto; James H. Lum, director of Clinton Laboratories; and Nordheim, director of the Physics Division at Clinton Laboratories; with Lilienthal, Ferris, and Pollard representing the ORINS executive committee. The proposal was discussed in detail, and some modifications dealing with the relationship between Clinton Laboratories and ORINS were adopted to clarify proposed advisory functions. Following this meeting, Thomas advised Colonel Nichols that Monsanto and Clinton Laboratories agreed with the proposal and would support its implementation.

On September 18, 1946, the executive committee met with Colonel Nichols and his staff in his Oak Ridge office. The proposal was discussed at length and committee members responded to questions about the intent and scope of its various provisions. The meeting was cordial and the committee was urged to proceed. Following the meeting, Colonel Nichols wrote Frank Graham to confirm the verbal agreement. The central paragraph of his letter read:

> *It was understood that in view of the present transition status of atomic energy organization no far reaching policy commitments should be made which would be binding on the Atomic Energy Commission. It was, however, agreed that the following steps, being of mutual advantage, should be taken to implement the proposal:*
>
> *a. The Executive Committee should initiate the organization of the Oak Ridge Institute of Nuclear Studies by the various interested universities. It was understood that the Institute would be represented by responsible officials of the participating institutions.*
>
> *b. The Government should enter into a contract with the Institute when it is incorporated in order to secure advice and assistance on matters pertaining to the acquisition of scientific personnel and to the cooperation between the Clinton Engineer Works agencies and the educational institutions.*
>
> *c. The Government should subsidize the expenses of two formal meetings each year of the Board [of Directors] and such other meetings of the Board that the Government may call, and should provide office facilities for the resident staff of the Institute at Oak Ridge.*

With this letter in hand, the executive committee turned to the final steps of incorporation and organization. Swidler assigned Robert H. Marquis of TVA's legal department to draft a charter of incorporation in accordance with Tennessee law and a set of bylaws and to help the committee implement them. It was necessary at that time to have at least five incorporators; the committee chose Frank P. Graham, Paul M. Gross, William G. Pollard, Paul W. McDaniel, and Francis G. Slack. Pollard and McDaniel signed the charter at the University of Tennessee in the presence of a notary public on October 4, 1946, and mailed it to Gross. Gross and Graham signed it with notarization at the University of North Carolina in Chapel Hill on October 10 and mailed it to Slack. Slack signed at Vanderbilt on October 14 and took it to the Tennessee secretary of state's office at the capitol in Nashville where it was recorded and issued on October 15. The next day Pollard received it, and he and McDaniel took it to the Anderson County Courthouse in Clinton for recording. When the council met on October 17, the Oak Ridge Institute of Nuclear Studies was fully incorporated and ready for business.

In the meantime, letters of invitation to membership were drawn up for Graham's signature to be sent to the 19 universities recommended by the Conference of Deans of Southern Graduate Schools. These letters were sent on October 3 and included a call for the first meeting of the corporate membership on October 17:

Dear President ______

Reference is made to our letter to you of January 14 which described the ends being sought by the Executive Committee and requested your cooperation on four specific matters, and also to the report of this Committee which was sent to you on June 1. The purpose of this letter is to report briefly on progress made in the intervening period and to request further action by you in line with the requests made in the earlier letter.

During the summer the Committee was engaged in the development of a concrete proposal for an Oak Ridge Institute of Nuclear Studies. This proposal was completed and submitted to the Manhattan Engineer District on August 7. In taking this action the Committee reorganized itself by authority of the December 27-29 Oak Ridge Conference at which it had been formed. This reorganization was undertaken because the nature of the proposal made it desirable to have the membership of the Committee submitting it drawn from universities alone. It *was decided to add to the four university members of the old Committee representatives from members of the American Association of Universities who were not already represented on the Committee and to add a representative of the Conference of Deans of Southern Graduate Schools. The present membership of the Committee is indicated on this letterhead.*

Copies of the Proposal were sent to a number of Graduate Deans by Dean Funkhouser so that you may already have had occasion to read it. In case you have not, a copy is enclosed with this letter. It contains a few minor revisions which have been made as the result of subsequent discussions with the representatives of Clinton Laboratories and the Manhattan District.

Favorable action on this proposal has now been taken by the Manhattan District as indicated in a letter from Colonel Nichols dated September 25, a copy of which is attached. As a result of this action it is now necessary that the universities incorporate according to Part II, Sections C and E of the Proposal, so that the Institute Council may meet and elect its Board [of Directors]. Steps are now being taken to form the corporation in the State of Tennessee with five members of the Executive Committee acting as incorporators.

At a meeting of the reorganized Executive Committee held in Knoxville on July 25, the members voted to accept the responsibility for selecting the institutions which would compose the Council for the first year. The institutions selected by the Committee for this purpose are:

Alabama Polytechnic Institute
Catholic University of America
Clemson Agricultural College
Duke University
Emory University
Georgia School of Technology
University of Kentucky
University of Louisville
University of North Carolina
University of Tennessee
Louisiana State University
Tulane University
University of Alabama
University of Florida
University of Georgia
University of Texas
University of Virginia
Vanderbilt University
Virginia Polytechnic Institute

In accord with this action, I am pleased to extend to you on behalf of the Executive Committee an invitation to accept Council Membership for your university. The first Council will meet in Oak Ridge on Thursday, October 17. At this meeting, the Board [of Directors] of the Institute will be elected, by-laws of the

Corporation approved, and some of the broad terms of the contract with the Manhattan District or the Atomic Energy Commission discussed.

In order to prepare for this meeting, it is necessary that I have your acceptance of this invitation by Saturday, October 12. It should be clearly understood that such acceptance implies an agreement to contribute a sum of $5,000 per year for at least three years according to Part II, Section C, of the Proposal, and the naming of a responsible officer of your university (preferably yourself) as its representative on the Council. This representative may, of course, bring with him one or more scientific or technical advisors.

Sincerely yours,

Frank P. Graham
Chairman

Fourteen of those invited accepted and became charter members of the institute: Alabama Polytechnic Institute (now Auburn University), Catholic University of America, Duke University, Emory University, Georgia School of Technology (now Georgia Institute of Technology), Louisiana State University, Tulane University of Louisiana, University of Alabama, University of Kentucky, University of North Carolina consolidated, University of Tennessee, University of Texas, University of Virginia, and Vanderbilt University.

With the first council meeting on October 17, 1946, the executive committee had completed its task, although at the request of the council it agreed to serve on an interim basis until the first meeting of the board of directors could be held.

3

A Year of Crisis

When the first council assembled on October 17, 1946, it was unable to proceed with business because of a crisis at Clinton Laboratories. Earlier in the year several scientists from midwestern universities with connections at Clinton Laboratories had expressed interest in the movement to establish the Oak Ridge Institute of Nuclear Studies. This interest was discussed by the executive committee, and Pollard was authorized to send them the same materials being sent to the participants in the December 27-29 conference. When Graham's letters of invitation to the schools suggested by the Conference of Deans of Southern Graduate Schools were sent on October 3, Clinton Laboratories advised that two midwestern institutions should also be invited to become members. Invitations were extended; but when Lilienthal heard of it, he raised strong objections to such a course. Graham agreed with him, and telegrams withdrawing the invitations were subsequently sent.

At the time no precedent existed for establishing such an organization of universities. Arguments for both regional and non-regional management were strongly presented and defended. One solution was to have each university associate itself with the national laboratory in which it expected its participation to be greatest. Lilienthal's argument against this arrangement was that it made little distinction between the role of staff members and students participating in specific research projects at the laboratory and the university's role as overall sponsor on a long-term basis of the entire laboratory operation. He argued for a sharp distinction between management and participation: Participation in the national laboratory should be open to everyone without any element of regional bias, but the sponsorship of ORINS should draw on the strength and coherence represented by the common aspirations and endeavors of the southern universities.

By the fall of 1946, the eminent theoretical physicist who later received the Nobel prize, Eugene Wigner, had taken leave from Princeton University to become director of research at Clinton Laboratories. During the war Wigner, with assistance from a young physicist, Alvin Weinberg, had developed and supervised the engineering design of the first production nuclear reactors at Oak Ridge and Hanford. With Wigner came his former student and colleague, Frederick Seitz (later president of the National Academy of Sciences and then of Rockefeller University), to organize a school of reactor technology during a leave of absence from the Carnegie Institute of Technology. These two appointments gave Clinton Laboratories outstanding scientific leadership and made it possible to attract a highly qualified research staff. Both scientists later served on the ORINS board of directors and Seitz was the institute's vice president from 1946 to 1949.

When Wigner and Seitz learned of the Lilienthal-Graham decision on membership in ORINS, they urgently requested the ORINS council to meet with them and other Clinton Laboratories staff members on October 17 before conducting its regular business in order that mutual agreement could be reached on this question. The council, therefore, moved to Clinton Laboratories for a morning meeting which extended through lunch. The chief spokesman for the council was Graham and for the laboratory, Wigner. Although the discussion was not entirely satisfactory to either party, it resulted in a sufficient degree of understanding to allow the council to proceed with its business that afternoon. Graham later summarized the position of the council in the following passage:

> *The regional associations of universities implied by it (the national laboratory plan) can have great vitality and strength because they are rooted in, and sustained by, the general aspirations of the region they represent, and because they can draw on, and give effective voice to, the pride of a region in the development of its own institutions. The alternative of a management for each national laboratory based on the shifting interests and momentary advantage of individual universities*

> *and other institutions without regional localization of responsiblity or the sustaining influence of regional aspirations seemed to provide an amorphous and incoherent structure which would be incapable of long survival or continued growth. From the point of view of sound management policy, such an entity is unreliable because it has no basis for its existence except the specific day-by-day services which it can render each of its members.*

Subsequent experience has shown that the decision in favor of regional management was a wise one. During more than 30 years of corporate existence, the organization has been sustained and strengthened by the enthusiastic support of its sponsoring institutions as a direct result of their regional coherence and identity.

Following this meeting at Clinton Laboratories, the five incorporators met and adopted the bylaws which had been prepared for them by Marquis. They elected to corporate membership the universities that had accepted Graham's invitation and then the incorporators resigned as members, leaving only institutional members as specified in the bylaws. After this brief meeting, the first meeting of the council convened and Frank P. Graham was elected chairman of the council and president of the corporation. A board of directors was also elected, including David Lilienthal, who accepted immediately.

On October 28, 1946, President Truman announced the appointment of the five commissioners of the new United States Atomic Energy Commission, with David Lilienthal as chairman. The other four members were Robert F. Bacher, Sumner T. Pike, Lewis L. Strauss, and William W. Waymack. Of course, Lilienthal's appointment necessitated his resignation from the ORINS board, and he requested that the board not meet until the commission could get organized and take over responsibility for Manhattan District operations. Consequently, the next few months were frustrating ones for those launching the Oak Ridge Institute of Nuclear Studies. All were anxious to move ahead, and the enforced loss of momentum was discouraging, although everyone understood the situation.

On January 1, 1947, the Manhattan District was dissolved by executive order and all its facilities, staff, and appropriations were transferred to the AEC. With this action, Graham decided that another month and a half was adequate to meet Lilienthal's request and that the institute could not afford a longer delay. The first meeting of the ORINS board of directors was held in Oak Ridge on February 14-15, 1947. In addition to the president, Frank P. Graham, the members attending were Jesse W. Beams, University of Virginia; Ernest W. Goodpasture, dean of the Vanderbilt University School of Medicine; Paul M. Gross, Duke University; George B. Pegram, Columbia University; Frederick Seitz, Carnegie Institute of Technology; and William G. Pollard. In addition to necessary financial actions, the board authorized the appointment of a committee to recommend candidates for the position of executive director. The committee included Eugene Wigner as chairman, Arthur H. Compton, Karl T. Compton, Farrington Daniels, Lee A. DuBridge, and J. Robert Oppenheimer. Pending the report of the committee, Pollard was appointed acting executive director.

A major part of the meeting was devoted to the contract request to be made to the Atomic Energy Commission under the agreement in Colonel Nichol's letter following his meeting with the executive committee on September 18, 1946. A majority of board members believed that the program outlined in the proposal was too meager to be dignified by a contract with the AEC. Pollard and Gross were asked to consider this matter during the evening and to write a proposed description of work to be done under the contract on which the board could take action the next day. The result added to the activities in the original proposal the organization and conduct of special training courses for professional personnel, especially in the techniques for using radioactive isotopes in research. Clinton Laboratories was already producing a variety of radioisotopes in the uranium-graphite reactor for sale to the public, and it seemed essential to provide researchers and technicians with a way to learn the necessary techniques. With this addition, the board approved the formal request for a contract.

What had been the Manhattan District headquarters had now become one of the regional administrative offices of the Atomic Energy Commission, called the Oak Ridge Operations Office (OROO). The day after the board meeting, Pollard formally transmitted the board's contract request to OROO, and after some background discussion the request was transmitted to the AEC general manager, Carroll L. Wilson, with the recommendation that it be approved. After waiting a month with no word from Washington, Pollard decided to go there and try to expedite matters. He found the AEC offices in a state of mild chaos with many new employees arriving every day and few opportunities for getting them started productively on their new jobs. Wilson was out of town, but his administrative assistant found the record of the contract transmittal from Oak Ridge Operations. It had been referred to a new member of the Office of General Counsel, Clark C. Vogel, for action.

When Pollard arrived at Vogel's office, Vogel was sitting at his desk staring at a high pile of documents. A search through the pile uncovered the ORINS contract, and Vogel welcomed the presence of someone who could explain in detail its background and purpose. Pollard gave him a general picture of the Oak Ridge area and the various operations carried out there as well as a history of the university activities that had led to the incorporation of the Oak Ridge Institute of Nuclear Studies. They went through the proposed letter contract in detail and agreed on some changes of wording. Vogel and Pollard reviewed the contract with the general counsel and obtained his approval. James B. Fisk, director of research, was also consulted. Agreement was reached on the proposal, and the contract was mailed back to Oak Ridge with instructions for its implementation.

Soon after Pollard returned to Oak Ridge, he had a signed contract in hand. A suite of two offices was assigned to him in the AEC administration building together with office equipment and supplies. Within a few days, J. Walter Mumford was employed as business manager and Barbara McClannahan as secretary, and the Institute for Nuclear Studies was launched as an AEC contractor. At a meeting of the board of directors in October 1947, the Wigner committee recommended that the board appoint Pollard executive director for a five-year term.

During Eugene Wigner's year as research director at Clinton Laboratories (soon to become the Oak Ridge National Laboratory,[1] two significant reactor development projects were conducted. One was the design of a high neutron flux research reactor based on an ingenious type of fuel element that has since been employed in

[1] In the fall of 1947, Clinton Laboratories became Clinton National Laboratory, and in early 1948 this name was changed to its current designation—Oak Ridge National Laboratory (ORNL).

numerous smaller lower flux reactors. The other was a power reactor designed under the leadership of Farrington Daniels and called the Daniels pile. Much of Monsanto's interest in ORNL centered on the opportunity to build these two advanced reactors. The statutory General Advisory Committee of the AEC on the other hand opposed any steps to strengthen ORNL at the expense of other national laboratories largely because of its isolation in the South. In an effort to reconcile these interests, the AEC found itself increasingly alienating Charles A. Thomas, Monsanto vice president. Despite a succession of major concessions by AEC, these negotiations led on May 22, 1947, to a firm decision by Monsanto to withdraw as contract operator of ORNL.

Prior to this decision, the second meeting of the ORINS board of directors had been called for June 14, 1947, and the second meeting of the council for June 30, 1947. With the future contract operator of ORNL now open for selection, both of these meetings were devoted largely to considering the possibility that ORINS might be selected. Following the council meeting, a formal proposal was sent to AEC by Graham asking that Monsanto be replaced by ORINS as the operating contractor for ORNL. The reasoning was that ORNL was the only national laboratory not managed by an association of universities. Argonne National Laboratory (ANL) had a Board of Governors elected by its Council of Participating Institutions, and Associated Universities, Inc., (AUI) was preparing to establish and operate the Brookhaven National Laboratory. This pattern would be completed if ORINS were given the contract for ORNL.

In response to the council's proposal, Carroll Wilson, AEC general manager, wrote that AEC considered it necessary to choose an operating contractor with established management and construction experience and a large reservoir of management and technical personnel. It was later announced that the Atomic Energy Commission was considering the University of Chicago as a replacement for Monsanto, and representatives from that University and the AEC met with Pollard and staff members of ORNL in mid-August to explore this possibility. Following this meeting, ORINS board members Graham, Beams, Gross, Pegram, and Pollard met with Wilson and Fisk at AEC offices in Washington on August 14. The view emerging from this discussion was that the Oak Ridge situation was not comparable to that at either Argonne and Carbide management were also held. No change in the AEC decision resulted, but Lilienthal and George T. Felbeck, then president of Carbide and Carbon Chemicals Company, sent letters of strong support to the board, support which was fully borne out in practice during subsequent developments.[2]

It is interesting in retrospect to note how events often outrun policy. The AEC General Advisory Committee was firmly convinced that ORNL was not worth saving. The committee's chairman, J. Robert Oppenheimer, told the commissioners on March 30, 1947, "Most of us think that the evidence is in that Clinton will not live even if it is built up." Now the AEC had been forced to carry out this policy. By January 1948, the scientific staff of ORNL, with few exceptions, was discouraged and had essentially no hope for the future of the laboratory. Yet within two years the outlook had changed radically for the better.

Union Carbide turned out to be an exceptionally able and perceptive contract operator of ORNL and uniformly cooperative in its relations with ORINS. A second reason for the improved situation was that reactor development was not, in fact, transferred from Oak Ridge to Argonne, largely as a result of urgent AEC requirements for the development of submarine reactors for the Navy and heavy water production reactors for the Savannah River Plant. The combination of requirements strained the ANL reactor groups to the limit and forced all other reactor projects to ORNL. The appointment of Alvin M. Weinberg as research director in December 1948 provided ORNL with vigorous and imaginative leadership. At the same time, Alexander Hollaender was engaged in building the ORNL Biology Division into what soon would become, for a time, the world's largest and most distinguished biological laboratory. By the early 1950s, ORNL was recognized by the AEC, Congress, and the entire scientific community as one of the nation's leading research institutions. The accelerating pace of national atomic energy development had completely erased the dark forebodings of 1947. This new optimism also pervaded ORINS, as will be seen in the next chapter.

[2] A detailed account of this crisis period in the history of ORNL is given in the second volume of the official history of the Atomic Energy Commission: Richard G. Hewlett and Francis Duncan, *Atomic Shield: 1947-1952* (University Park: Pennsylvania State University Press, 1972), pp. 66-71, 76-79, 103-6, and 121 26.

or Brookhaven. The contract for Argonne National Laboratory was with the University of Chicago, which had full responsibility for operating the laboratory and for achieving AEC objectives. The ANL council and board were only superimposed over laboratory management and had no direct responsibility to the AEC. Brookhaven, on the other hand, was just being organized, and AUI could develop its management and technical pool as the laboratory developed. The ORINS board was assured of the full cooperation of both the University of Chicago and AEC in meeting its objectives along the lines already agreed upon with Monsanto. The formal announcement of the new contractual arrangement was made on September 25, 1947.

This arrangement ran into increasing difficulties, however. On December 30 Wilson and Fisk came to Oak Ridge to announce to ORNL staff members and to ORINS that Union Carbide, rather than the University of Chicago, would take over the contract from Monsanto; that all reactor development, including work on the high flux reactor and the Daniels power reactor, would be moved to ANL; and that ORNL would henceforth become primarily the chemical technology laboratory in the AEC research and development program. The effect of this announcement on the scientific staff of ORNL was catastrophic. All their dreams and aspirations were shattered. Reaction was bitter and angry, and many of the scientific staff made plans to leave the laboratory at the first opportunity. For ORINS, it seemed that the effort to deprive the South of a first-rate national laboratory (the effort that had elicited the *Science* article the previous year) had at last succeeded.

These concerns were shared with Graham, who was on an assignment for President Truman as the United Nations arbitrator of the Dutch-Indonesian problem. For neutrality, the negotiations were being conducted aboard a ship off Batavia, Java, and it was impossible to reach Graham by telephone. The following day, however, January 5, 1947, Graham came in to Batavia and Pollard reported to him in detail by telephone. As a result, Graham sent a cablegram to President Truman emphasizing the effect of this decision on scientific progress in the South. Graham also outlined what steps should be taken by the board of directors; his concerns were aired at a meeting in Washington on January 8, 1948, between Beams, Gross, Pollard, and Seitz for the ORINS board and Lilienthal and Waymack of the AEC. Meetings between the board

4

A Year of Rapid Growth

The Oak Ridge Institute of Nuclear Studies derived one major benefit from the negotiations with AEC over its selection of the University of Chicago to operate ORNL. For several months Pollard had been trying to get Oak Ridge Operations Office officials to assign to ORINS a building to house the Resident Graduate Program and the proposed radioisotope courses. Pollard wanted one wing of a four-wing brick laboratory structure adjacent to ORO. The building was originally intended for the Electromagnetic Separation Plant but was no longer used for this purpose. At the August 14, 1947, meeting in Washington, James B. Fisk agreed as a consolation to ORINS to order the assignment of this building to the institute.

Pollard and his office staff immediately moved into this building, which was prepared as office space, five classrooms, and chemistry and physics laboratories for the Resident Graduate Program of the University of Tennessee. A subcontract (under the ORINS prime contract with the AEC) had been negotiated with the University of Tennessee: ORINS would furnish all necessary space, equipment, supplies, and materials needed to conduct the program, as well as maintenance and custodial services. The university would enroll the students, provide instruction, and award resident graduate credit. ORINS would reimburse the university for the difference between the actual costs of onsite administration and instruction and fees collected from students. A full account of this highly successful off-campus graduate program is given in chapter 8.

Although a facility was now available for the proposed radioisotope techniques courses, there was no money. Two problems had to be resolved before funds could be obtained. Locally, Pollard had persuaded Ralph T. Overman of ORNL to help him develop the proposed courses. Overman, in turn, had appointed a committee of ORNL scientists to advise ORINS concerning them. Overman and Pollard were convinced that a way must be found to restrict the courses to a maximum of four weeks, if the practicing scientists needing such training were to be able to attend them. Many on Overman's committee, however, were equally convinced that a much longer period was required for adequate training. This difference was never fully resolved, although Overman persisted in designing a combined lecture-laboratory program which could be completed in four weeks.

The other problem was with the AEC in Washington, which had just established a Division of Biology and Medicine (DBM) under Shields Warren of the Harvard Medical School. The staff of this new division also questioned whether adequate training could be accomplished in four weeks. Moreover, they preferred to establish academic training programs in university medical schools and to avoid using the national laboratories for training purposes. In attempting to begin this program, however, they found that the universities insisted that training for their faculty would be essential. This requirement aroused an interest in the ORINS proposal as a temporary expedient. In the spring of 1948, DBM requested that ORINS conduct three of its proposed courses that summer, reserving one for participants from universities involved in its program.

Funding was provided to equip teaching laboratories, employ staff, and conduct three four-week courses during the summer of 1948. Overman began a crash effort to procure equipment. He assembled a staff of four instructors, and the three summer courses were held as planned. Only the third course had sufficient equipment on hand for the laboratory component, however. Demand for these courses proved great, and for many years they were offered six to eight times a year.

The success of these courses, which dispelled earlier reservations about their brevity, was a result of the large amount of laboratory practice they included. The participants received radioisotope shipments from ORNL, prepared them for each experiment under radioactive fume hoods with adequate lead brick shielding, and monitored radiation exposure at each step. Various experiments demonstrated the effects on activity measurements of background, scatter, absorption, etc. At the end of the four weeks, researchers were able to handle radioisotopes safely and reliably from shipment to final disposal, no matter what their field of research. This practical and effective training contributed greatly to the rapid postwar growth of radioisotopes as a research tool.

With the establishment of the Resident Graduate Program and the radioisotope courses in permanent facilities, the program outlined by the board in its initial contract proposal to AEC was complete. However, the AEC initiated two other programs that resulted in a considerable expansion in the scope of the work to be carried out under the ORINS contract, although they came as a surprise to the board.

Early in its first year of operation, the AEC established an Advisory Committee on Biology and Medicine under the chairmanship of Stafford L. Warren, who had been chief medical officer of the Manhattan District. This committee had assisted in setting up the DBM. As this new division's initial major program, the advisory committee recommended establishing at each of the national laboratories a clinical research facility to study the use of short-lived radioisotopes in diagnosing and treating cancer. The primary facility was to be the Argonne Cancer Research Hospital, as an adjunct to the School of Medicine of the University of Chicago, with smaller units at Oak Ridge and Brookhaven. This plan was approved by the AEC and steps to implement it were taken early in 1948.

In February 1948, the representative of the Division of Biology and Medicine in the Oak Ridge Operations Office briefed Pollard on this plan and asked that he determine the interest of ORINS in assuming responsibility for the Oak Ridge clinical research facility. As the first step, Pollard called a conference of representatives of the 20 medical schools in the region covered by ORINS membership. The conference was held in Oak Ridge on March 1-2, 1948. AEC representatives discussed the purpose and scope of the proposed activity with the participants, who then looked at the unused wing of the Oak Ridge Hospital that would house the proposed clinical facility. At the end of this conference, a recommendation was made to the board of directors that ORINS undertake the proposed program under certain stipulated conditions.

The recommendation was presented to the board at its meeting on March 13, 1948. The board authorized the executive director to negotiate a suitable amendment to the contract and to proceed with establishing a board of medical consultants as recommended by the conference. This medical board consisted of Marshall Brucer of the University of Texas Medical School at Galveston, chairman; Wilburt C. Davison, dean of the Duke University School of Medicine; Roy R. Kracke, dean of the University of Alabama School of Medicine; Vernon W. Lippard, dean of the Louisiana State University School of Medicine; Paul F. Hahn of the Meharry Medical College; and George T. Harrell of the Bowman-Gray School of Medicine. This board held several meetings in Oak Ridge and Washington and developed a detailed operating plan for the clinical research program. Upon approval of this plan by the AEC, the program became fully operational. A detailed account of the history of this program is given in chapter 11.

In the spring of 1948, Frank P. Graham was appointed by the governor of North Carolina to an unexpired term in the Senate. His new post made it necessary for him to resign from ORINS, leaving two key vacancies, president of the corporation and chairman of the council. At the third meeting of the council in June 1948, the bylaws were amended to separate these two offices; the chairman of the council would be elected from its membership for a term of three years and would serve ex officio as a member of the board of directors, and the president and vice president would be elected annually by the board from among its own membership. Under this amendment, J. Harris Purks, Jr., the representative of Emory University, was elected chairman of the council, and at a meeting of the board following this council meeting, Paul M. Gross was elected president and Jesse W. Beams vice president. The members of the board (in addition to Gross, Beams, and Purks) at this time were Ernest W. Goodpasture (Vanderbilt University), George B. Pegram (Columbia University), Theophilus S. Painter (University of Texas), Harold W. Stoke (Louisiana State University), Samuel C. Lind (University of Minnesota), and Eugene Wigner (Princeton University). Since its first meeting the council had elected 10 additional universities to membership in the corporation, bringing the total number of ORINS sponsors to 24.

The leadership which Paul Gross gave ORINS as president for the next 21 years was a major factor in its growth and competence.

His scientific stature and his wisdom in management were invaluable. He was at the time dean of the Graduate School of Duke University and later its vice president. He was a member of the first National Science Board, established in connection with the National Science Foundation, and its vice chairman for 7 years. In 1962 he was president of the American Association for the Advancement of Science, and in 1969 he received the Atomic Energy Commission Citation for outstanding service to the nation's nuclear energy program.

At its next meeting the board adopted an organizational structure with three divisions: medical, university relations, and special training. The board appointed Marshall Brucer chairman of the Medical Division, Russell S. Poor chairman of the University Relations Division, and Ralph T. Overman chairman of the Special Training Division.

The other major program development initiated by the AEC was equally unforeseen. At that time the entire Oak Ridge area was still enclosed by a high security fence, all access roads passed through guard posts, and visitors had to obtain temporary badges. By the end of 1948, the AEC decided that this level of security no longer served any purpose. On March 19, 1949, the Oak Ridge area, including the City of Oak Ridge, would be opened to the public although the three plant areas would be enclosed and guarded with even greater security. One of the problems of this plan was what to do with the tourists visiting the "atomic city." In response to the great public interest in Oak Ridge, aroused by the disclosures at the end of World War II, the number was expected to be quite large.

At the same time, many of the AEC contractors had designed and constructed a variety of exhibits for the New York City Golden Jubilee celebration. When that celebration ended in September 1948, the entire exhibit called "Man and the Atom" had been shipped to Oak Ridge where the exhibit was set up in a warehouse and shown to the Oak Ridge community beginning in October. The exhibit was then shipped to Cincinnati for a two-week showing. This trip, however, required 11 large trailers for transport and a sizable staff of workers and technical personnel. The AEC abandoned further plans for showing the exhibit and simply returned it to Oak Ridge for storage.

When plans for opening Oak Ridge to the public were announced, A. Dixon Johnson, head of the Information

Department of ORINS, urged that "Man and the Atom" be installed in a permanent museum of atomic energy in Oak Ridge so that visitors could see and learn something meaningful about atomic energy. Such an attraction would also reduce, if not eliminate, pressures for visits to the plant sites. Johnson and Pollard discussed this idea with the manager of ORO and his staff, and the AEC approved the plan early in February 1949. A wartime cafeteria building at Jefferson Avenue and the Oak Ridge Turnpike was assigned to ORINS to house the museum, and an administrative assistant, Paul M. Elza, was assigned to oversee its remodeling and make sure the exhibit was ready for the formal opening on March 19, 1949.

At its meeting in Oak Ridge on February 5, 1949, the board of directors established the American Museum of Atomic Energy as an ORINS division and appointed David L. DeJarnette as the first curator. In spite of the tight schedule, everything was ready when the city opened its gates to the public, and 800 people visited the museum that first day. Thus began ORINS's national role in public education in science and technology, a role that has been an integral, important facet of the association's program since its earliest days.

On January 1, 1948, ORINS had 3 employees; six months later on July 1, employment had grown to 29. By mid-1949, the number of employees was 68. The administrative and service functions of the organization were quite unprepared for such growth, and severe management strains developed. For example, there was neither a system of wage administration nor a job classification plan. In view of his extraordinary performance in readying the museum on time, Elza was placed in charge of administration. Fiscal management was already in good hands under J. Walter Mumford and James W. Rose, Jr. Elza also developed an effective personnel department and a technical services department under a competent engineer, Teackle W. Martin. Martin provided effective buildings, equipment, and grounds maintenance; construction management; and excellent instrument and cabinet shops. Elza later became assistant director for administration.

5

Consolidation and Advance

The four operating divisions established between March 1948 and March 1949 developed important, vigorous programs during the next few years under the leadership of their chairmen. A few significant developments have been singled out here for discussion.

Fellowship Administration

In April 1948, the Atomic Energy Commission began the first federally supported graduate fellowship program in the United States. To implement it, the AEC signed a contract with the National Research Council of the National Academy of Sciences, effective May 1, 1948. As a result of an incident with one of the fellows, Congress adopted a rider to the 1950 Independent Offices Appropriation Act requiring an FBI investigation and subsequent AEC review of loyalty before the fellows could be paid. This action led to the withdrawal of NRC from the administration of this program. The AEC then turned to its contractors for the Brookhaven and Argonne National Laboratories, the Lawrence Berkeley Laboratory, and ORINS for regional administration of the program during the year 1950-1951. From the next year until the program ended in 1973, the entire fellowship program was administered under contract with ORINS, and then ORAU.[1] A detailed report of these programs appears in chapter 10.

[1] As will be discussed later in this chapter, the Oak Ridge Institute for Nuclear Studies became Oak Ridge Associated Universities in 1966.

Atoms for Peace

On December 8, 1953, President Eisenhower delivered his famous "Atoms for Peace" speech to the United Nations General Assembly. This address resulted in the formation of the International Atomic Energy Agency, with headquarters in Vienna, and a large expansion of the AEC's international programs. The impact of this development was significant for the Special Training and Museum Divisions of ORINS.

In the Special Training Division, "Atoms for Peace" was inaugurated in May 1954 with a course in basic radioisotope techniques exclusively for students from other free world countries. Thereafter, 30 to 50 percent of the participants in each basic course have been foreign nationals, and increasing numbers have attended the variety of advanced courses being offered.

The division designed a mobile radioisotope laboratory: four radioactive chemical fume hood stations and four counting stations that fit into a van. The van was driven to host institutions to provide the laboratory component of the basic course, while the lectures were given in the institution's own classrooms. ORINS built three of these mobile laboratories, two of which were presented as gifts from the United States to the International Atomic Energy Agency. Later, two more mobile laboratories, which were even larger, were procured by ORINS; all three were operated by the Special Training Division for two-week training sessions for faculty and advanced students at small colleges throughout the United States.

The AEC also developed two large exhibit units called "Atoms at Work"; one was operated for extended periods in various European and Southeast Asian nations and the other in Latin America. ORINS provided instruction in nuclear instrumentation, radioisotope handling techniques, and in basic science for high school science teachers in the specially designed and equipped classroom and laboratory facilities that were included in these exhibits.

In its first year, the Museum Division provided many exhibits for showings outside of Oak Ridge. Nine exhibits were shipped to the Michigan State Fair in Detroit in September 1949 for a special atomic energy display, and in October 1949 the museum provided exhibits for an atomic energy exhibit hall at the Texas State Fair in Dallas.

In the meantime, the National University Extension Association (NUEA) at its 1948 annual meeting established a committee on the implications of atomic energy, under the chairmanship of Lorentz H. Adolfson, extension director at the University of Wisconsin. As a result of discussions with the AEC, it was decided that the most effective method of widely disseminating information on atomic energy would be a traveling exhibit, which the AEC asked ORINS to design and construct. Designed for transport in a large tractor-trailer, the components to fit an exhibit hall with 7,500 square feet of floor space were completed in the fall of 1951. NUEA sponsored the exhibit and made all scheduling arrangements with state extension services, which paid ORINS for the showings. ORINS maintained the vehicle and exhibits and provided a truck driver and exhibits manager. The first exhibition was in Alabama in October 1951, and the program continued with many successful showings until 1956.

In 1956 the AEC decided to launch a domestic "Atoms for Peace" program through traveling exhibits. As a result, the Museum Division launched a major design, fabrication, and procurement program for a number of entirely new exhibits. Three large trailer exhibits were completed to replace the older NUEA exhibit and were turned over in the fall to the NUEA, which scheduled them without charge to state extension services. In addition, five mobile walk-through exhibits mounted in specially constructed air-conditioned vans were built. These constituted the primary national program of the U.S. Junior Chamber of Commerce; the showings were locally promoted and managed by individual Jaycee chapters. These major design and fabrication activities continued as part of the museum's responsibility until 1964. The last major exhibit produced by ORINS was for the New York World's Fair. It was a self-contained children's museum called "Atomsville, USA," located on the lower level of the permanent Hall of Science building. It was opened to the public on June 15, 1964, in a ceremony conducted by Robert Moses, president of the fair, and AEC Chairman Glenn T. Seaborg. Since then, Museum Division traveling exhibits have been designed and constructed by contract through AEC headquarters in Washington and delivered to ORINS/ORAU to operate.

Another component of the 1956 "Atoms for Peace" exhibit was the high school assembly lecture-demonstration program "This

Atomic World," which is carried in a small panel truck; three units were built. They were operated by specially trained teacher-demonstrators, who drove to different high schools each day. At the same time, a grant was received from the National Science Foundation to support a program of traveling science teachers. Seven teachers were given extensive training in the summer of 1956 and visited high schools during the following school year, carrying inexpensive laboratory apparatus and demonstration equipment in station wagons donated for the program by the Ford Motor Company. Both programs were operated separately for a few years and then consolidated under "This Atomic World." By 1973, there were 22 units visiting a large number of high schools throughout the United States each year. That year the AEC decided to develop other types of traveling exhibits, and ORAU decided to continue the program with private funds, chiefly from electric utilities. On July 1, 1973, ORAU established the Energy Education Office under Courtland Randall, and the AEC transferred title to the vehicles and demonstration equipment to ORAU. Since then, the program has grown and flourished as a purely corporate operation, with an annual budget of more than $1 million. A history of this development is detailed in chapter 12.

Land and Buildings

One of the early actions of the AEC Oak Ridge Operations Office was to commission the firm of Skidmore, Owens, and Merrill to draw up a master plan for the development of the City of Oak Ridge. This plan would guide the AEC in carrying out the rather massive construction program of houses, apartments, and municipal facilities made necessary by the extremely temporary character of many of the wartime structures. All property in Oak Ridge was then government owned, and the objective of the plan was an orderly transition to the time when all residential and commercial properties could be sold and Oak Ridge could incorporate as a normal city.

In the master plan, a choice 36-acre tract in the very center of Oak Ridge was designated for educational institutions. The plan was not specific as to what this designation meant, but the planners possibly had in mind a community college or, even at that early stage, ORINS itself. In any event Pollard showed Paul M. Gross this plan in early 1956 and suggested that ORINS purchase the designated tract. The AEC had already sold a number of pieces of land to churches for $300 an acre, and it seemed reasonable that ORINS would qualify for the same rate. Gross became convinced of the wisdom of such a course and persuaded the other members of the board.

In 1956 the annual meeting of the council was scheduled for October 16. Since the charter of incorporation had been granted by the state on October 15, 1946, a tenth anniversary banquet for the board of directors and council was planned at the Deane Hill Country Club in Knoxville the evening before the council meeting. The manager of ORO, Samuel R. Sapirie, attended as a guest of ORINS. Gross had with him a check in the amount of $10,902 drawn on the corporate account, and Sapirie had a deed to 36.34 acres drawn in favor of ORINS. At the banquet, they exchanged these documents with appropriate comments.

The AEC continued the Manhattan District's pattern of designing and constructing all production and research facilities, which were then turned over to a contractor to operate. Thus, all plant facilities and equipment are government owned, and AEC prime contractors are referred to as GOCO contractors, meaning "government owned, contractor operated." Throughout its history, ORAU has been a GOCO contractor, with most of its buildings and practically all of its equipment owned by the government. Under its prime contract, ORAU has custodianship liability for the proper care and maintenance of all such property it occupies and uses. It was, therefore, a major departure from the established pattern when, in 1956, ORINS proposed erecting on its newly acquired land a building to house its central administration.

There were, however, strong pressures on both ORINS and AEC to construct such a building. In the late 1950s, ORINS was in a period of rapid growth, and the administration building furnished by the AEC was inadequate; it was, moreover, badly needed to house new activities of the ORINS divisions. Suitable space in other AEC facilities was simply not available, and limits placed by Congress on the AEC for new construction made it difficult to provide space needed for the ORINS programs already approved and funded by the AEC. It was agreed, therefore, that if ORINS would construct the building, the AEC would include in its contract a negotiated space allowance for its use by ORINS to carry out AEC programs. With this agreement in hand, grants for the building in the amount of $10,000 from the Benwood Foundation and $35,000 from the Lilly Endowment were obtained. These grants, combined with corporate monies accrued over the years, made it possible to proceed with architectural design and construction. A bank loan that would eventually be repaid from the AEC space allowance was also obtained. The building was occupied on October 5, 1959.

Soon after completion of the administration building, equally urgent pressures developed for housing the technical library, which occupied cramped quarters incapable of further expansion in the original building provided to ORINS for the Resident Graduate Program and the radioisotope courses. Again with the concurrence of AEC, ORINS constructed the library building, which was occupied in February 1963. This building has since been remodeled for the Institute for Energy Analysis and the Energy Education Division.

The original radiopharmaceutical production facilities of the Abbott Laboratories were near the ORINS Medical Division; they had been located in Oak Ridge in order to be near the source of radioisotopes at ORNL. When ORNL ceased commercial production of radioisotopes, Abbott Laboratories moved its facility to its main plant in North Chicago. The building remained vacant for a number of years while the company tried unsuccessfully to sell it. ORINS was interested in acquiring the building and finally purchased it on January 6, 1967, for $67,500.

In the meantime, a problem arose regarding the colony of South American marmosets used at ORINS for medical research. This colony was maintained outside the AEC contract under private grants and was housed in a rented wartime apartment building of substandard construction. The colony was threatened by the poor environment and conditions inadequate for disease control; the bank also foreclosed on the owner who leased it to ORINS. The board of directors responded to the need for proper housing by authorizing the construction of a new facility which was occupied in May 1968.

In 1979 the acquisition cost of ORAU's corporately owned land, paved areas, buildings, and equipment stands at more than $2 million; the market value, of course, is substantially higher. Even for those involved in the transactions, it is something of a mystery how a corporation with such limited resources was able to acquire an investment of this size. The boldness and wisdom of the board of directors, in 1956, when it was decided to buy the land, have been amply justified by subsequent developments. ORAU continues to be classed as a GOCO contractor of what is now the Department of Energy (DOE), but the size of its corporately owned facilities devoted to carrying out DOE activities places it in a unique category among GOCO contractors.

One final comment on buildings is appropriate at this point. The eastern boundary of the ORAU property is formed by Badger Avenue. Between Badger Avenue and the major thoroughfare, South Tulane Avenue, is a 17-acre tract held by DOE. When Oak Ridge was included in the congressional district of Congressman Joe L. Evins (now retired), he announced that he would do all in his power to have the federal government construct a proper building for the American Museum of Atomic Energy. He was successful, and in the spring of 1974, the museum moved from the wartime cafeteria building into the beautiful new $3.6 million facility. The land and building have been placed in the custody of ORAU as operating contractor for the museum, so that ORAU now manages both this property and its own as a single continuous entity. The Museum building is architecturally compatible with the three nearby ORAU buildings, the four forming a pleasing group.

Flexibility

In following the history of ORAU, one sees clearly the flexibility of its activities and programs, their great diversity, and the complexity of the pattern they form. The programs and activities of one year often bear little resemblance to those 10 years earlier or 10 years later. Even 5-year intervals sometimes show marked changes. New programs appear, grow to peak activity, and then decline. When this pattern occurs in the several divisions simultaneously (covering the whole spectrum of fields from public education to medical research), the effect is kaleidoscopic. The organization is surely characterized by a broad diversity of program responsibilities and highly flexible and imaginative responses to changing needs and opportunities.

At its spring meeting in 1965, the council discussed the need to change the institute's name. For almost 20 years ORINS had been growing, developing, and changing to such an extent that the name no longer fully expressed its many endeavors and directions. In the October meeting, the council members voted to change the name of the Oak Ridge Institute of Nuclear Studies to Oak Ridge Associated Universities, effective January 1, 1966. In making the change, the council, in effect, legitimated the organization's true role in the academic and research communities, and it broadened the opportunity for member institutions to participate through ORAU in many fields of education and research beyond those related to nuclear energy. On the other hand, as Paul Gross said, "The new organization, while providing the broad flexibility needed to accept challenging assignments in many areas of endeavor, will in no way diminish its continued interest in doing a more effective job in matters related to atomic energy."

In 1973, because Pollard was approaching mandatory retirement at age 65, the board of directors began the task of selecting his successor as executive director. In August 1974, Philip L. Johnson replaced Pollard as executive director. Johnson, who came to ORAU from the National Science Foundation, has brought the organization to the highest funding level in its history and negotiated a very favorable extension of its DOE contract through June 1982. ORAU is flourishing and, assuming it can maintain the flexibility and imaginative response to new needs and opportunities that have characterized it in the past, its prospects for the future are bright indeed.

ORAU and Its Sponsoring Institutions

The program that the university representatives primarily had in mind when they decided to form ORINS in 1945 was one that would make the facilities of ORNL available to their scientific faculties. In response to this need, the Faculty Research Participation Program was developed. The program had 2 participants in the summer of 1947, its first year, and 6 the next year. Under Russell Poor, it expanded rapidly to 21 participants in the summer of 1949 and 70 in the summer of 1950, a level that was maintained each summer for many years. Several participants returned for a second summer and all were placed on travel reimbursement contracts, which permitted return visits to the laboratory research group. This program was supplemented by a program of traveling lectures—ORNL staff members visited universities to give seminars and to consult with faculty on the development of their graduate programs and research.

The effect of these programs was the rapid development of close personal working relationships between the scientists at ORNL and the universities. New research techniques and instrumentation developed at ORNL quickly became familiar to university researchers, resulting in an acceleration in the number of research grants to academicians. This interaction was certainly a major factor in the spectacular growth of graduate education and research programs in the sciences that occurred in southern universities during the 1950s and 1960s. As part of the celebration of ORAU's 25th anniversary in 1971, a book was published documenting and describing this growth and the part played in it by ORAU, ORNL, and directly by the AEC.[1]

As valuable as faculty research participation proved to be for the growth of science programs in southern universities, it also resulted in some very important contributions to the Atomic Energy Commission.

One of the early faculty participants from Vanderbilt University, Dr. Newton Underwood, developed a new method for fabricating barrier tubes, the essential components for separating uranium isotopes in the nation's gaseous diffusion plants, which was considerably less expensive and more reliable than the method then in use. This contribution during a participation assignment was adopted, and thus saved the government many times its total investment in this program.

Another research participant, Dr. Harold H. Garretson of Lynchburg College, during a research-participation assignment and subsequently, made a significant contribution in developing solvents and chemical reflux methods for the separation of lithium isotopes that were of prime importance for the achievement of national objectives in this period.

Manpower Development

A characteristic of ORAU from its earliest days has been the cooperative and enthusiastic spirit that has marked the meetings of the council. Many have expressed amazement that such a large number of universities could work together over so long a period without dissension or conflict. There was, however, one exception to this enviable record of consensus between the membership and management of ORAU.

In June 1964, Wendell Russell, who was then the administrative officer in the Museum Division, requested a leave of absence for one year. The National Sharecroppers Fund had received a grant from the Department of Labor to study untapped manpower resources in the South and had engaged J. Earl Williams, an economics professor at the University of Tennessee, to direct the study. Williams had asked Russell to join him in this endeavor and the requested leave of absence was granted. Williams and Russell,

[1] William G. Pollard, *Atomic Energy and Southern Science* (Oak Ridge: Oak Ridge Associated Universities, 1971).

however, experienced increasing frustrations in working for the National Sharecroppers Fund, which is primarily an activist organization not well equipped for the management of a study of this sort. In April 1965 they requested that ORINS accept a contract from the Department of Labor to continue and complete this study. The ORINS board of directors considered the request reasonable and saw no problem with ORINS accepting what seemed at the time an appropriate accommodation for a valued employee. The contract with the Department of Labor was signed.

Before the ORINS program could be implemented, Williams was called to Washington for President Johnson's "War on Poverty" program, and Russell took over direction of the study. A team of university faculty and graduate students was assembled, and throughout the summer of 1965 the team visited university and state departments concerned with human resources and collected data for the study. The final report was issued by ORINS in October 1965.[2] Soon after the distribution of this report to interested departments in member colleges and universities, Pollard began receiving letters from their presidents objecting to the association's entry into a field outside the natural sciences. Apparently social science faculty members objected to what they supposed were physical scientists in Oak Ridge entering their fields and appropriating a choice Department of Labor contract which they felt should rightfully have gone to university researchers. They had gone to their presidents to ask that ORINS cease activities of this sort. During the year, it became increasingly evident that these were not isolated instances of disgruntled faculty members, but expressions of growing concern and dissatisfaction by an increasing number of presidents of ORINS sponsoring institutions.

The annual meeting of the council in 1966 was held on October 18, with a banquet on October 17 to celebrate the twentieth anniversary. At that time, there were 40 member universities of ORINS (now ORAU)—and 13 of the presidents accompanied their council representatives to the meeting. Much of the meeting was

2 Southern Manpower Technical Assistance Program of the ORINS, *Resources for Southern Manpower Development*, Report to the U.S. Department of Labor, Office of Manpower, Automation, and Training (Oak Ridge: Oak Ridge Institute of Nuclear Studies, 1965).

devoted to discussion, led by the presidents, of the scope of ORAU activities and to the adoption of guidelines for new program initiatives in the future. It was the only meeting of the council ever marked by a sense of tension and crisis about the relations between ORAU and its member universities.

In the meantime, during the winter of 1966, Wendell Russell and William R. Ramsay (then head of ORAU's General Services Department) had been implementing some of the recommendations in the Department of Labor report. One recommendation, which drew heavily on the long history of effective cooperation between ORAU and Union Carbide, planned the use of abilities and experience for training in industrial skills available at Union Carbide's Y-12 Plant, the wartime electromagnetic isotope separation facility. Both Union Carbide and the AEC enthusiastically received the idea, and Russell succeeded in obtaining Department of Labor funding as a special Manpower Development Training Administration program. Called "Training and Technology," it was designed to train high school dropouts and disadvantaged and minority youths in machining, drafting, welding, and a number of other industrial skills. The program got under way in June 1966. Another program developed by Ramsay was for student internships in economic and resource development. Students undertook summer projects desired by various community, county, and regional development associations, under the direction of a faculty adviser. The initial program in the summer of 1966 was funded by the TVA and the Economic Development Administration.

Because the Training and Technology project was carried out in AEC facilities in Oak Ridge as a cooperative effort of ORAU and Union Carbide, it fell within the program guidelines established later that year by the council and was continued. It is now well established and is considered by the Department of Labor to be a model for industrial skill training for the disadvantaged. The student internships in economic development did not, however, conform to council guidelines, and ORAU transferred the program to the Southern Regional Education Board in Atlanta.

Population Research

Two unsuccessful ventures in population research, each with a large component of university participation, were undertaken by ORAU as corporately supported activities. The first originated in

1970 at ORNL, which, as part of its major civil defense research program under the direction of Eugene Wigner, had acquired an extensive data bank for urban population studies and projections. The laboratory procured the 1970 census data on magnetic tape; combined with its extensive computer and data processing facilities, this tape constituted a unique resource for demographic research. Two demographers serving as consultants to ORNL, Everett S. Lee of the University of Georgia and William W. Pendleton, Jr., of Emory University, approached ORAU with the possibility of sponsoring an organization of southern research demographers. As a result, the Southern Regional Demographic Group (SRDG) was formed under ORAU sponsorship in the fall of 1970 with its proposed bylaws approved by the ORAU board of directors. The initial membership meeting with 140 social science faculty members principally from ORAU universities was held in Oak Ridge in March 1971 in conjunction with the "Research and the 1970 Census" conference that was supported by a grant from the Center for Population Research of the National Institutes of Health. On February 1, 1972, a two-year grant was made to ORAU by the Ford Foundation to support a resident staff and travel expenses of SRDG members with the hope of establishing the organization on a permanent basis. ORAU supplemented this grant for all indirect costs in the amount of approximately $12,000 per year. The SRDG staff and executive committee were, however, unsuccessful in obtaining additional funding for this activity, and with the termination of the Ford Foundation grant on March 31, 1974, the SRDG office was closed. However, ORAU continues to oversee the activities of SRDG, which has continued to grow as a professional organization.

The other parallel activity was the formation of the Oak Ridge Population Research Institute (ORPRI) as a cooperative venture in reproductive biology of ORAU, the Biology Division of ORNL, and the Department of Zoology of the University of Tennessee. The ORAU board of directors approved this venture as a corporate activity in June 1971. The institute began functioning on July 1, 1972, with Melvin M. Ketchel as director for an assured term of three years. Later, Joseph C. Daniel, Jr., of the University of Tennessee became a part-time associate director. Plans for the research program of ORPRI were carefully drawn and supported by a high level of staff competence. The timing, however, turned out to be wrong, since federal funding for new population research centers ceased after 1972; the program was ended on June 30, 1975.

University Isotope Separator—Oak Ridge

A unique and highly effective cooperative project of ORAU and some of its member universities was initiated by Joseph H. Hamilton, Jr., of Vanderbilt University in 1969. This research project has been highly productive in a frontier field of nuclear physics. Joint experiments have been conducted by more than 30 researchers from the 12 university members of the University Isotope Separator (UNISOR) consortium. In terms of the original aspirations of the ORAU founders, UNISOR more closely realizes the ideal of active use of the national laboratory by universities in an ongoing research program than any other activity of ORAU throughout its history. The history of UNISOR is detailed in chapter 13.

Institute for Energy Analysis

In the summer and fall of 1973 following the Arab oil embargo, Alvin Weinberg became convinced of the need for an energy policy "think tank" modeled after the Air Force's Rand Corporation. The AEC became equally persuaded of this need and believed that Weinberg, who had worked on Dixy Lee Ray's report to President Nixon (*The Nation's Energy Future*), was the ideal person to organize and head such an effort. Several universities and national laboratories were anxious to sponsor this entity and made considerable efforts to persuade Weinberg to join them. Others urged him to locate in the Washington, D.C., area.

ORAU appealed to AEC as a sponsor because of its large constituency of participant universities, since a growing number of universities were pressuring AEC and NSF to support energy analysis institutes on their campuses. Weinberg did decide on ORAU, which then completed arrangements with AEC, and on January 1, 1974, the Institute for Energy Analysis (IEA) was organized, with Weinberg as director. Two unforeseen developments, which greatly perturbed initial plans, arose in the first month of IEA's existence, however.

The first development was an urgent request that Weinberg become director of the Office of Energy Research and Development

Organizational Initiatives

In 1953 a number of people associated with ORNL and ORAU had discussed with others outside of Oak Ridge the desirability of forming a separate professional society devoted to nuclear energy. By the fall of that year an interview committee was formed to explore this matter formally. The chairman was Jerome Luntz, editor of *Nucleonics* magazine; and one of the members was James Lane of ORNL. The work of this committee led to the decision to form the American Nuclear Society (ANS). An organizing committee was established to carry this out, the members including Lane, Alvin Weinberg of ORNL, and William Pollard of ORAU. With the incorporation of ANS, interim officers and a board of directors were selected by the committee to serve until officers and board members could be elected under the by-laws at the first meeting of the society scheduled for June 1955 at Pennsylvania State University. Pollard served as a member of this first board.

W. W. Grigorieff was appointed to serve part-time as executive secretary of the society with the full-time assistance of his wife, Lilian. The ANS headquarters were housed in the ORAU University Relations Division of which Grigorieff was chairman. By 1958 the society had over 2800 members—American and foreign. At this time Grigorieff went to Vienna on a leave of absence to work with the International Atomic Energy Agency. A full-time executive secretary was employed by ANS and its offices were moved to Chicago. In 1979, ANS has about 12,000 members and a staff of over 60 in La Grange Park, Illinois, with smaller offices in Washington, Paris, and London.

Another similar initiative developed in the early 1970s in the ORAU Museum Division. Because the Museum's traveling exhibits program made long-term loans of suitable exhibits to other science and technology museums, close relationships developed between the directors of these museums and the chairman of the Museum Division. After Burrel Wood of the AEC suggested that these relationships become the basis for a more formal association, Courtland Randall discussed the idea with Joel Bloom, director of the Franklin Institute; and both became enthusiastic about its potential. In 1972 the Association of Science and Technology Centers (ASTC) was founded with 18 original members including the American Museum of Atomic Energy (now Science & Energy). In 1974, ORAU sponsored and hosted a meeting of ASTC.

of the new Federal Energy Office, which had just been established in the Executive Office of the White House under William Simon and John Sawhill. Weinberg was reluctant but in the end could not refuse such important public service. He was granted a leave of absence by ORAU and left for Washington. Secondly, the Office of Management and Budget removed IEA's funding from the AEC budget and transferred it to the Department of Interior, earmarked for the Federal Energy Office, with a directive that FEO use Interior's contract authority to contract with ORAU for the operation of IEA.

The first crisis was resolved by the appointment of H. G. MacPherson as acting director of IEA, but the second was more difficult. Administratively, AEC funding was terminated on February 28, 1974, and the new contract, when negotiated, had to be effective on March 1. Pollard and Elza, now assistant director for administration, became involved in complex and extended negotiations with FEO personnel, who knew nothing of ORAU and to whom the structure and mode of operation of an AEC prime contract were entirely foreign. Staff members of the Oak Ridge Operations Office were very helpful in resolving many questions, and finally an acceptable contract was signed in June 1974. For the next fiscal year, the Federal Energy Administration (to replace the Federal Energy Office) was established by Act of Congress with its own contract authority, and IEA's contract was extended for an additional year under FEA. Finally, on July 1, 1975, IEA was returned as a component of ORAU's prime contract with the Energy Research and Development Administration (ERDA), which had succeeded the AEC, with Weinberg as director.

The Institute for Energy Analysis is relatively unstructured, and its atmosphere is much more academic than most government laboratories. Its staff is multidisciplinary and its environment intellectually stimulating and scholarly. These characteristics have made it very attractive to university faculty members, especially those in the sciences, engineering, and economics. Consequently, it has had from the beginning at least one staff member from an ORAU member university on a one-year appointment and many others for summer or shorter appointments. Thus, IEA shares with UNISOR the character of directly involving sponsoring universities in an ORAU contract activity. The history of IEA is detailed in chapter 14.

7

Retrospect and Prospect

One of the most important legacies of World War II has been the Atomic Energy Commission's national laboratories. These large, multipurpose research and engineering development institutions, including those at Los Alamos, Livermore, and Berkeley, have proved to be a source of great scientific strength for the nation. Before the war nothing like them existed, and the government was scarcely involved at all in scientific research and the technologies it spawned. Now, 30 years after the establishment of the Argonne, Oak Ridge, and Brookhaven National Laboratories, it is clear that they have become permanent institutions of such proven value to the nation that they are certain to be continued indefinitely.

The national laboratories brought with them a new imperative for the creation of associations of universities closely involved with them. We have already noted in chapter 2 that independent moves were already under way in December 1945 toward the creation of such associations around all three laboratories. No such entities had existed before and there were no precedents to follow. Each group approached the problem of designing such a novel kind of institution in its own way. Each has had its own unique history, and the outcome in Associated Universities, Incorporated, Oak Ridge Associated Universities, and the Argonne Universities Association is marked by the special circumstances encountered in the development and maturation of each. The basic concept and purpose are the same for all of them, but each differs in its relationship to the national laboratory with which it is associated.

The wartime effort in the Northeast had concentrated on the separation of uranium isotopes by gaseous diffusion in the SAM

Laboratories at Columbia University, and soon after the end of the war those laboratories, with their residual research staff, were moved to the Gaseous Diffusion Plant in Oak Ridge. This circumstance defined a clear-cut mission for the newly incorporated university association AUI, namely, to construct and then operate an entirely new national laboratory for the Northeast. The result was the distinguished Brookhaven National Laboratory on Long Island and later the National Radioastronomy Facility at Green Bank, West Virginia. In the Midwest, the Argonne National Laboratory continued to be operated by its wartime contractor, the University of Chicago. The first approach to a regional association of universities through the Council of Participating Institutions with its elected Board of Governors of ANL did not prove practical and was later replaced by Associated Midwest Universities (AMU) working closely with ANL, and the Midwest Universities Research Association (MURA) working independently of ANL. Still later, they were both replaced by AUA through a tripartite government contract under which AUA and the University of Chicago share in the operation and management of ANL.

In the Southeast, the mission of ORAU was defined by the fact that Oak Ridge National Laboratory had from the beginning been operated by industrial contractors. As a result, ORAU began initially under a separate prime contract in parallel with, but independent of, Union Carbide's contract for the operation of ORNL. The mission of ORAU with respect to ORNL has, therefore, been carried out from the beginning through noncontractual mutual understandings or, when desired, memoranda of agreement, without disturbing the independence which each exercised in the performance of its prime contract with the government.

The discovery of quantum mechanics in 1925 came at a stage when only three elementary constituents of the natural world were known: the electron, the proton, and the photon. In the subsequent half century a continuous series of brilliant fundamental discoveries has enlarged and unified human understanding of the physical and biological world with startling and unexpected clarity. The middle half of the twentieth century, 1925 to 1975, has unmistakably been the golden age of science and will certainly be recognized as such in future history. To this period belong also the technological achievements of radio, television, and radar; both the curse and the blessing of the practical release of nuclear energy; the transistor and the computer; and the thrilling exploits in space among most of the solar system's planets and their satellites.

During the last half of this golden age, from 1950 to 1975, major contributions to its remarkable achievements were made by the government's national laboratories and their associated universities. The spirit of the age permeated both sets of institutions and molded the sense of purpose and identity of the national laboratories. In the case of ORNL and ORAU this spirit and the means for its implementation flowed from them into the southern universities, which were at first weak in the natural sciences compared to the universities of the Northeast and Midwest. This circumstance created a special mission for ORAU not shared by the other regional university associations and their national laboratories. A major accomplishment of ORAU during its first two decades was its contribution to the development of the natural sciences in the universities of the South to a level comparable to that of universities elsewhere in the nation.

It is natural for those who have participated in the excitement of a golden age to long for and believe in its indefinite continuation. Yet history teaches otherwise. Already in 1970 the scientific community experienced an abrupt change in the momentum of federal funding for basic research. By the time of the Arab oil embargo in 1973, a radical shift in public expectations of science was evident. There is a growing and insistent demand that science serve the immediate and pressing needs of society. A universal passion for discovery and new knowledge is no longer evident. Basic research support has had its ups and downs, but is still sizable and will doubtless continue. But research in the frontier fields of particle physics and space exploration has become dreadfully expensive and must compete with rising public demands for scientific solutions to the energy crisis and the preservation of the environment. The spirit which drove the golden age is no longer with us. A clear indication of this change was the conversion of AEC into the Energy Research and Development Administration (ERDA), followed by the absorption of ERDA into the new Department of Energy. In its place has arisen a spirit of uncertainty and anxiety as we make the transition to a very different stage in human history.

What the last quarter of this century will be like is impossible to foresee. Only two certainties stand out. One is that by the end of the century the number of human beings precariously trying to inhabit this finite earth will be between 8 and 10 billion, at least. The other is that the total planetary production of petroleum will be declining year after year. For the immediate future, we face the ominously growing political and social instability of the world around us: Southeast Asia, the Middle East, Africa, and Latin America. The industrialized societies experience growing and intractable strains from inflation and unemployment. The environmental movement increasingly faces immense economic penalties in the achievement of its objectives. Progress in dealing with our energy crisis is thwarted by unrealizable hopes on one hand and irrational fears on the other. The public is entranced by the shining hope of solar energy and sustained by the childlike conviction that, given sufficient funds, scientists can achieve any goal—a hope that is certain to be dashed by the economic realities of the practical use of solar energy and the voracious appetite of solar collectors and energy storage systems for great quantities of nonrenewable materials. On the other hand, the public holds exaggerated and irrational fears of nuclear energy. It is my ardent wish and expectation that ORAU and its member institutions will not yield to the temptation of the immediate benefit to be derived from feeding these false hopes and fears. Institutions which do so must inevitably perish in the harsh light of the true situation.

Actually ORAU is much better fitted than most institutions for finding a course through the uncharted seas of the tumultuous age which we have just entered. This fitness results from the dual role which has characterized Oak Ridge from the beginning, in contrast to other regions. The liaison function which ORAU exercises between ORNL and universities is independent of the shifting program emphasis within ORNL. The nature of ORAU programs over the last three decades has left it far less committed than either the national laboratories or the universities to the preservation of the past. Its wide range of educational activities has always been addressed to the pressing needs of the time; their present scope and content are especially timely. These programs have always endeavored both to eradicate false hopes and calm unnecessary fears by holding as close to reality as human frailty allows. The newly established Institute for Energy Analysis is a bastion of sober judgment in the midst of many contending forces and pressures. The reconstituted Medical and Health Sciences Division is closely attuned to public needs for health protection in the use of all forms of energy. Above all, through the enthusiastic support of its 46 member universities, ORAU is deeply rooted in the sturdy soil of the region that produced it—and which it continues to serve. As much as any institution in a violently changing world, ORAU has the potential to survive and prosper. Sometime in the next decade, when false hopes and groundless fears have lost their hold, ORAU will emerge as a vitally important source of strength and guidance for a bewildered nation. It has the capacity, the resources, and the spirit to meet any challenge with which the future may confront it; and I am convinced that it will do so.

The remaining chapters of this history are written by persons most closely associated with particular programs. Dr. Hilton Smith was involved with the Resident Graduate Program from its inception and, during most of the period covered here, was responsible for it at the University of Tennessee as vice chancellor for graduate studies and research. He also served two terms as a member of the ORAU board of directors from 1969 to 1975, a capacity in which he had responsibility for all ORAU programs.

Dr. Marshall Brucer played the lead role in formulating the concept for the ORINS Medical Division and later, as its first chairman, in executing that concept in physical facilities, staff, and program. A reprint of one of his Vignettes of Nuclear Medicine gives a vivid description, in his inimitable style, of the initial clinical research carried out by his division.

Soon after the termination of all AEC graduate fellowship programs, ORAU prepared a final report to the AEC covering their entire period from inception to termination. Excerpts from this report make up the chapter on these programs.

Dr. Gould Andrews, who is now at the University of Maryland, was one of the first senior staff members of the Medical Division. He served first as a hematologist, then as chief of clinical services, and from 1961 to 1975 as division chairman. More than anyone else he has been intimately associated with the Medical and Health Sciences Division throughout its entire history.

Courtland Randall, while serving as chairman of the Museum Division, fostered and developed the AEC program of high school demonstration lectures in atomic energy. He went with this program when it was removed from AEC support and launched as a major independent activity of the ORAU corporation. He tells the story of this venture through its growth to its present full divisional status, with himself as chairman, in the chapter on this significant educational program.

Dr. J. H. Hamilton had the original idea for the UNISOR consortium and was responsible for its promotion among the universities and for initial funding commitments. He has continued throughout as an active research leader in the project. Since 1973 he has represented Vanderbilt University on the ORAU council and has served as vice chairman of the council. He was, therefore, the ideal choice for writing the chapter on this significant ORAU program.

Alvin Weinberg first promoted the idea of a "think tank" on energy and tells the story in the final chapter of the development of this idea into the ORAU Institute for Energy Analysis, which he directs.

A concluding appendix lists the corporate officers and members of the board of directors and their terms from the formation of ORAU to the present time, the sponsoring institutions and their appointed representatives on the ORAU council for the same period, and gives statistical information on the growth of ORAU employment and expenditures.

8

The Oak Ridge Resident Graduate Program of the University of Tennessee

Hilton A. Smith*

By the end of World War II, a large number of scientists and engineers had come to Oak Ridge to participate in the various programs designed to produce atomic bombs. They were either associated with the U.S. Army or were employed by one of the Oak Ridge contractors, primarily Monsanto, Tennessee Eastman, and Carbide. Some were eminent scientists who had taken leave from their home institutions, and others were students whose graduate education had been interrupted. Many from both groups planned to return to their home institutions to resume their teaching and research activities or to continue their graduate studies. Obviously such an exodus would cripple further developments at Oak Ridge and render the large investments made by the federal government quite useless.

Under these circumstances, the top scientists and administrators turned to the southern universities for aid in maintaining the resident talent both by providing opportunities for senior personnel to participate in local educational programs, and by providing opportunities for junior personnel to continue their graduate studies while remaining at Oak Ridge.

The closest major university was the University of Tennessee located some twenty-five miles distant at Knoxville, but this institution had just initiated its first doctoral program (chemistry, 1944) and was not immediately prepared to provide a broad spectrum of advanced level courses. Initial efforts to start a major

*Vice Chancellor Emeritus, Graduate Studies and Research, The University of Tennessee, Knoxville.

graduate education and research institute by a consortium of universities were largely unsuccessful, and it soon became evident that only the University of Tennessee, either by use of its own Knoxville staff or by part-time employment of some of the senior scientists at Oak Ridge, could satisfy the instructional needs. In general, university enrollments were increasing rapidly due to the influx of war veterans, and efforts to enlist the cooperation of other major southern universities by release of regular faculty members who could teach in the graduate program as well as use the research facilities resulted in the participation of only one such individual, Dr. Douglas Hill, professor of chemistry at Duke University.

The university did make arrangements for some special graduate courses to be taught during regular working hours at the Clinton Laboratories (Monsanto) by several of its senior scientists during the fall quarter of 1945 and the winter quarter of 1946. However, attempts to make similar arrangements with the Y-12 (Tennessee Eastman) and K-25 (Carbide) plants resulted in certain questions from the labor relations men of the Y-12 plant. What at first seemed to be minor legal complications arising from the wage-hour law turned out to be a major stumbling block, and in the spring quarter of 1946 such courses were moved to the Oak Ridge High School and taught outside of regular working hours. Instructors included Dr. Henry Levy from the Clinton Laboratories, Dr. Douglas Hill from Duke University, and Dr. Hilton Smith from the Knoxville campus. All courses carried regular graduate credit.

The general relationship between the University of Tennessee and the Oak Ridge installations was brought before the University of Tennessee Board of Trustees at its February 21, 1946, meeting. Dean Fred C. Smith stated in part that:

> *The United States Government has recently spent two billion dollars to make bombs utilizing the unbelievably powerful atomic energy. The best possible plants, equipment, and personnel were assembled for the purpose. Under war incentive, scientists and industrialists cooperated admirably to achieve an outstanding success. With the end of the war, the top scientists returned to their war-interrupted work and disintegration faced the project. The industrial elements in the form of plants, equipment, and personnel still remain in operation at Oak Ridge. Specialized scientists and laboratories are there also but not the impelling war incentive nor the equally*

important environment in which science naturally flourishes.

In September, those scientists that remained at Oak Ridge were searching either for big-name leadership to come to the project or for some outstanding university to which the project could go. Neither was immediately available. In the meantime, The University of Tennessee had little to offer except proximity and an unwillingness to let the opportunity go by default. After a survey of the situation it became apparent that the best approach was to strengthen greatly the science departments of the University and to cooperate with the Oak Ridge scientists in creating the environment in which science would flourish. By December, those at Oak Ridge were convinced of the University's sincerity and were working with it toward a common goal.

Within the next several years, doctoral programs in physics, botany, mathematics, bacteriology, zoology, and chemical engineering were developed and approved by the Graduate Council of the university, and advanced courses as well as thesis and dissertation research were made available at Oak Ridge as well as at Knoxville.

From September 1946 to August 1947, courses in chemical engineering, chemistry, mathematics, and physics were provided in the high school, with quarterly enrollments of 141, 84, 60, and 58 students. In the meantime, Dr. William Pollard and the executive committee of the Oak Ridge Institute of Nuclear Studies had been working with the University of Tennessee, with the result that the Atomic Energy Commission made available the 2714 G Building to the institute for its use including the Resident Graduate Program. Classroom and laboratory space were provided as rapidly as renovations could be completed, and the program has operated continuously in this building from the 1947-48 school year through the present date. In March 1947, a contract for the operation of ORINS was issued by the Atomic Energy Commission, and the first subcontract under this general contract (AT-40-1-GEN-33, Subcontract No. 1) was issued on July 15, 1948, effective October 6, 1947.

As might be expected, there was some initial concern among member institutions as to whether the Oak Ridge Institute of Nuclear Studies tended to give preferential treatment to the University of Tennessee in its graduate programs. In a discussion at the second (June 30, 1947) meeting of the ORINS council, it was pointed out that the Resident Graduate Program was open only to employees of Oak Ridge contractors and was instituted by the University of Tennessee at the request of member and other universities by formal action of the Oak Ridge Conference of December 1945. It was further noted that the support from the institute was limited to securing from the Atomic Energy Commission facilities to house the program.

This concern was again shown when some of the council members insisted that a wooden sign outside of building 2714 G indicating the presence of the program be removed. However, this was later replaced with a permanent bronze sign on the outside of the building.

According to the initial subcontract the University of Tennessee was to provide all instructional costs plus those associated with records, fee collections, and general administration, while ORINS was to provide space, and laboratory supplies and equipment. After several years, it became apparent that the university should not be asked to provide from its own funds the amount required to operate the program in a satisfactory manner. Therefore, in 1952, the subcontract was modified so that ORINS would reimburse the university for the appropriate fraction of the salaries of instructors from the Knoxville faculty, for the full cost of compensating those instructors who were not regular faculty members, and for the cost of a clerical university employee to be stationed at the university's Graduate Office at Oak Ridge, in addition to providing facilities and supplies. However, the fees collected by the university from students in the program would be subtracted from the amount due from the institute. The university would continue to underwrite travel and general administrative expenses.

Since 1952 a number of further modifications in the subcontract have been made. Primarily these achieve the following:

1. Allow the employment of one full-time or part-time person to direct the program
2. Increase the scope of the subject matter, so that the program now includes graduate courses in the sciences, mathematics, management, library science, languages, and other areas related to nuclear science
3. Allow with institute approval certain supplementary students (undergraduate employees, non-AEC graduate or postdoctoral students, and residents of Oak Ridge and vicinity)

4. Change somewhat the formula for compensating the university for its regular faculty members and special instructors
5. Allow the employment of laboratory assistants

Fundamentally, however, the program has operated under the 1952 modifications up to the present.

Initially, the Oak Ridge Resident Graduate Program was directed by the dean of the Graduate School with the assistance of one clerical employee at Oak Ridge. However, the contract modifications in 1963 allowed for the employment of a full-time or part-time director, and four individuals reporting to the chief administrator of the Graduate School have filled this position.[1] These directors have helped maintain good liaison between the Oak Ridge contractors, ORINS, and the university as well as providing general guidance to the program.

Dr. Cooper served as full-time director. The others were all part time. Total enrollment in the Oak Ridge Resident Graduate Program has been relatively constant, with 200 to 300 registrations in around 15 courses during the academic year, and 50 to 100 in 4 or 5 courses during the summers. However, the distribution of course registrations has undergone several major changes, reflecting changes in areas of emphasis of the Oak Ridge contractors, levels of employment, policies of the contractors, and scope of the graduate program. At first chemistry courses were very popular, but the number of registrations has decreased fairly steadily until there is a relatively small demand. Physics course registrations, initially also quite popular, increased during the early years and then remained constant until the early 1970s when the enrollment in physics fell off quite rapidly to become a small part of the program. The pattern in mathematics has been much like that of physics, although there is still considerable demand. Enrollment in engineering courses has been relatively steady, with more emphasis on chemical and metallurgical engineering, but with occasional courses taught in aerospace, electrical, industrial, and nuclear engineering and engineering science. There has been an occasional course in languages, library science, and industrial education.

[1] E. C. Campbell, physicist, 1963-1967; Albert H. Cooper, engineer, 1968-1972; Lawrence K. Akers, physicist, 1972-1976; William Konnert, university administrator, 1976-present.

Although business courses were not originally included in the Oak Ridge Resident Graduate Program, a considerable demand for a graduate degree in management led in 1953 to the development of a master of science degree program with a major in industrial management. The courses were very popular at once, and the university was at first unable to provide enough instruction for all qualified students. All of the classes were taught by members of the Knoxville departments, since at that time there were few individuals in Oak Ridge qualified to teach them. The demand for this and other programs was enhanced in 1956 when Carbide initiated its educational assistance program, but by the early 1960s, there were practically no new students available, and management courses were discontinued.

In the fall of 1967, the university began a master of business administration program; there soon arose a considerable interest in this program at Oak Ridge. The first course in this general business graduate program was offered at Oak Ridge in 1969, and a strong and steady demand for such courses (industrial management, accounting, business law, economics, finance, statistics, and transportation) has continued.

Computer science is also taught under the College of Business Administration of the university, and since 1972 there has been a significant demand for courses in this area.

Almost from the beginning of the Resident Graduate Program, there has been an occasional demand for courses in the biological sciences. However, in the mid-1960s a rather interesting situation developed at the three major Oak Ridge installations. The demand for physical scientists and engineers, as such, was decreasing while the demand for those with an understanding of biology was increasing. Unfortunately, many of the physical scientists and engineers had no training in biology and could not satisfy the current needs. The University of Tennessee was asked to remedy this situation by offering a beginning biology course open only to those with at least a bachelor's degree in science or engineering. This unusual course was taught by a number of outstanding biologists lecturing for a few periods on special topics, and was accompanied by laboratory periods providing exposure to modern biology techniques. During the next four years almost 100 physical scientists and engineers, many holding doctorates, took this course and became major contributors to some of the important interdisciplinary developments at Oak Ridge.

The Oak Ridge Resident Program has been a unique and highly successful venture between a group of government laboratories and a major university. Two important studies have been made of this effort. In the early 1960s, Dr. David S. Anthony, who was spending a year at ORINS on leave from the University of Florida, completed a study of the program covering the period 1951-1961. Dr. Anthony concluded that:

> *The Oak Ridge Resident Graduate Program is a valid, largely healthy program with a few problem areas. It continues to be of value both to the individual for personal advancement and to the Atomic Energy Commission and its contractors in recruiting of technical personnel, and it has contributed substantially to the overall Ph.D. program of the University of Tennessee.*

There followed certain recommendations for closer administrative ties between ORINS and the university, critical examination of its part in the program by each department of the university, and the development of a brochure describing the program. There was also a recommendation for some additional studies.

The second study was conducted in 1969. Until that time the Southern Association of Colleges and Schools had generally limited its accrediting activities to institutions as a whole, including any branches in the evaluation of the overall program. In the mid 1960s, the association decided to evaluate individual off-campus programs, and the University of Tennessee invited the association to evaluate its Oak Ridge Resident Graduate Program. First a self-study of the program was conducted by a committee chaired by Hilton A. Smith.[2]

[2] Committee members were as follows: Lawrence K. Akers, head, Special Training Division, ORAU; John H. Barrett, professor and head, Mathematics Department, the University of Tennessee (deceased, January 1969); Albert H. Cooper, director, Oak Ridge Resident Graduate Program, and professor of Chemical Engineering, the University of Tennessee; Homer F. Johnson, professor and head, Chemical and Metallurgical Engineering Department, the University of Tennessee; Allen H. Keally, associate dean, College of Business Administration, professor and head, Industrial Management Department, the University of Tennessee; Robert M. McConnel, associate professor of mathematics, the University of Tennessee (replacing Dr. John H. Barrett, deceased); Lewis Nelson, director, Education and University Relations, ORNL; Alvin H. Nielsen, dean, College of Liberal Arts, professor and head, Physics Department, the University of Tennessee; Herman M. Roth, director, Laboratory and University Division, AEC; George K. Schweitzer, professor of Chemistry, the University of Tennessee; and Samual R. Tipton, professor and head, Zoology and Entomology Department, the University of Tennessee.

The study, dated April 1969, gave detailed information about the program for September 1963 through June 1969. (Information concerning course offerings and registration has since been updated through June 1977.) The report also contained suggestions for the future of the program. In May 1969, a committee of the Southern Association of Colleges and Schools spent two days studying the Oak Ridge Resident Graduate Program.[3] They interviewed representatives of the university administration and of the departments concerned, representatives of the AEC, Union Carbide, ORAU, and ORNL. In their report to the Southern Association, the committee said in part:

> *The committee wishes to commend the Atomic Energy Commission, Oak Ridge National Laboratory, Oak Ridge Associated Universities, Union Carbide and the University of Tennessee for developing the Oak Ridge Resident Graduate Program. It uniquely blends the resources of industry, government and the University into an exciting educational program of genuine accomplishment and tremendous promise. A program of such complexity is neither easily conceived nor easily implemented. The vision and patience of all parties involved deserves commendation.*
>
> *The committee observed that the program was designed to provide graduate education for Oak Ridge personnel in the areas of biology, chemistry, engineering, industrial management, mathematics and physics. The program is working well in physics, chemistry and some branches of engineering. It is not working well in biology and industrial management. Mathematics is a relatively small operation and the recent death of the head of mathematics on the Knoxville campus has had an obvious effect on the program and plans for mathematics.*
>
> *As a result of interviews the committee is convinced that the program works well in chemistry, physics, and engineering because (1) the Oak Ridge scientists and the Knoxville faculties in these areas have worked together through consultant appointments and Ford Professor appointments; (2) both groups believe in the program and are committed to its development; and (3) scientific personnel at Oak Ridge and at Knoxville are*

[3] Committee members were Mario J. Goglia, Georgia Institute of Technology; Robert Johnson, Florida State University; Charles T. Lester (chairman), Emory University; Paul Penningroth, retired businessman; and Thomas J. Turner, Wake Forest University.

willing to make accommodations in the interest of the program. As a result, Knoxville faculty travel to Oak Ridge to teach graduate courses. Supervisors at Oak Ridge allow their staff time to attend classes and time and space to do thesis or dissertation research. There is a wholesome flow back and forth of faculty and students from Knoxville and scientists and students from Oak Ridge in those areas where the program is working.

The deliberate effort of the University to avoid isolating the Oak Ridge resident students is especially gratifying. By using the same admission and registration procedures, by allowing Knoxville graduate students to enroll in courses offered at Oak Ridge, and by requiring the Oak Ridge resident graduate students to take some work on the Knoxville campus, the University of Tennessee Graduate School avoids isolating the Oak Ridge residents from the other University of Tennessee graduate students. This required movement to and from both locations is a unique and valuable feature of the entire operation.

In the areas of chemistry, engineering and physics there is a remarkable convergence of opinion from students, Knoxville faculty, and Oak Ridge scientists on the positive benefits each has received from the program. Complaints were minor, compliments were frequent and criticism stemmed from a genuine desire to be helpful.

Where this free intermingling of Knoxville faculty and Oak Ridge scientists does not occur, the program is languishing. Mathematics is not a large program but its problems are not in any sense the same as those in biology and industrial management.

Based on the committee's report, which was favorably received by the Southern Association, the situation in business management was carefully reviewed and greatly improved, particularly by the availability of the MBA curriculum at Oak Ridge. Also the Life Sciences Council of the university carefully studied the recommendations of the committee and worked out a series of courses to be offered at Oak Ridge which would allow an individual to achieve a master of science degree with a major in biology.

Over the past 31 years, the Oak Ridge Resident Graduate Program has served as a mechanism whereby many of the employees of the federal government and its Oak Ridge contractors have been able to increase their knowledge in various areas of science, engineering, and management and often to complete degree programs. Because of the intermingling of staff, course offerings, and facilities between Knoxville and Oak Ridge, one cannot state just how many individuals have obtained advanced degrees because of the availability of this program, but those who have participated in the Oak Ridge Resident Graduate Program and received master of science or doctor of philosophy degrees from the University of Tennessee may well number more than a thousand.[4]

The influence of the program in recruitment and education of Oak Ridge personnel and on their contributions to the scientific and engineering community cannot be properly assessed. Certainly it has been considerable. Two persons who took much of their work at Oak Ridge have received E. O. Lawrence Awards from the AEC in recognition of their outstanding contributions. The director of ORNL, several who hold superintendents positions at Oak Ridge or Paducah, and a number of division directors have received significant portions of their education through the program. In academic circles, one individual is a graduate dean at a major university, and several are department heads or professors. In industry there is at least one corporation president, a vice president, and a director of research.

The desires of all concerned parties to continue this major cooperative investment in graduate education resulted in another extension of the subcontract between the University of Tennessee and ORAU for a period of five years effective July 1, 1977.

[4] In his study, Dr. Anthony identified 62 students who, over a 3-year period, received advanced degrees with their work taken primarily at Oak Ridge.

9

Early Clinical Research

Marshall H. Brucer, M.D.*

Bone scanning is indelibly associated in my mind with Chanel No. 5 on an untidy pig. The Empire State Building conjures a vision of King Kong beating an osteogenic sarcoma with a piece of sewer pipe. The younger generation of nuclear medics thinks bone scanning is their latest triumph, but we were doing it, or at least trying to, 'way back before nuclear medicine got its name.

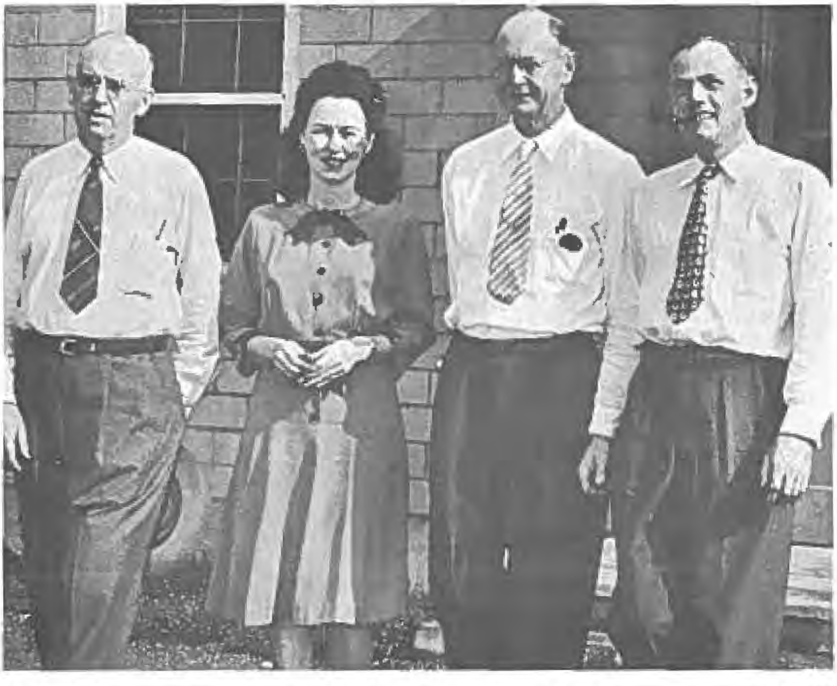
John Lawrence's treatment of leukemia with P-32 was still fresh in our minds back in 1949. Lowell Erf's polycythemia therapy was just as good as a cure. Sam Seidlin had cured cancer (well, he did cure one thyroid cancer patient). Maybe we were too enthusiastic about the therapeutic value of the new "isotopes," but we had good reason. Radiotherapy was successful in cervix, skin, and various head and neck tumors. Success seemed to be directly related to the precision of delivering sufficient radiation to the proper point at the right time. Now we had the perfect way to assure precision of delivery.

Every cancer has a suicidal dependence upon its own metabolism, so just select the proper compound "specific" for that cancer. We would make the compound radioactive and feed it to the patient, and the cancer would irradiate itself to death. We had almost a thousand "isotopes" to work with in those days. (Never mind the sparsity of radioisotopes at the lower end of the periodic table; physicists were turning out a new one every week.)

*Published in 1975 under the title "Bone Scanning, Comar's Pig, and the King Kong Kollimator" by Mallinckrodt, Inc., St. Louis, Missouri as one of a series of *Vignettes in Nuclear Medicine*. Reprinted here by permission of the publisher and the author. Dr. Brucer now lives in Tucson, Arizona.

Dr. Harvard Hull (standing) is shown addressing the members of the Oak Ridge Conference of December 27-29, 1945, which set up an executive committee and charged it with organizing the Oak Ridge Institute of Nuclear Studies. The picture was made at the first meeting of the conference. Many of the men shown in the photograph are still associated with Oak Ridge Associated Universities.

First Council Meeting. The photograph above shows the first meeting of the institute council held on October 17, 1946. Clockwise around the table are Walter M. Nielsen, Duke University; J. Harris Purks, Jr., Emory University; Francis J. Slack (standing) and Harvie Branscomb, Vanderbilt University; Robert I. Sarbacher, Georgia Institute of Technology; J. C. Morris, Tulane University; Robert H. Marquis and John P. Ferris, Tennessee Valley Authority; Karl F. Herzfeld, Catholic University of America; L. G. Hoxton, University of Virginia; W. D. Funkhouser (deceased), University of Kentucky; William G. Pollard, then of the University of Tennessee; Frank P. Graham, first chairman of the council and president of the institute; Russell S. Poor, then of the Alabama Polytechnic Institute (Auburn University); and James R. Cudworth, University of Alabama. Fred C. Smith of the University of Tennessee was also present at this meeting but is not shown.



ORAU pioneers. The photograph above, taken in the summer of 1947, shows E. A. Waters, dean of the University of Tennessee graduate school, and the first three ORAU (then ORINS) employees: Barbara McClannahan, then secretary, later administrative assistant, and now retired; J. W. Mumford, assistant treasurer (deceased); and William G. Pollard, then acting director—a post he later assumed on a permanent basis. The group is shown leaving the 2714-G building turned over by the Atomic Energy Commission to the new organization as a permanent base of operations.

The ORINS Board of Directors at its fourth meeting on October 31, 1947. From left: Eugene P. Wigner, Oak Ridge National Laboratory; E. W. Goodpasture, dean of the Vanderbilt University School of Medicine; Frederick Seitz, director of the Clinton Laboratories Training School and chairman of the Department of Physics, Carnegie Institute of Technology; William G. Pollard; George B. Peagram, dean of Columbia University's Graduate Division; Theophilus S. Painter, president of the University of Texas; Paul M. Gross; and Jesse W. Beams, professor of physics, University of Virginia.

ORAU's second home. When the staff of ORAU outgrew the 2714-G building, the Atomic Energy Commission turned over the building on Illinois Avenue that had originally housed the Oak Ridge Health Department to serve as the organization's central administration building.

Charles G. Wilder, chairman of the ORINS Museum Division, with one of the walk-through, van-type mobile "Atoms for Peace" traveling exhibits that began touring the nation in 1955.


At the institute's tenth anniversary banquet on October 15, 1956, S. R. Sapirie, manager of AEC's Oak Ridge Operations, congratulates Paul M. Gross, second president of ORINS, on the institute's purchase of a 36-acre site in Oak Ridge for its proposed permanent headquarters. Onlookers are, from left, Frank P. Graham, first ORINS president; Marten tenHoor, chairman of the ORINS council; William G. Pollard, executive director; and H. M. Roth, director of the AEC Research and Development Division.

ORINS executive director William G. Pollard, who officiated at an informal groundbreaking for the new Central Administration Building early in 1959, eschewed the traditional shovel in favor of more modern equipment. Standing, from left, are Wayne Range and H. M. Roth of the Atomic Energy Commission's Oak Ridge Operations and Paul M. Elza, J. Walter Mumford, and Lawrence K. Akers of ORINS.

The Central Administration Building is in the foreground and the Energy Education Building in the background of this 1964 view of ORAU's main facility.

John R. Dunning of Columbia University, a long-time member of the ORINS Board of Directors, was the featured speaker at the twentieth-anniversary banquet in October 1966.

Frank P. Graham (left), first president of ORINS, was an honored guest at the twentieth-anniversary banquet in October 1966. He is shown here with executive director William G. Pollard; Paul M. Gross, second president of ORAU; and John R. Dunning of Columbia University, a member of the ORAU Board of Directors.

In 1969 Paul M. Gross received an AEC award for his contributions to atomic energy education. He is shown here with S. R. Sapirie (left), then manager of AEC's Oak Ridge Operations, and Clarence E. Larson (right), president of Union Carbide Corporation-Nuclear Division from 1965 through 1969.

Paul M. Elza joined the staff of ORINS in 1948. From 1949 until his retirement in 1977, he served as manager of administration.

Paul M. Gross, president, 1949-1970.

Frank P. Graham, president, 1946-1949.

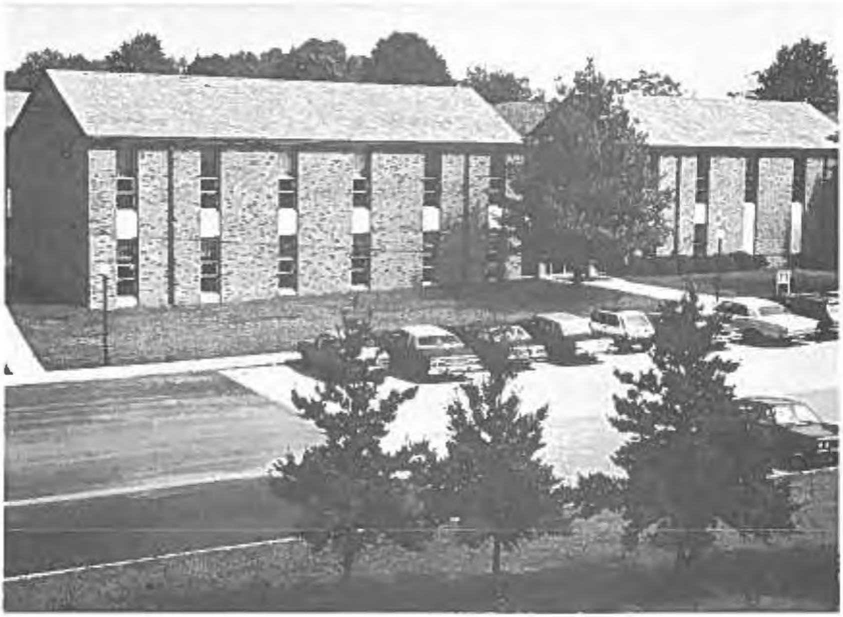
H. W. Davis, president, 1970-1976

Oscar Touster, president, 1976-present.

William G. Pollard, executive director, 1946-1974.

Philip L. Johnson, executive director, 1974-present.

A recent aerial view of the Energy Education Building (left), adjoined by the new IEA building. On the right is the Central Administration Building.



This photograph shows the front entrance to the Institute for Energy Analysis, completed in the summer of 1979.

The American Museum of Science & Energy opened in early 1975.

The Marmoset Research Center, which opened in 1977, lies on the western edge of ORAU's 36-acre campus.

These buildings, on Laboratory Road, house the Manpower Education, Research, and Training Division.

Charles Counts' mosaic-mural *Hymn to Life* over the entrance of the Medical and Health Sciences Division's main building.

This building, on the grounds of the Oak Ridge National Laboratory, houses UNISOR's magnetic isotope separator.

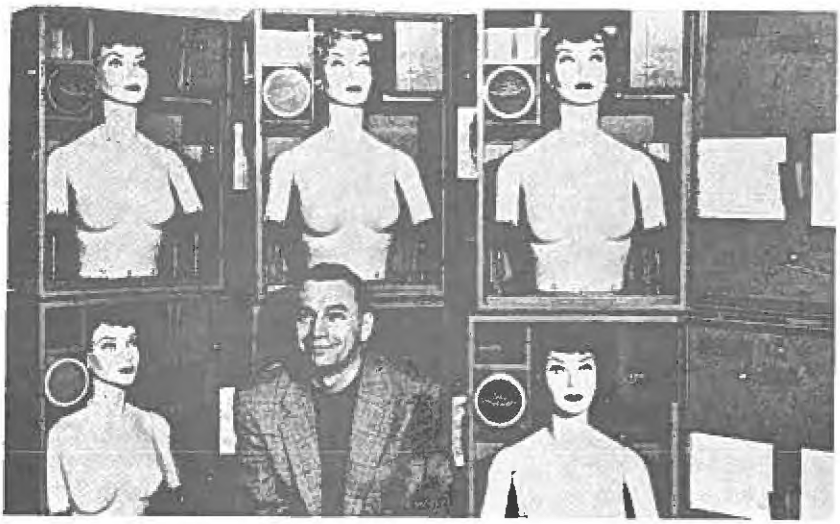
The March 1955 meeting of the AEC Radiological Physics Fellowship Committee. From left, Edwin C. Watson, Hanford Works; Ronald Geballe, University of Washington; Wade T. Batson, ORINS; Hoyt Whipple, University of Rochester; J. B. Hursh, University of Rochester; W. D. Chaus, AEC, Washington; Ann Hicks (now Ann Patton), ORINS; W. W. Grigorieff, ORINS; R. A. Patterson, Brookhaven National Laboratory; John I. Hopkins, Vanderbilt University; Elda E. Anderson, Oak Ridge National Laboratory; and C. S. Shoup, AEC, Oak Ridge.

The March 1955 meeting of the AEC Industrial Hygiene Committee. From left, Bernard F. Nebel, AEC, Washington; T. F. Hatch, University of Pittsburgh; Anna M. Baetjer, Johns Hopkins University; N. V. Hendricks, Esso Laboratories; Wade T. Batson, ORINS; Ann Hicks (now Patton), ORINS; Edgar Barnes, Westinghouse Electric Corporation; W. W. Grigorieff, ORINS; H. F. Schulte, Los Alamos Scientific Laboratory; Leslie Silverman, Harvard University; H. J. McAlduff, Jr., AEC, Oak Ridge; and William G. Pollard, ORINS.

Gould Andrews began his career with ORINS in 1949 as chief of hematology in the Medical Division. He was division chairman, 1962-1975, and director of clinical applications from 1975 until his retirement in 1977.

Marshall Brucer, first chairman of the ORAU Medical and Health Sciences Division (formerly ORINS Medical Division), and Cyril L. Comar (now deceased), principal scientist, confer with visiting scientist Kuang-chu Wang of Formosa and Hirotake Kakehi, Japanese Fulbright fellow on leave from Tokyo University, July 1956.

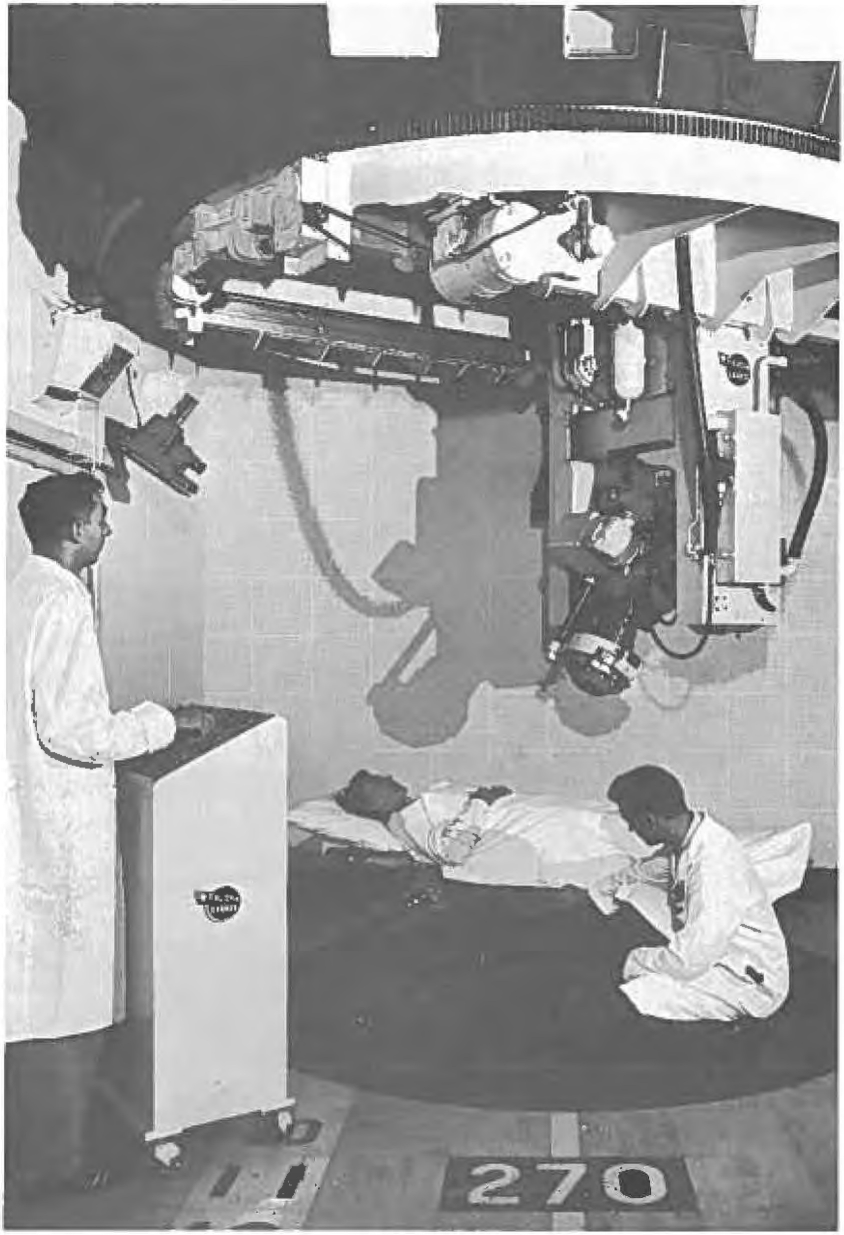
During her visit to Oak Ridge in 1955, Eleanor Roosevelt toured the ORINS Medical Division and is shown here being greeted by head nurse Mary Sutliff.



Marshall Brucer, first chairman of the ORINS Medical Division, with his "harem" of mannequins used in the division's extensive, and highly successful, radioiodine-uptake-calibration program.

One of the whole-body scanners used in the Medical and Health Sciences Division to determine the location and intensity of diagnostic or therapeutic radioactive materials in a patient's body.

The ECAT$_{tm}$ (Emission Computerized Axial Tomography) scanner in the ORAU Medical and Health Sciences Division produces scan patterns that show the localization of injected or ingested radiopharmaceuticals in great detail in two-dimensional slides. The scanner is the fourth ever made and the second to be used in the United States.



A major development of 1955 was the installation in the Medical Division of a 1540-curie, cesium-137 teletherapy unit. Used in the division's teletherapy-evaluation program, the machine was capable of focusing a beam of nuclear radiation on diseased tissue from any point in a hemispherical locus, permitting maximum damage to the diseased tissue while minimizing the radiation effects on surrounding healthy tissue.

Nazareth Gengozian, research scientist with the Medical Division and director of the division's marmoset research program, holds two baby marmosets who will shortly take up residence in the new ORAU Marmoset Research Center.

A closeup of two young marmosets of the type used by the ORAU Medical and Health Sciences Division for research in immunology and colon cancer.

Radiation-emergency accidents are simulated in the training programs conducted by the Radiation Emergency Assistance Center/Training Site (REAC/TS) of the Medical and Health Sciences Division.

Courtland Randall, director of ORAU's Energy Education Division, came to the Museum Division in 1964. He has headed the Energy Education Office (now Division) since 1973.

This building (built as a cafeteria in World War II) housed the Museum of Atomic Energy for 26 years.

One of the volunteers who serve as receptionists and carry out other duties at the American Museum of Science & Energy.

King Mahendra of Nepal, who visited Oak Ridge in May 1960, is only one of many distinguished visitors to the then American Museum of Atomic Energy. He is shown receiving a souvenir radioactive dime from Ralph T. Overman, chairman of the ORINS Special Training Division.

A view of exhibits in the new Museum of Science & Energy.

J. H. Hamilton (left) of Vanderbilt University was a major force in the establishment of the UNISOR project. He is shown here with UNISOR director Eugene H. Spejewski, staff scientist Ronald L. Mlekodaj, and a group of visitors to the facility.

Alvin M. Weinberg (seated), director of the Institute for Energy Analysis, speaks with senior IEA scientist Doan Phung.

It took us almost five years to find out that this dream was a lot of baloney.

Horace Dudley (biophysicist, University of Illinois, then with Bethesda Naval Hospital) had discovered a "specific" for bone tumor. An "easily" made gallium-72 was picked up by metastases in bone. The lesion could be detected with radiation counters long before it could be seen on roentgenogram. With large enough doses you should be able to blast the tumors.

Of course there were a few minor problems with Ga-72. It had a half-life of only 14 hours (virtually instantaneous in 1949). It had a quite high gamma energy, 2.5 MeV—even a small dose would rattle the counters in the next building. Its 3 MeV beta emission was hot enough to melt the paint off the G-M tubes.

But the whole project could be moved to Oak Ridge where an isotope research hospital had just been set up. Oak Ridge had the only isotope production nuclear reactor. We had financial backing, could make new equipment, and could support patients. What were difficulties at Bethesda were only minor problems at Oak Ridge. The Navy sent E. R. King (now radiologist, Medical College of Virginia) to Oak Ridge to teach us how to exploit this gallium breakthrough. (Or were we supposed to teach him? Expertise in "radioisotope medicine" was conjectural in those days. We all did a lot of learning, but what was there to teach?)

We ran some mouse studies (à la Hamilton) and they looked promising. But our G-M tubes were bigger than the mice. Dosage control in therapy required precise external localization of the distribution of Ga-72 within tumors. We would be more certain of our initial doses if we first tried Ga-72 on an animal about the size of a human and with the same basic metabolism, like, say, a pig.

Cyril Comar[1] had just set up a large-animal radioisotope research facility at Oak Ridge. Our small-animal laboratories adjoined his large-animal laboratories just out of town, about ten miles from the hospital. We asked Comar to get us a little piglet and feed him up to human size, about 100 pounds, by which time we would be ready to administer the first "human therapy dose." We would do extensive whole body manual scanning, sacrifice the pig,

[1] Before his death in 1979, Dr. Comar was director of the Environmental Assessment Department of the Electric Power Research Institute, Palo Alto, California.

and check our external counting against complete tissue sampling and autoradiography. Comar got us a piglet and started to feed it.

Gallium was an exotic element; it wasn't in the standard pharmacopoeia—it wasn't even in some chemistry texts. First we would have to run a quick MLD study, check out the toxicity, and make sure our minute chemical doses were within reason. Comar kept feeding the pig.

This chemistry was not a cookbook subject. Our chemists had to make sure the compounds we might use were compatible with blood pH, did not degrade, and would be distributed and excreted properly. We tried the citrates and the lactates on a variety of laboratory animals. Comar kept feeding the pig.

Making Ga-72 is not simple. A proper sample had to be sealed in aluminum, inserted into the reactor for neutron irradiation, retrieved the next day (provided the reactor was working normally), then dissolved behind heavy shielding, converted to citrate form, small samples assayed, and then diluted into a sterile human administration packet. The logistic details were formidable. Meanwhile, Comar's East Tennessee farm hands were proud of their ability to raise pigs. (To them a healthy pig was a happy pig and they knew how to keep a pig happy.) Soon, all too soon, Comar told us, "The pig now weighs 100 pounds."

But there was a hangup in reactor processing; we would have to hold off for a week or so. Comar kept feeding the pig.

Then it was national scientific meeting time. Most of us went off to deliver papers on "Radioisotopes, the Greatest Thing Since the Microscope." Upon return we had to get back into the swing of a "short-lived" production routine. Comar kept feeding the pig.

In those days 2.7-day gold-198 was a very short-lived isotope; preparing a "human therapy dose" of 14-hour Ga-72 was chemical legerdemain. Because "Comar's pig" (that was his official name now) was to get the first "human dose," everything had to be perfect. Ray Hayes, still festering from his doctorate in analytic chemistry, had quite high standards of perfection. He wanted a few dry runs, to debug the logistics. Comar kept feeding the pig.

A split-second protocol was set up: Remove irradiation can from reactor at 8:06 A.M.—transport back to the hospital lab, 12 minutes—winch lead shipping container up to laboratory, 4 minutes. Time, 8:32 A.M.. Dissolve the sample, reprecipitate, redissolve, adjust the pH, 16 minutes—allow 2 minutes to pass certain magical incantations beloved by analytical chemists—take sample for calibration, calibrate, load the injection dose. Time 8:52 A.M.. Transport to the farm, 12 minutes—unload and set up for injection, 8 minutes—allow 2 minutes for error. We would inject Comar's pig at 9:15 A.M. Comar kept feeding the pig.

Finally we were ready. Early on the appointed morning an internist, a physiologist, a pathologist, our chief nurse, a radiologist, a health physicist, the all-important anesthesiologist (because there would be no inhumane treatment of our pig), plus an assortment of medical, x-ray, and radioassay technicians, all gathered in our animal autopsy laboratory at the farm. Survey meters were set up to monitor the dose. G-M tubes were adjusted for continuous external localization. Cutie Pies[2] were at the ready for a quick look at the perfusion throughout the pig's body. One hundred sample jars were half filled with Zenker's solution for the autopsy samples. Sterile surgical instruments and drapes were laid out.

Betty Cooper, the anesthesiologist, had decided to start with a quick general ether anesthesia. We could then cut down to the jugular for a perfect injection in this crucial experiment. She would back off to a mild stage III with I.V. barbiturate for one hour, and then we would start the autopsy. She brought along an extra-large pediatric face mask to fit the pig's snout—and an extra can of ether just in case. Everything was set and ready by 9:03 A.M. But where was Comar's pig?

The agricultural experimental farm extended over quite a few miles of Clinch River bottom land. Comar's pig was not in the habit of hanging around the laboratory area. Comar dispatched a couple of scouting parties. Eventually a large truck backed up to the open door of the autopsy room. With heaves and grunts five farm hands pushed Comar's pig down the ramp. The little piglet we had purchased only a few months ago could hardly be squeezed through the door. One female technician fainted. Betty Cooper broke out the spare can of ether.

The pharmacologist and two technicians grabbed the right front leg. The physiologist, out of Texas, bulldogged the neck, assisted by a health physicist on the left foreleg. With a pathologist, two assay technicians, and a farm hand controlling the right hind leg, the radiologist grasped gingerly under the massive belly for the

[2] The name of an early type of portable survey meter for the detection and measurement of gamma radiation (editor's note).

left hind leg. The internist, an expert on the birds of Michigan, realized that since a pig's tail screws counterclockwise, a simple right hand twist would fell the beast . . . or was it clockwise in the northern hemisphere?

Betty, discarding her pediatric face mask and substituting her lab coat, quickly revised her planned doses from 12 drops/nostril/min. to a full can. Comar calculated that at the rate of evaporation of ether, we would all be anesthetized in 7 minutes. He dashed back to his own laboratory for an electric fan. Betty was no longer striving for stage III. Survival was her goal. But the beast had been felled, or at least rolled on its side. Gould Andrews, the internist, remembered in the nick of time that it was the toilet flush that swirled counter-clockwise in the northern hemisphere.

The physiologist picked a sterile scalpel up off the floor and made a delicate incision to expose the jugular vein. The scalpel barely got into the subcutaneous fat. Calling for a butcher knife, he excavated deeper: 1 inch, 2 inches, and finally laid bare a vessel—but was it a vein or an artery? It wasn't colored blue like in the anatomy book. This was no time for details. He'd take a chance; and so he called for the Ga-72 dose.

Off on the horizon, Hayes could be seen breathlessly jogging toward the farm. He had run out of gas. We dispatched a pickup truck for the dose, and Betty started heroic injection of intravenous barbiturate (or was it arterial?) At least the pig had calmed down. (Or was it dead?) A friendly grunt assured us the experiment was still on. Comar's fans were clearing the thick haze of ether from the room and the younger technicians were beginning to revive.

We finally got the dose of Ga-72 injected into what must have been a fairly large vein. Quickly the Cutie Pies were activated to test the initial distribution. They were frozen off scale; the G-M tubes wouldn't budge; the survey meters were saturated even when backed off 500 feet from the autopsy room. Comar's autoradiography technician, at least 100 yards away, later complained that all of his films had been fogged.

The pig grunted uneasily; at least the injection had been a success. We would have to cancel the external counting portion of the protocol, but the tissue assay and autoradiography phases were intact. Time, 2:16 P.M.

The autopsy would begin, according to protocol, in exactly one hour. Betty went back to the hospital to replenish her depleted supply of anesthetics. Carolyn Rust, a medical technician, went with her. Ray Hayes jogged on down the road to a service station to pick up another gallon of gas.

Carolyn was a well-trained technician and did not find the odor of the pig, per se, objectionable; but, due to ether or excitement, the pig had relaxed a number of his sphincters. We cleaned up part of the mess and went outside to relax and exhale ether. Mary Sutliff, with a nurse's compulsion, resterilized the instruments for the autopsy. By this time Carolyn had returned from her mysterious errand. She was just trying to be helpful. She finished tidying up the autopsy room by sponging the pig with a full bottle of Chanel No. 5.

The autopsy results on Comar's pig were a great step forward in the treatment of bone disease with Ga-72. We had not been able to get the external counting verification we desired, but this was now an instrumentation or, specifically, a collimator problem. The autoradiograms demonstrated conclusively that Dudley's contention was true: a therapeutic dose could be delivered to regions of osteoblastic activity.

But even now, 25 years later, whenever I get a whiff of Chanel No. 5, no matter on whom or where it is applied, I get a vision of piles of freshly emptied sausage casings.

But We Need a Collimator

Our failure to localize the Ga-72 by external counting was a serious setback to therapeutic control. Some kind of super collimator[3] would be necessary for the multimillion-volt radiation. Tracer doses were calibrated against RaDEF standards on a Lauritzen electroscope. We could "scale up" volumetrically for therapeutic purposes. We knew with academic precision how much "radium equivalent" we were giving patients. But we also knew that Ga-72's searing 3 MeV beta radiation was monstrous compared to anything previously used (remember, this was before the "rad" or the "rem"). Death would be inevitable for any metastasis within range of that hot beta—if we could only be sure of its location. In vivo localization should be simple with external scanning. The 2.5 MeV gamma ray was almost the highest energy available from a nuclide.

[3] I.e., one that would only pass radiation in the line of sight (editor's note).

Ga-72 emitted rays far beyond the Compton scatter limits. Our shielded G-M tubes measured only degraded radiation and then only after multiple scatter. Any collimator would first of all be a scatter chamber. To constrain a field-of-vision to a fine, or even to an acceptably coarse, resolution would be difficult. Dick King went into a huddle with Rex Fluharty, the physicist who had designed our thyroid counting equipment. If a small, insensitive G-M tube were surrounded with a couple of tenth value layers of lead (the TVL of lead for 2.5 MeV is 4.5 cm), a long narrow "aperture" might collimate a beam of vision. King got a length of 6-inch-diameter sewer pipe, had it filled with lead, and drilled a small hole down the axis. It did collimate an extended source of Ga-72, but had a fuzzy cross-section. He was measuring the solid angles for visualizing Ga-72 gamma rays when the Korean War started. The Navy called King back to work.

Herbert Kerman (now doing radiotherapy in Daytona Beach, Florida) came down to Oak Ridge from the University of Louisville, primarily to work on cobalt-60 teletherapy. Localization of Ga-72 was much the same problem reversed: the collimation of a beam of high energy radiation. By then we were giving therapeutic doses of Ga-72 to patients with osteogenic sarcoma who also had metastases. The primary tumor did, we knew from autoradiography following surgery, take up large amounts of Ga-72. Did the metastases that we detected radiographically also pick up gallium—and how much? King's collimator was perfect for this job (well, not perfect, but better than anything else we had available). But King's collimator weighed a quarter ton.

Kerman had an over-the-bed frame made from 2-inch iron pipe. It sagged precariously when the collimator was suspended from it. A 2-inch "I" beam which would also serve as a track was placed on a pair of 2 by 4's and lashed to the frame. Now King's collimator could be positioned precisely over a patient. One of Cassen's first scanners had just been purchased and was producing remarkable pictures of the thyroid gland. Kerman selected his strongest x-ray technician, and with relative facility (that word "relative" stretches things a bit) he too could scan hot spots and cold spots inside a human body. To honor its inventor, Kerman chose to call his device the King Kong Kollimator.

With the King Kong Kollimator, Kerman proved that, although a primary osteogenic sarcoma picked up large amounts of Ga-72, its distribution was highly variable throughout the tumor mass. However, autoradiography demonstrated dramatically that it was not the tumor itself, but the osteoblastic reaction in and around the tumor, that had the uptake. The external counter results thus were never published.

Metastases to bone from carcinoma of the prostate were demonstrated to pick up Ga-72, and occasionally these could not be seen on x-ray. King's group at Bethesda confirmed this on a much wider variety of patients. They were more concerned with the diagnostic implications. Horace Dudley contended, purely on metabolic theory, that radionuclide detection of metastases to bone would be possible long before there was sufficient calcium loss to be seen radiographically. We believed him and thought we might be demonstrating it, but we could not, nor would it ever be proved with Ga-72. In another 10 years Sklaroff and Charkes, with Sr-85 scanning, would prove that radionuclide detection of metastases was far more sensitive than radiographic detection. Still another 10 years would pass before radiologists would accept a similar proof with another kind of metastases—pulmonary emboli.

An important concept grew out of the comparison of the King Kong Kollimator and the remarkable pictures produced by Cassen's new scanner: we couldn't handle extremely high-energy radiation. Delivery of controlled beams by teletherapy was a simple mechanical problem. But the localization of a metabolic distribution required a low-energy emitter.

There were better isotopes of gallium. Both the Oak Ridge and the Bethesda groups began studies with Ga-67 and Ga-68. However, these isotopes required cyclotron production which was not well funded in the early 1950s. Besides, the scanner had to be perfected, and there was a lot of exciting competition from other branches of nuclear medicine. The first whole-body human scan with Ga-68 was not done until June 1965 (Hayes, Oak Ridge) and then it demonstrated that gallium was not, after all, a bone- but a tumor-scanning agent. All the work with Comar's pig and the King Kong Kollimator was eventually confirmed; gallium does deposit in regions of osteoblastic activity. But so do many other nuclides, among them Sr-85 and then the polyphosphates.

I can't really make much of a case for gallium being the beginning of bone scanning. It was provocative, a good try, but only a side show to the main event. Ten years later, and then for almost ten years, Sr-85 held the center ring in bone scanning. It was gradually being replaced by Sr-87m when F-18 caused a brief flurry. But all three nuclides have the gallium flaw—too high an energy for scanning. Then in 1971 G. Subramanian tagged polyphosphate with low-energy Tc-99m.

More than ten years earlier, Ervin Kaplan had discovered that polyphosphate would do the therapeutic job we had envisioned for gallium. But Kaplan was just improving J. R. Maxfield's 1958 combined testosterone-P-32 therapy for metastases to bone. And Maxfield was just applying H. Friedell's observation of ten years earlier which was an extension of the 1942 studies on Sr-89 by a University of California team—Lawrence, Friedell, and the Low-Beers. (You won't find the name Anne Treadwell, so often quoted at first, in the later literature. Low-Beer knew a good technician when he saw one and married her.)

But even Low-Beer was not the beginning. Just before the outbreak of World War II, a Belgian physician came to San Francisco as a graduate student in pharmacology. He saw a therapeutic use for Sr-89 in bone metastases while working with Joe Hamilton in the cyclotron laboratory in Berkeley. Sr-89 therapy was tried on a few patients, but then Charles Pecher was recalled to Belgium for military duty. His unfinished notes were edited for publication by C. D. Leake, dean of the Department of Pharmacology. Pecher's article appeared in the local pharmacology journal in 1942, posthumously.

10

*Atomic Energy Commission Fellowships**

Predoctoral and Postdoctoral Fellowships in Physical and Biological Sciences

Following World War II, there was widespread enthusiasm for a major scientific research effort on many new and promising frontiers. A rapid, substantial increase in the numbers of scientific researchers in the nation was required, however. The only federal agency with a broad enough scientific mandate to meet this need was the Atomic Energy Commission. The AEC responded quickly to this challenge by developing a program of federally supported predoctoral and postdoctoral fellowships in all of the sciences. The fellowship program, which began in 1948, received strong support in the Congress. To administer the program, the AEC contracted with the National Research Council (NRC), which made fellowship appointments in 1948, 1949, and 1950.

The adoption of a rider to the 1950 Independent Offices Appropriation Act requiring a determination of loyalty prior to the payment of any funds to fellows from that appropriation led to a policy crisis within the NRC and its parent body, the National Academy of Sciences. After protracted debate on this question, the NRC decided that it would not make any new appointments, but would continue its responsibility for AEC fellows already in the program.

*Based on *Scientists and Engineers for the Nuclear Age: Final Report on the Atomic Energy Commission Fellowship Programs 1948-1973* (Oak Ridge, Tennessee: Oak Ridge Associated Universities, 1974).

In response, the AEC asked four universities and university associations, with which it already had operating contracts, to establish regional fellowship boards to administer the program. These boards, the AEC contractors responsible for them, and the associated AEC installations were as follows:

The Northeastern Fellowship Board, Associated Universities, Incorporated (Brookhaven National Laboratory)

The Midwestern Fellowship Board, The University of Chicago (Argonne National Laboratory)

The Western Fellowship Board, The University of California (Radiation Laboratory, Berkeley)

The Southern Fellowship Board, Oak Ridge Institute of Nuclear Studies (Oak Ridge National Laboratory)

This administrative arrangement was in force only for the academic year 1950-1951. The lack of administrative uniformity and national identity inherent in this regional system led the AEC to transfer administrative responsibility for the entire program to ORINS on July 1, 1951. ORINS administered the program until 1954. By 1953 the National Science Foundation (NSF) had been established by Congress, and among its first programs were general fellowships in the physical and biological sciences, which did not require a determination of loyalty. As a result, the AEC decided to end its general fellowship program, since the two programs were identical in nature and purpose.

The AEC Fellowship Board, appointed by the ORINS board of directors to establish policies for program administration and to make appointments of fellows, included the following:

George B. Pegram, chairman, Columbia University
George E. Boyd, University of Georgia
Robert B. Brode, University of California
Detlev W. Bronk, John Hopkins University
Leland J. Haworth, Brookhaven National Laboratory
Warren C. Johnson, University of Chicago
Homer W. Smith, New York University College of Medicine
Elvin C. Stakman, University of Minnesota
Douglas Whitaker, National Research Council

The National Research Council fellowship panels, which had provided evaluation assistance to the four regional boards, continued to assist the ORINS board. All applications were sent to the NRC for screening, and appointments were made by the ORINS Fellowship Board on the basis of the NRC panel's evaluations, within the limits of available funds.

The following table shows the number of new applications received each year and the number of awards made (fellowship renewals are not included). Applicants and fellowships awarded between May 1 and June 30, 1948, are included in the totals for the academic year 1948-1949. No original applications were accepted after March 15, 1951.

	Predoctoral							
	Physical Sciences		Biological Sciences		Postdoctoral		Total	
Academic Year	Applicants	Awards	Applicants	Awards	Applicants	Awards	Applicants	Awards
1948—1949	740	154	314	57	127	39	1,181	250
1949—1950	403	118	201	65	98	72	702	255
1950—1951	371	121	65	27	0	1	436	149
1951—1952	442	159	127	64	91	43	660	266
Total	1,956	552	707	213	316	155	2,979	920

The number of applications decreased sharply after the first year of the program but increased in the final year. The number of awards remained at about 250, except for 1950-1951 when they dropped to 149. The decline in applications for that year coincided with the transfer of administration from the NRC to the four regional boards.

Over 60 percent (552) of the 920 fellowship awards were for predoctoral study in the physical sciences (chemistry, physics, geology, mathematics, metallurgy, and engineering). An additional 23 percent (213) were for predoctoral study in the biological sciences (agronomy, zoology, botany, and related fields). Seventeen percent (155) of all fellowships were postdoctoral; of these, 59 were in physical sciences, 57 in medical sciences, and 39 in biological sciences.

In 1953, after all fellowships had been terminated, ORINS conducted a follow-up study of all former fellows (except for the 57 postdoctoral fellows in medicine) to determine their occupation at the completion of their fellowship. The results are in the following table.

Type of Fellowship	AEC	Other Government Agencies	Private Industry	Universities or Colleges	Further University Study	Unknown	Totals
Predoctoral—Physical	71	20	119	177	100	65	552
Predoctoral—Biological	6	7	21	65	89	25	213
Postdoctoral—Physical	3	1	3	36	5	11	59
Postdoctoral—Biological	4	0	4	20	6	5	39
Total	84	28	147	298	200	106	863

Health Physics Fellowships

On December 2, 1942, the first man-made nuclear chain reaction was started under the bleachers of Stagg Field at the University of Chicago. Humanity would now have to learn to live safely with quantities of radioactive materials no longer measured in milligrams but in tons of radium equivalent. This awesome prospect led to the formation of a committee of physicists at the University of Chicago to develop ways of successfully coping with such unprecedented radiation hazards. Since this group of physicists was concerned with the health of workers around radiation, they were called "health physicists." So was born a new, specialized discipline that has become extremely important in the age of nuclear power.

In 1944 it was necessary to train the health physicists who would be responsible for radiation protection at the production reactors being built at Hanford, Washington. To meet this need, a formal training program was organized in the Health Physics Division at Oak Ridge National Laboratory. The program continued until 1950. With the establishment of the AEC Fellowship Program in 1948, the health physics trainees at ORNL were supported as a special group of fellowships administered by the NRC. In 1949 ORINS took responsibility for this program for fellows to be appointed for the 1950-1951 academic year. Vanderbilt University and the University of Rochester were chosen to provide an academic year's instructional program in health physics. The fellows at Vanderbilt University went to ORNL and the fellows at the University of Rochester went to Brookhaven National Laboratory for three months of field experience before completing their fellowships.

ORINS responsibility for the administration of this program continued until the program ended in 1973. The members of the

Health Physics Fellowship Board appointed by the ORINS/ORAU board of directors were as follows:

Elda E. Anderson, Oak Ridge National Laboratory, 1950-1961
R. Christian Anderson, Brookhaven National Laboratory, 1955-1956
Howard L. Andrews, Puerto Rico Nuclear Center, 1966-1967
Edgar C. Barnes, Westinghouse Electric, 1958-1961
Werner A. Baum, Florida State University, 1961-1963
Henry A. Blair, University of Rochester, 1954-1955, 1957-1961
Hanson Blatz, New York Office of Radiation Control, 1968-1970
Allen Brodsky, University of Pittsburgh, 1969-1970
Walter D. Claus, Atomic Energy Commission, 1950-1952, 1956
Frederick P. Cowan, Brookhaven National Laboratory, 1957, 1968-1970
H. Willard Davis, University of South Carolina, 1962-1965
Joseph Fitzgerald, Cambridge Nuclear Corporation, 1966-1968
Ronald Geballe, University of Washington, 1954-1957
William T. Ham, Jr., Medical College of Virginia, 1965-1967
H. Floyd Herr, Westinghouse Electric, 1970
Frank E. Hoecker, University of Kansas, 1957
John I. Hopkins, Vanderbilt University, 1951-1957
John Horan, National Reactor Testing Station, 1962-1965
Arthur R. Keene, Battelle Memorial Institute, 1957, 1966-1967
Wright H. Langham, Los Alamos Scientific Laboratory, 1963-1965
John Manley, University of Washington, 1953
Dean D. Meyer, Los Alamos Scientific Laboratory, 1968-1969
M. L. Mickelson, Hanford Works, 1953-1954, 1956
Karl Z. Morgan, Oak Ridge National Laboratory, 1962-1964
W. E. Nolan, University of California, 1958-1962
C. Maurice Patterson, Savannah River Laboratory, 1964-1966
Robert A. Patterson, Brookhaven National Laboratory, 1951-1955
Robert B. Platt, Emory University, 1965-1967
Clinton C. Powell, National Institutes of Health, 1958-1963
Herman M. Roth, Atomic Energy Commission, 1950-1953
Leslie Silverman, Harvard University, 1962-1964
Francis G. Slack, Vanderbilt University, 1950-1951
J. Newell Stannard, University of Rochester, 1950-1953, 1968-1970

Isabel Tipton, University of Tennessee, 1967-1969
Edwin C. Watson, Hanford Works, 1955
Paul L. Ziemer, Purdue University, 1970

Initially only two universities (Vanderbilt and Rochester) and two AEC laboratories (Oak Ridge and Brookhaven) were involved in the program. Vanderbilt was to emphasize the physical sciences and health physics, with supplementary courses in the biological sciences. Rochester was to emphasize the biological sciences, with supplementary courses in the physical sciences. Both programs would provide a first-year curriculum acceptable toward a conventional master's degree. As the program developed, however, the health physics boards were more specific in defining courses to be included in the first-year program of study at all universities participating in the program. Eventually, 18 universities made proposals which met AEC requirements and were accepted as participating universities. When the program was expanded to include work toward a Ph.D., those universities in a position to award this degree and to provide health physics-related research for theses were permitted to accept fellows for the second (intermediate) and third (terminal) years of the fellowship.

After completing the first academic year program as specified by the AEC, the fellows were assigned for the three summer months to an AEC laboratory for practical experience in health physics operations. At first, these sessions were confined to Oak Ridge National Laboratory and Brookhaven National Laboratory, but subsequently assignments were made each summer at two other AEC laboratories selected in rotation from seven laboratories that agreed to provide summer training every third year. In 1971-1972, the last full year of operation, the universities and laboratories participating in the program were as follows:

University	Adviser
Georgia Institute of Technology	H. G. Dulaney
Harvard University	Jacob Shapiro
New York University Medical Center	McDonald Wrenn
Purdue University	Paul L. Ziemer
Rutgers University	A. J. Kaplovsky
Texas A & M University	Richard Neff
University of California, Berkeley	Roger Wallace
University of Illinois	Marvin E. Wyman

University of Kansas	Frank E. Hoecker
University of Kentucky	Joseph A. Sayeg
University of Michigan	G. Hoyt Whipple
University of Minnesota	Donald E. Barber
University of Pittsburgh	Allen Brodsky
University of Puerto Rico	Peter Paraskevoudakis
University of Rochester	Irving L. Spar
University of Tennessee	Robert J. Lovell
University of Washington	Kenneth L. Jackson
Vanderbilt University	P. Galen Lenhert

Laboratory	Adviser
Argonne National Laboratory	John F. Ege, Jr.
Brookhaven National Laboratory	Charles Meinhold
Lawrence Radiation Laboratory/B	Roger Wallace
Lawrence Radiation Laboratory/L	David S. Myers
National Reactor Testing Station	Charles A. Pelletier
Oak Ridge National Laboratory	Karl Z. Morgan
Pacific Northwest Laboratory	Ronald L. Kathren
Puerto Rico Nuclear Center	Peter Paraskevoudakis
Savannah River Laboratory	C. Maurice Patterson

Various studies were made to see how effective the program was in producing highly trained health physicists. Surveys were made in 1954, 1956, 1962, 1964, 1966, and then each year until 1971. These studies consistently showed that 70 to 80 percent of the fellows were either employed in health physics or continuing their education. The last study (1971), summarized in the following table, surveyed 882 former health physics fellows of whom 823 replied.

Category	Total Responding	In Health Physics	Not in Health Physics	Percent in Health Physics
Industry	150	116	34	77
Government	260	242	18	93
AEC	6	5	1	83
University Teaching	162	145	17	90
Military	30	16	14	53
Other	53	17	36	32
Subtotal Employed	661	541	120	82
Further Study	162	136	26	84
Total	823	677	146	82

This record shows the program achieved its objectives remarkably well. Few educational programs can claim as high a retention in the specialty for which training was provided.

Another significant evaluation of the success of this program comes from the experience of the Health Physics Society, which certifies health physicists. In a 1970 report to the society, health physicist Dade Moeller makes the following statement:

> *The study shows that the performance on the examinations of the AEC supported candidates was outstanding, far surpassing the group as a whole. Of the total of 134 candidates whose graduate training was supported by the AEC, final decisions have been made on 132 and of these 112 (84.9%) have been certified. This compares with a certification percentage of 63.7% for the 433 candidates on whom decisions have been reached. Decisions on 18 candidates are still pending.*
>
> *Of 149 candidates who attended graduate school for one year or more, but whose training was supported by sources other than AEC, only 78 (51.7%) have been certified.*

Advanced Health Physics Fellowships

When the Health Physics Fellowship program began, this specialty was so new that a number of those working as health physicists at the time had no formal education in the field. In response to their needs, the AEC established in 1960 a special program of fellowships for persons who had been working as health physicists for at least two years. By 1967 the needs of most persons in this category had been met, and the program was ended.

The regular and advanced health physics fellowships were important in providing trained personnel to ensure safe conditions for workers, as well as the general public, in the field of atomic energy and nuclear power. Today recipients of these fellowships are a major part of the professional leadership for radiation protection in industry, universities, and government.

Industrial Hygiene Fellowships

By the mid-1950s, it became evident to the AEC that the development of nuclear reactors and nuclear energy would involve the use of exotic metals, such as beryllium and zirconium, as well as other unusual materials for which rigorous toxicity controls would be required. To meet this need, graduate fellowships in industrial hygiene were offered on the recommendations of an ad hoc committee established by the AEC to review existing university programs and to recommend the number of fellowships to be provided. It was decided that the program should be designed to support eight fellows each year for one year of graduate study. For the initial year, 1952-1953, four of the fellows were paid by the University of Rochester and the remaining three by ORINS as part of its health physics program. ORINS assumed full administrative responsibility for the program thereafter. The program began at Harvard University and the University of Pittsburgh, and the University of Michigan and the University of Cincinnati were added later. In 1961 extensions beyond the first year were authorized for a few fellows to enable them to complete a master's degree.

Compared with other fellowship programs, this one was small, since the number of industrial hygienists needed for AEC programs remained quite limited. Consequently, a large recruitment effort was not justified. Nevertheless, at times there were not enough qualified applicants for even the small number of fellowships available. The Industrial Hygiene Fellowship Board, therefore, resisted adding more universities to the program, although several universities wanted to be included.

The few universities with graduate programs in industrial hygiene included it as a specialty within their schools of public health. As a specialty within an already small and specialized program, the AEC industrial hygiene program was difficult to define adequately and to implement in a way that would meet AEC objectives. A further problem was the concurrent development of large traineeship programs by the U.S. Public Health Service in all schools of public health; these trainees tended to swamp the small AEC special fellowship program. These problems, combined with the difficulties experienced in recruiting qualified applicants, brought the program to an end in 1963. The members of the Industrial Hygiene Fellowship Board, their institutions, and terms of service were the following:

Anna M. Baetjer, John Hopkins University, 1954-1963

Edgar C. Barnes, Westinghouse Electric Corporation, 1954-1958

Newell Bolton, Oak Ridge National Laboratory, 1963

Allen D. Brandt, Westinghouse Electric Corporation, 1955-1960, 1963

Warren Cook, University of Michigan, 1961-1963
H. Willard Davis, University of South Carolina, 1963
Phillip Drinker, Harvard University, 1953
John F. Ege, Argonne National Laboratory, 1962-1963
Merril Eisenbud, Atomic Energy Commission, 1953, 1963
Theodore F. Hatch, University of Pittsburgh, 1953-1960, 1962-1963
William Hazard, Owen Illinois Glass Company, 1961-1963
N. V. Hendricks, Esso Laboratories, 1953-1954, 1959-1963
H. F. Schulte, Los Alamos Scientific Laboratory, 1953-1956, 1958-1961
Leslie Silverman, Harvard University, 1953-1961

Nuclear Science and Engineering

The AEC general fellowships ended in 1954, although there was still a growing need for nuclear scientists and engineers, and the general National Science Foundation fellowships were not producing enough. The development of safe, reliable nuclear power was becoming a primary concern of the AEC, and both the AEC laboratories and private industry would need many more highly trained nuclear scientists and engineers if the commission's goal was to be reached. In 1956 the commission asked ORINS to establish a new program, initially called Nuclear Energy Technology Fellowships, for one year only of specified graduate study, with initial appointments for the academic year 1957-1958. The following year, the fellowship program included renewals of fellowships for a second and third year, and it was renamed the AEC Special Fellowships in Nuclear Science and Engineering.

The first year of graduate study under these fellowships was defined for each of the participating universities. The program included specified courses in reactor physics and chemistry, reactor technology, and other relevant topics, plus approved electives. To be eligible, applicants were required to have an undergraduate major in science or engineering with a high academic performance and appropriate courses, including mathematics through calculus and differential equations.

Members of the Nuclear Science and Engineering Fellowship Board were appointed by the ORINS board of directors on the basis of nominations obtained from the current fellowship board, fellowship advisers at participating universities, the AEC, and other sources. Board nominees were approved by the AEC, and appointments were for staggered, three-year terms. Board members were as follows:

R. Christian Anderson, Brookhaven National Laboratory, 1962-1965
Robert Avery, Argonne National Laboratory, 1969-1971
Manson Benedict, Massachusetts Institute of Technology, 1957-1963
Robert A. Charpie, Oak Ridge National Laboratory, 1957-1959
Robert G. Cochran, Texas A & M University, 1968-1970
Kenneth S. Colmen, Atomic Energy Commission, 1958
Thomas Connolly, Stanford University, 1970
George W. Courtney, Atomic Energy Commission, 1959-1961
Trevor R. Cuykendall, Cornell University, 1963-1965
Mario J. Goglia, Regents of the University System of Georgia, 1969
Henry Gomberg, University of Michigan, 1957-1961
William Havens, Jr., Columbia University, 1964-1966
Walter H. Jordan, Oak Ridge National Laboratory, 1960-1961
John F. Kaufman, Atomic Energy Commission, 1957
William Kerr, University of Michigan, 1968-1970
John W. Landis, The Babcock & Wilcox Company, 1957-1962; 1967-1968
Willard F. Libby, University of California, 1964-1966
Harold Lurie, California Institute of Technology, 1961-1963
H. G. MacPherson, Oak Ridge National Laboratory, 1966-1968
Ross J. Martin, University of Illinois, 1962-1964
Glenn Murphy, Iowa State University, 1957-1960
Thomas H. Pigford, University of California, 1967-1969
Philip N. Powers, Purdue University, 1965-1967
Lawrence R. Quarles, University of Virginia, 1965-1967
Sidney Siegel, Atomics International, 1963-1965
Thoma Snyder, General Electric Company, 1969-1970
Marvin E. Wyman, University of Illinois, 1966-1968

The participating universities for the Nuclear Science and Engineering Fellowships were selected by the AEC on the basis of proposals submitted by the universities. The fellowship board and ORINS, in collaboration with the AEC, developed course content requirements for the first year of the graduate program. Those universities that agreed to meet these requirements were accepted by the AEC as participating universities. Throughout the history of the fellowships, 43 universities participated at one time or another:

Participating University	Fellowship Adviser
California Institute of Technology	Noel Corngold
Carnegie-Mellon University	Claude G. Poncelet
Case Western Reserve University	Osman K. Mawardi
Catholic University of America	Robert W. Deutsch
Columbia University	Charles F. Bonilla
Cornell University	Trevor R. Cuykendall
Georgia Institute of Technology	R. J. Johnson
Iowa State University	Glenn Murphy
Kansas State University	Curtis G. Chezem
Massachusetts Institute of Technology	Kent F. Hansen
New York University	John Lamarsh
North Carolina State University	Thomas S. Elleman
Northwestern University	D. T. Eggen
Ohio State University	Arliss L. Roaden
Oregon State University	C. H. Wang
Pennsylvania State University	Warren F. Witzig
Purdue University	Alexander Sesonske
Rensselaer Polytechnic Institute	V. L. Parsegian
Stanford University	Thomas J. Connolly
Texas A & M University	Robert G. Cochran
Tulane University	Ralph M. Rotty
University of Arizona	Robert L. Searle
University of California (Berkeley)	George Yadigarogly
University of California (Davis-Livermore)	George D. Sauter
University of California (Los Angeles)	Thomas E. Hicks
University of Cincinnati	James H. Leonard
University of Florida	M. J. Ohanian
University of Illinois	Marvin E. Wyman
University of Kentucky	O. J. Hahn
University of Maryland	Joseph Silverman
University of Michigan	John S. King
University of Minnesota	Herbert S. Isbin
University of Missouri (Columbia)	Thomas F. Parkinson
University of Missouri (Rolla)	Daniel S. Eppelsheimer
University of New Mexico	Glen A. Whan
University of Oklahoma	David M. Elliott

University of Puerto Rico ....Donald S. Sasscer
University of Rhode Island ....Vincent C. Rose
University of Tennessee.................... P. F. Pasqua
University of Texas .... R. N. Little
University of Virginia ....J. Lawrence Meem, Jr.
University of Washington .... A. L. Babb
University of Wisconsin .... Max W. Carbon
Virginia Polytechnic Institute
and State University.................Andrew Robeson

The fellowship advisers at each institution were responsible to ORINS for

1. Ensuring that the fellows were registered and enrolled in the courses necessary to meet the first-year requirements.
2. Reporting periodically on the progress of each fellow.
3. Recommending fellowship extensions or renewals.
4. Ensuring that thesis work was in the proper area.
5. Providing an abstract of completed master's and doctoral theses.

Throughout the period covered by this program, various follow-up studies were conducted by ORINS/ORAU to evaluate the extent to which the objectives were being achieved. The first was conducted in 1961 largely for the benefit of the fellowship board which sought to improve its selections. It compared graduate school academic performance of fellows with various elements used by the board in rating applicants. Other studies to determine employment or further educational patterns of former fellows were conducted in 1962, 1964, 1966, and annually thereafter through 1971. This series of studies up through the final survey in 1971 included questionnaires sent to 1,330 former fellows, of whom 1,272 responded with the following results:

Category	All Fellows	In Nuclear Field	In Nonnuclear Field	Percent Nuclear
Industry	385	304	81	79
Government	255	227	28	89
Government/AEC	21	20	1	95
University Teaching	170	145	25	85
Military	114	75	39	66
Other	38	16	22	42
Further Study	289	266	23	92
Total	1,272	1,053	219	83

In 1972, after the decision was made to discontinue all AEC special fellowship programs, a questionnaire-letter was sent to all participants. The responses were used to help prepare a final report on the program.

Of the 683 who replied, 504 or 85 percent were still pursuing professional careers in the field for which they were trained under the fellowship. Much depended on the nature of the particular opportunities for employment which happened to exist at the completion of the fellow's graduate program. Several had changed employment since completing their education, but the character of the first job after graduation seemed to determine future career development. A number of those not employed in the specialty field for which they were trained under their fellowship explained that they probably would have been if they had received an attractive offer of employment at the time of graduation.

The total investment of AEC in all of these programs and the total number of fellows trained is summarized in the following table from the preceding separate tabulations.

Program	Fellows	Fellowship Years	Cost
Predoctoral and Postdoctoral	920	1,061	$ 4,382,000
Health Physics	910	1,381	6,078,000
Advanced Health Physics	30	77	597,000
Industrial Hygiene	80	89	466,000
Nuclear Science and Engineering	1,380	2,457	12,960,000
Total	3,320	5,065	$24,483,000

For a total investment of $25 million over a 25-year period, 3,320 young men and women received graduate training for an average of one and a half years in scientific and engineering specialties needed to develop nuclear energy. This represents a cost of less than $5,000 per fellow per year, a modest investment by almost any educational standard.

11

The Medical Division

Gould A. Andrews, M.D.*

In chapter 4, a brief account is given of the establishment of the board of medical consultants whose duty it was to set up a clinical research unit. Plans moved rapidly after the decision was made in 1948 to develop such a program. Late that year Marshall H. Brucer was appointed chairman and promptly began to assemble a scientific and technical staff and to obtain a suitable building. The one-story wing of the Oak Ridge Hospital that had been provided by the Atomic Energy Commission was extensively remodeled, and a new, two-story wing for laboratory facilities was added on its western end. During the late summer of 1949 while this construction was continuing, the members of the division's scientific staff who were already in Oak Ridge were housed in the ORINS administration facility and were occupied with planning research and ordering equipment. Brucer made an intense study of laboratory hoods, work surfaces, and storage for radioactive waste as these problems related to radiation safety, and he oversaw every detail of the construction and remodeling process. His good-natured impatience was communicated to all of the workers. When there appeared to be a delay or cessation in the work, he would telephone everyone remotely connected with the project, including some who seemed in no position to be of help, communicating his eagerness, enthusiasm, friendliness, and utter despair about the delay. After these outbursts, work was always promptly resumed.

By early 1950 the clinical facilities were ready, and the first

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patient, a woman with extensive cancer of the thyroid, was admitted in May. Contributing to the clinical care of patients then and through succeeding years were many consulting physicians from Oak Ridge, Knoxville, and the supporting ORINS/ORAU medical schools. In a large number of instances, this help, including surgical procedures, was given without financial compensation. A devoted nursing staff was established under the direction of Mary Sutliff, and many warm and lasting relationships were developed with patients and their families. Through the years important clinical and research care was provided by S. W. Root, B. W. Sitterson, A. L. Kretchmar, C. L. Edwards, D. White, R. Tanida, H. Vodopick, F. Goswitz, K. Hübner and a number of other staff physicians.

By the summer of 1950, visiting students and scientific staff began to come to the Medical Division for training for work on collaborative projects. Through the years a large number of persons have participated on temporary appointments of various types. These visitors have included students from the undergraduate through all later stages of training and well-established scientists. Quite a number of trainees have come from overseas, including a sizable contingent from Japan, primarily from the department of Hirotake Kakehi at Chiba. For a number of years, radiology residents from Massachusetts General Hospital made a regular rotation through the division, usually for three or four months. These visiting physicians and other scientists have come under a variety of auspices, including the research participation programs administered by ORINS/ORAU. Short training courses were given to physicians to prepare them for clinical nuclear medicine. These courses qualified them to obtain licenses from the AEC. A number of these physicians later became leaders in nuclear medicine.

Most of the radioisotopes available during the early years of nuclear medicine research were not supplied in suitable form for direct administration; therefore, the Medical Division's staff developed methods of synthesizing labeled compounds and preparing them for clinical use. An early project of the division was the attempt to use gallium-72 to treat malignancies of the bone, especially osteogenic sarcoma, as described earlier by Dr. Brucer in chapter 9. The selection of such a radioresistant tumor as osteogenic sarcoma now appears to have been naive, but in those days workers were so encouraged by the good results obtained in the treatment of thyroid cancer with iodine-131 that there seemed no limits to the possibilities of radioisotope therapy. A group of patients admitted to the Medical Division's hospital were given gallium-72 in maximum tolerated doses, but no significant therapeutic benefit was achieved. In the latter part of the study, gallium-67 became available and, when given without much carrier (stable isotope of the same element), was shown to localize in soft tissue cancers. However, the diagnostic possibilities were not recognized because in 1951 and 1952 clinical devices for external detection of radiation were extremely crude. The important effect of the amount of carrier element on biological behavior, seen with gallium in this early work, is a general principle which has clinical application with many radionuclides. At the end of the therapeutic trial of radiogallium, a very extensive report was published in *Radiology:* afterwards the interest in gallium declined for many years.[1]

At the same time that gallium-72 was being explored as an internally administered therapeutic radioisotope, there was an active program to develop external radioisotope sources that could be used in place of x-rays to produce an external beam that could be directed into the body as a treatment for cancer. The nuclear reactor had made available high-energy gamma emitters with radiation characteristics ideal for this purpose. The main requirements were, first, to produce the radioisotope in very concentrated form so that a small source would produce a high output and, second, to devise a shielding containment allowing the beam to be properly directed and turned on and off. Experience had been gained in England with such devices containing radium, although radium was not the ideal radioisotope. A cooperative project was started with M. D. Anderson Hospital in Houston to develop radiotherapy machines using the newly available radioisotopes. Leonard G. Grimmett, a British physicist, came to the United States to work on this project. Gilbert Fletcher of M. D. Anderson and Brucer and Herbert Kerman of ORINS were participants. Scientists in other countries and in private industry were working along similar lines. By October 1951, an efficient cobalt-60 teletherapy machine had been designed and placed in a specially built room at ORINS. After testing, it was moved to M. D. Anderson for clinical trials.

[1] *Radiology*, 61(4): 534-613.

Early in 1952, the Medical Division launched a teletherapy evaluation project involving participants from medical schools in the South and consultants from around the country. The objectives were to determine which of several potentially useful radioisotopes would prove most useful in teletherapy and to resolve some of the problems involved in using these new instruments. Extensive cooperative work was done by several committees, and over the next few years their accomplishments were reflected in numerous publications. Cobalt-60 became the most widely used teletherapy source, and soon this form of therapy was common all over the world.

The Medical Division also played a role in the development of brachytherapy devices. These structures are made of or contain radioactive materials that can be inserted into or fastened directly upon malignant tumors and thus irradiate them from very close range. This was also a cooperative project involving scientists from several schools and private industry.

In this same period radioiodine-131 had become available from ORNL and numerous clinics throughout the country were using it for the diagnosis and treatment of thyroid cancer. There was, however, no uniformity in methods used to measure the administered dose or the amount localized in the thyroid gland, and there were wide inconsistencies in results obtained in different laboratories. In 1954 Dr. Brucer initiated a radioiodine uptake calibration program with the assistance of Dr. Harold Oddie, an Australian scientist working at the medical school of the University of Arkansas in Little Rock and on temporary appointment in Oak Ridge. Because the eight-day half-life of iodine-131 was too short for standardization purposes, a carefully proportioned mixture of barium-133 and cesium-137 was developed which, with a suitable metal shield, gave nearly the same gamma spectrum as iodine-131. Absorbed on an ion exchange resin, this long-lived "mock iodine," as it was called, was ideal for the purpose. Several fashion store mannequins were purchased, and artificial thyroid glands with accurately known levels of mock iodine were placed in their necks and the rest of the cavity packed with low activity resin to simulate body background. These mannequins were installed in sturdy shipping cases together with a metal "dixie cup" containing an accurately measured simulated "atomic cocktail" administered dose. These calibration kits were sent from one laboratory to another where each clinician used his own instruments to measure the administered dose and uptake in the thyroid of the mannequin "patient." The mannequins were named Abigail, Bridget, Chloe, Drucilla, Euphemia, and so on through Rhoda with a special one for a different purpose named Anne Boleyn. All results were reported to the Medical Division and there compared with the known values for the mannequin measured. As expected, there were extremely wide discrepancies from the standard in the results obtained on the same mannequins.

P. R. Bell and J. E. Francis, Jr., of ORNL collaborated with ORAU in this program. They realized that the source of these wide discrepancies was the large diffuse component of radiation scattered in the body from the source and degraded in energy. To solve the problem they designed and built a single channel analyzer which would detect only radiation whose energy was within a narrow movable "window" which could be set to admit only the primary radioiodine gamma energies. With this instrument, measured values of the uptake in the thyroid of an administered dose agreed well with the known values in the standard mannequins. This Bell-Francis Single Channel Analyzer soon became widely available commercially and made radioiodine thyroid diagnosis and treatment a reliable and standard clinical procedure.

This success led to another fruitful collaboration between ORAU and ORNL. The radioisotope scanner had recently been introduced by Benedict Cassen of the University of California. This device consists of a shielded radiation detection head on a cantilevered arm which moves back and forth over a patient, measuring the radioactivity and printing it out in such a way as to yield a two-dimensional map of its distribution. Bell and Francis, working with Brucer and his staff, built experimental scanners which incorporated the spectral selection of gamma rays and special collimators designed in Oak Ridge to provide a focusing effect that improved the resolution of the images. These instruments were tested on patients in the Medical Division's research hospital and some of the design features became incorporated in commercial models.

Meanwhile, basic animal distribution studies were being done on many radioisotopes in a variety of chemical forms. These studies included complete assays on all important tissues at a large number of time intervals after administration. Many of these materials never reached clinical trials. H. D. Bruner directed many of the assay techniques. Gross and microscopic autoradiography were also extensively used. Through the years the list of materials studied became a long one.[2]

The Medical Division became a center for work on rare earth elements and clarified the distribution and carrier effect for many of them. This work was supervised by Granvil Kyker. An interesting finding, which had never been reported, was that, when given in stable form, these rare earth elements produce an acute fatty change in rat liver to a degree seen with few, if any other, agents. In animals that survive the acute phase, the fatty change is reversed. This phenomenon led to an extensive investigation of the metabolism of fatty substances in relation to radiation and cancer; the program has subsequently grown under the direction of Fred Snyder. One important result of this research was the discovery that many cancers contain significant quantities of glyceryl ethers, which are found in only small amounts in other tissues.

In the early years, Medical Division personnel treated many patients who had cancer-caused fluid accumulation in the chest and abdomen. Treatment with colloidal gold-198 injected directly into the body cavity had often been found by H. J. Muller, a Swiss investigator, to stop the fluid accumulation in some of these patients. Researchers at ORINS explored this treatment in depth, describing in great detail the fate of the injected isotope. As part of this study, ovarian cancer patients were accepted, many of whom appeared to benefit from repeated abdominal operations with multiple resections of recurrent cancer.

A totally unexpected duty fell to the Medical Division in mid-June 1958 when eight men were exposed to total-body neutron and gamma radiation in an accident at the Y-12 Plant in Oak Ridge. Doses ranged from 23 to 365 rads, with five of the men receiving more than 225 rads.[3] They were all treated at the Medical Division

[2] They included manganese-54; antimony-122, -124; yttrium-90, -91; lutetium-177; iodine-130, -131, -132; carbon-14; calcium-45, -47; cesium-137; chromium-51; cobalt-57; copper-64; europium-152; -154; gold-198, -199; hafnium-181; indium 192; iron-59; molybdenum-99; nickel-63; potassium-42; ruthenium-103; sodium-24; zirconium-95; holmium-165; and lanthanum-140.

[3] A rad is the unit of absorbed radiation energy. A dose of 1 rad is obtained when 1 g of exposed matter absorbs 10^{-5}J of radiation energy.

with the help of many consultants. Two of the exposed men reached serious levels of bone marrow depression, but all recovered uneventfully. Bone marrow transplants were considered but were not given. The men were studied more thoroughly than those in any other radiation accident, and many articles were published about various aspects of the clinical, hematologic, cytogenetic, and metabolic effects of the radiation exposure.

Partly as a result of this accident, the division devoted a major effort to human total-body radiation studies to improve the treatment for certain types of leukemia and lymphoma and to learn more about total-body radiation effects in man. Two irradiation facilities were built. The first was completed in 1960 and provided a fairly high dose rate (between three and four rads per minute). The later, rather elaborate facility, funded primarily by the National Aeronautics and Space Administration, allowed the patient to move about freely in a special room that had a uniform dose rate of approximately one rad per hour, thus providing prolonged low-level exposure. NASA also funded an extensive prospective and retrospective study of accidental and therapeutic total-body radiation under C. C. Lushbaugh, who later succeeded me as Division Chairman.

A few successful bone marrow graft attempts were made in patients given the high dose-rate exposure. Studies in acute leukemia showed that certain young patients in the late stage of the disease could be put into remission by a single dose of about 300 rads *without* bone marrow administration. The studies with the low dose-rate irradiation were continued for several years and showed good control of chronic granulocytic leukemia without any significant acute radiation effects. The series was not large enough, however, to determine whether irradiation contributes to a hastening of acute transformation of the leukemia late in the disease.

The division staff developed a special interest in hematologic and histopathologic effects of radiation and in the prevention and management of radiation accidents. This research resulted in consultation visits by some of the staff members, especially Lushbaugh and myself, to other institutions where accidents had occurred and to participation in national and international meetings on this topic. The resources and capabilities in this area were the basis for the development of the Radiation Emergency Assistance Center/Training Site (REACTS).

Late in 1961, Brucer retired as chairman, and in the following year, I was appointed his successor. Ralph M. Kniseley became assistant, later associate, chairman.

As new research directions emerged, additional areas of competence were added. In 1960, because of the importance of immune aspects of marrow transplantation, an immunology program was started under Nazareth Gengozian. In 1961, as part of this program, a colony of South American marmosets was begun, but only after great difficulty in obtaining initial financial support. The colony succeeded, the marmosets were bred successfully in captivity, and a facility to house them was built with corporate funds in 1968. The greatest research value of marmosets lies in the fact that the two nonidentical twin fetuses exchange tissues in utero and develop natural tolerance to the foreign tissues of the other. A significant, unexpected finding has been that spontaneous colon cancer, rare in most experimental animals, occurs in one marmoset species.

The immunology program has been devoted largely to studies of the effects of radiation on immune processes and the immunology of allogeneic bone marrow transplantation. It was found that radiation delivered at a rapid rate (a few minutes) was more immunosuppressive than that given more slowly (a few hours), and the quality of radiation also made a difference in the acceptance of marrow grafts. Another set of studies showed that animals successfully transplanted with marrow genetically different from their own continued to have an impaired immune system, which was found to result from the suppressor effects of T-lymphocytes.

In the early 1960s, computer facilities were established in the division. This activity has subsequently grown under the direction of J. H. Harmon to serve much of ORAU in ways other than the purely biomedical applications.

The cytogenetics laboratory, established in 1964, has become a major resource in providing a technique for assessing human total-body radiation injury.

In order to study the types of infections that occur in patients with bone marrow damage from radiation and other causes, a research program in microbiology was initiated in 1960, and laminar air-flow sterile rooms were installed.

In 1968 the resources for a broad attack upon cancer were extended by the establishment of a program in cellular biology, including electron microscopy, which has since contributed significantly to studies of submicroscopic localization of radioactive materials, of the morphology of colon cancer, and of changes produced by radiation. The first electron microscope, which has since been replaced, was a surplus instrument obtained through the special help of Sam Shoup of the AEC.

Under the leadership of Roger J. Cloutier, a dosimetry center was established in 1971; it was supported by the Food and Drug Administration and the AEC. The center worked closely with the internal radiation dose group of the Society of Nuclear Medicine. Emphasis was placed on nuclides used in medical diagnosis rather than on those related to industrial use or environmental contamination.

Throughout its history the Medical Division has been involved with instrument development. In addition to teletherapy and brachytherapy devices, methods have been developed to measure and visualize the amount and distribution of radioactivity in patients. One of the early instruments was a profile scanner that showed the distribution along the long axis of the body in a quantitative fashion. After improvements in 1960, this instrument also served as a medium sensitivity whole-body counter.[4]

The Medical Division has participated actively with researchers at Oak Ridge National Laboratory. This collaboration resulted in such nuclear medicine applications as pulse height analysis, early development of the focusing collimator, and certain computer scanning applications. D. A. Ross was active in this work, especially in bringing together the ORNL and the ORINS clinical groups.

In 1960 the former D wing of the Oak Ridge Hospital was turned over to ORINS to serve as a part of its Medical Division, providing a pronounced increase in the space available for the division's programs. With the demolition of most of the rest of the original Oak Ridge Hospital, the Medical Division would no longer have direct indoor continuity with the city hospital; however, the D wing

[4] An interesting side note to this program appeared in the studies resulting from the Y-12 accident in 1958: Although the men were irradiated with only a small amount of activity (neutron-induced), it was too much to be measured by the whole-body counters of the Health Physics Division at ORNL; it was, however, easily handled by the profile scanner at ORINS.

was contiguous with the existing Medical Division facility and was extensively remodeled, providing administrative space on the first floor, special laboratory resources on the second, and patient facilities on the third.

Starting in 1960, plans were made for whole-body counting facilities in the division. Most whole-body counters elsewhere had been designed for extreme sensitivity. The Medical Division objective has been to detect all levels of activity from the extremely low ones resulting from nuclear weapons testing fallout to the largest amounts administered therapeutically. The Medical Division's whole-body counting equipment, built in the early 1960s, included a highly shielded, sensitive counter that was used extensively to follow the levels of fallout activity from nuclear tests and to show the late phases of retention of gamma-emitting isotopes used in nuclear medicine. Later, an intermediate level counter was added, as well as an inexpensive low sensitivity counter, which consisted of a single, modest-sized crystal detector mounted in the ceiling above a patient bed.

Stimulated by earlier efforts made in Sweden early in the 1960s to scan marrow with a colloidal agent, the Medical Division, especially C. L. Edwards, Ralph M. Kniseley, and myself, developed images of much greater resolution and detail with colloidal gold-198 and modern scanners. At about the same time, investigators at the Donner Laboratory in California were showing excellent marrow images with iron-52. In the mid-1960s, division staff members were attempting to make a contribution to bone scanning. Recalling the bone-seeking properties of gallium that had been studied some 15 years earlier, Raymond L. Hayes of the radiopharmaceutical group and Lowell Edwards, chief of the clinical program, decided to reinvestigate the isotopes of this element. They knew stable gallium carrier would need to be added to get good bone localization, but they did not know the amount needed, so various levels were tried. Among the patients was a young woman with Hodgkin's disease. She received the gallium without significant carrier, and to the surprise of the investigators, while her skeleton did not visualize well, the areas of soft tissue tumor were clearly seen on the scan. This was the beginning of widespread use of gallium-67 as a tumor-localizing agent. While it did not show uptake in all cancers, it did so enough to be clinically important. In patients with known cancers of various types and sites of origin, the gallium-67 scan often shows additional, unknown areas of involvement. Positive findings are much more important than negative ones, since failure to show a tumor does not by any means prove that none is present. Work done at other institutions showed that some nonmalignant disease clinical processes are also demonstrated, although this finding proved to be useful in some situations and confusing in others.

As a result of the great interest in gallium-67, a group of medical schools banded together under the leadership of Robert Greenlaw, then of the University of Kentucky, to develop an interinstitutional evaluation program. This was only the second or third time that such an approach had been attempted on a radioisotope problem, although the multiinstitutional attack on other medical problems is widespread. This particular study centered on the statistical significance of gallium-67 findings and helped to show where it could be most useful.

The Medical Division has long emphasized the development of radioactive labeled compounds for the diagnosis of disease. This program, under the direction of Hayes, has recently turned its energies toward the use of a special group of radionuclides with short half-lives, which can be produced advantageously in Oak Ridge because of the proximity of the 86-inch cyclotron at ORNL. Three of these nuclides are of special interest—carbon-11, nitrogen-13, and oxygen-15. These elements are important because they are the basic building blocks of all organic compounds. Furthermore, these nuclides decay in a special manner (positron emission) which results in two simultaneous photons being released in diametrically opposite directions. Because of this type of decay, special detection instruments can be developed to localize the source of radiation in three dimensions. The disadvantage of these nuclides is that they have very short half-lives, the longest being 20.4 minutes for carbon-11. They must be used promptly, and this requirement presents many problems in handling and synthesizing labeled agents. Of these three nuclides, only carbon-11 has been employed at ORAU so far. It has been incorporated in naturally occurring amino acids and in modified or unnatural amino acids. Among the former are two that have shown pronounced localization in the pancreas, ^{11}C-valine and ^{11}C-tryptophan. Among the unnatural ones, ^{11}C-ACPC (1-amino-cyclopentanecarboxylic acid) and a similar compound ^{11}C-

ACBC (the cyclobutane analog) have been found to show pronounced, rapid localization in a variety of malignant tumors, making possible tumor detection by external radiation recording devices.

To take advantage of these radioisotopes, and some other positron emitters that do not require a nearby cyclotron for production, the division has obtained a special device designed for what is known as emission computerized axial tomography (ECAT). This instrument, made by the Oak Ridge firm of ORTEC, was only the second of its type to be built. It was financed jointly by the National Cancer Institute and by ERDA. In early 1977, ECAT began to be used in clinical trials.

The major component of the division's program in clinical cancer research was terminated in 1975 when the Atomic Energy Commission was incorporated in the new Energy Research and Development Administration. C. C. Lushbaugh was appointed chairman, with Fred Snyder as assistant chairman, and the name was changed to Medical and Health Sciences Division. The scope of the program was broadened to include all types of environmental pollutants. The inpatient care program was eliminated, but nuclear medical research was continued on an outpatient basis.

The clinical program had been expensive, because federal regulations prevented collecting charges from any patients or funds from third party carriers. Although not part of its stated mission, the clinical program did care for many patients who might otherwise have found only limited medical resources. The division made some indirect contributions to the quality of medical care in East Tennessee and brought the first fully qualified, full-time radiotherapist, Frank Comas, to the Knoxville/Oak Ridge area.

A sidelight to the division's history is that all of its directors have been interested in art, and through the assistance of patients' families and others, a substantial art collection has accumulated. The most important component of this collection is an outdoor mosaic-mural *Hymn to Life* by Charles Counts, a nationally known ceramicist who came from Oak Ridge. The mosaic hangs on the main division building as a reminder of the Medical and Health Sciences Division goal.

12

The Energy Education Division

Courtland Randall*

The Energy Education Division evolved from a set of circumstances through which ORAU, in July 1973, assumed corporate responsibility for funding and operating a seasoned AEC traveling education program. "This Atomic World" (TAW) had been developed for the AEC in the 1950s based upon the ORINS traveling teacher program which had been developed under grants from the National Science Foundation. By the early 1960s, it had achieved recognition among educators as a useful science enrichment activity in secondary schools. Ten or more units took to the field each year, depending upon AEC funding. Each field unit was comprised of an ORINS-trained teacher and a van-load of demonstration equipment. Typically, the teacher visited 140 schools each year, providing general assembly programs and several classroom lectures on nuclear topics. The traveling teachers mixed elements of entertainment with technical content. The positive reception by students, teachers, and administrators gave rise to a similar program in the National Aeronautics and Space Administration consisting of a traveling demonstration called "Spacemobile."

By the late 1960s, certain investor-owned utility managers became aware of "This Atomic World" and considered it useful in gaining public acceptance for new power reactors. Companies in Texas, New York, Michigan, and North Carolina expressed interest in arranging for permanent units in their service regions. The dozen or so units funded by AEC had to attempt national coverage

*Chairman, Energy Education Division, Oak Ridge Associated Universities.

and could not be scheduled for prolonged periods within a single state. It appeared that by pooling private and public funds, ORAU could operate more units and spend more time in regions where nuclear plants were being announced.

General Earl Rudder, the late president of Texas A & M University, was in touch with several investor-owned utilities in his state through an engineering research foundation. He learned of the prospect of a jointly funded Texas TAW unit upon a visit to ORAU in 1967. The AEC agreed with the matching arrangement and the program began permanent operation in Texas the next year under a contract between ORAU and Texas A & M. Texas utility companies provided funds for salary, travel expenses, and scheduling costs. ORAU used AEC funds to provide equipment, training, maintenance, and supervision. The Texas program, which is still in operation, set a pattern for more than 25 jointly funded TAW units.

Late in 1972, the AEC, in order to pursue other approaches to public education, wished to divest itself of the jointly funded "This Atomic World." ORAU was asked whether it might wish to assume the task of full private funding and operation of "This Atomic World." Pollard considered the prospect risky but one that also offered ORAU important opportunities. The programs the Information and Exhibits Division had been operating for the AEC were in transition, ground was being broken for the new American Museum of Atomic Energy (now the American Museum of Science and Energy), and planning was under way for the new AEC programs devoted to all forms of energy.

The mode of operating field programs through universities, where utility company grants could be made to a local educational institution, appeared to offer some prospects for success. Although the ORAU board of directors had doubts about the viability of a venture funded other than through the contract relationship with AEC, they agreed to try the program as a corporate activity. Paul Elza negotiated through the Oak Ridge Operation Office of AEC to enable the ORAU corporation to take title to the trucks and equipment of "This Atomic World." The Energy Education Office was formed as a spinoff from the Information and Exhibits Division, with Courtland Randall as its head. Its staff of three immediately set about raising funds for "This Atomic World." The ORAU division responsible for AEC contract activities was renamed the Museum Division and placed under Gary English as chairman.

The new Energy Education Office faced two problems: funding and obsolescence. Most of the instructional equipment had been on the road for more than 10 years and had been refurbished many times, and the truck fleet was over 5 years old. Prospective sponsors were hopeful about funding, however, and the need for the information presented by "This Atomic World" appeared ever more timely as orders for power reactors grew in number. In an attempt to pin down prospects for success, Randall visited Romney Wheeler, vice president of corporate communications of Consumers' Power Company in Jackson, Michigan; Warren Witzig, head of nuclear engineering at Pennsylvania State University; and John Conway of Consolidated Edison in New York. All had been involved in the jointly funded program. The question was whether they were willing to buy the same service at double the cost. Wheeler was the most encouraging. He was willing to commit his company's support for the total cost of $30,000 that it would take for one TAW unit for the academic year 1973-1974.

ORAU would probably not have made the decision to attempt a privately funded venture solely on the basis of TAW prospects. Rather, this established program was seen as a base upon which a diverse set of educational services for the private sector could be developed. Such services would need, however, to avoid special interest pleading and to conform to the traditional ORAU mission of public understanding of energy issues.

Some new efforts had already begun. Grants for an environmental experiments program had been received from the National Science Foundation. Work had been completed by the Information and Exhibits Division in developing a series of do-it-yourself environmental education kits and information on these kits remained to be disseminated. The general area of environmental education appeared attractive for further program development and private sector support; the Energy Education Office assumed responsibility for completing the work under these two grants.

Another effort involved the development of a traveling high school program patterned logistically after "This Atomic World," but dealing with a broader span of energy issues. A short-term, but successful program called "Science in Your Life" had been developed and field-tested under an NSF grant by Randall while he was chairman of the Information and Exhibits Division—an experience which demonstrated the wider applicability of TAW's logistical system. Thus encouraged, Randall had proposed a new energy program in 1972 to Georgia Power Company, Alabama Power Company, and the Edison Electric Institute. In the spring of 1974, toward the end of the first operating year of the new Energy Education Office, the Georgia Power Company agreed to fund development and operation of a new program soon named "Energy Today and Tomorrow." The company provided ORAU with $90,000 for development and fabrication of a prototype unit and a year's trial operation, scheduled for the 1974-1975 school year.

Development began in May 1974 and a prototype unit was operating in schools near Oak Ridge on a trial basis in November. Toward the end of the developmental period, the Edison Electric Institute provided $35,000 to augment the Georgia Power grant and to assist in marketing the program within the electric industry.

The new program, "Energy Today and Tomorrow," (ETT) opened formally in Georgia schools in the winter term of 1975. Its reception was evaluated by the Institute for Behavioral Research of the University of Georgia.[1] The investigator, Laurence B. David, found evidence that meaningful knowledge of energy issues was imparted and that attitudes toward energy problems were altered in a positive fashion.

The new program proved successful beyond expectations and soon attracted the attention of other utilities. The Edison Electric Institute and the Atomic Industrial Forum aided in its promotion, and ORAU soon received commitments for the second and third units from Consumers Power Company and Public Service Gas & Electric Company of Newark, New Jersey. Capitalization of additional units appeared to be a hurdle of some proportions. Here there was no government gift of a fleet of trucks and 20 sets of equipment. Initial startup costs, including vehicle and equipment fabrication costs, would, it appeared, come close to $20,000. Moreover, the contract with Georgia Power Company had anticipated interest on the part of other utilities and called for a payback of $3000 for each of the first 11 replications of the basic unit. ORAU was required not only to raise a full year's operation cost, but must

[1] Laurence B. David, "Evaluation of the Impact of an Energy Lecture-Demonstration Program on High School Students," unpublished master's thesis, University of Georgia, 1973.

also recover a one-time startup fee of $25,000 amounting to total capitalization of the new program. It was feared that this might be an insurmountable penalty, but ORAU wished to retain title, if at all possible, to such new units as it might be able to field. The program was timely enough to override this penalty. Following the 1975-1976 year in which units operated in Georgia, New Jersey, and Michigan, the number of ETT units grew to 6, then 12, then 20, and at present 25. In 1979 the program is expected to top out at about 30 field units.

Based on experience with "Energy Today and Tomorrow," EED began developing other new programs to improve public understanding of energy issues. The base program, "This Atomic World," remained alive and plans were made to revise and update it. Growing from its educational work in energy conservation, the office developed the Home Energy Conservation Simulator, a portable computer which provided homeowners with energy cost and retrofit data regarding their individual houses. A corporation in the instrument field plans to market a computer based on this ORAU development. The computer also attracted the attention of Ed Spitzer of Oak Ridge, who was appointed energy director of the State of Tennessee in 1976. Spitzer asked ORAU to conduct a pilot energy reduction study in 30 state buildings in 1977, which provided ORAU with another opportunity that is described later.

By June 1979 the Energy Education Office's budget was approaching $2 million, and it had a staff of 30-45 engaged in field programs, training, and development. Training activities had been extended beyond the internal needs of ORAU traveling teachers through a series of energy workshops for members of the utility industry and others. Development activities were being conducted for power-plant visitors centers in Tennessee and Nebraska. Work was under way to produce new traveling shows dealing with oil, gas, coal, conservation, and the economics of energy. At the fall 1977 meeting, the board of directors made the Energy Education Office an ORAU division, the Energy Education Division.

Through its five-year gestation period, the division had learned that its basic approach, inherited from AEC, was viable, even if the old TAW program itself was becoming obsolete. This approach might be characterized by live teaching, entertainment, and adequate academic credibility to gain entrance into schools. The last was seen to be fragile in the light of special commercial concerns of the program funders. Several conflicts between EED's sense of credibility and the specific wishes of sponsors had been resolved over the first five years by insistence on adhering to basic facts underlying a controversial issue. Commercial funders and academic teachers could generally agree to approach touchy issues through an explanation of the underlying facts. Both students and the general public appeared to be underinformed on the basics.

In 1978 Exxon provided a grant of $120,000 for EED to develop a traveling high school program named "Energy Adventure," which treats the economics of direct fossil energy resources. Distrigas Corporation of Boston (a Godfrey L. Cabot subsidiary) funded the initial development of a comparable program on natural and synthetic gas resources. The division also developed a one-man dramatization of Albert Einstein as part of the centennial of the scientist's birth. The play was written and performed by a young Tennessee actor, William Landry, and suggested the possibility of further activities bridging the science-humanities gap.

Perhaps the most far-reaching development of the past year (1978) has been the evolution of an energy management program for universities, hospitals, public buildings, and similar institutions. This onsite audit and advisory activity has evolved from the Tennessee state building assessment mentioned earlier. EED is now fielding a technical staff of experts on energy conservation in large buildings. This group has been able to achieve substantial reductions in the energy cost of buildings on the Meharry Medical College campus in Nashville, the Oak Ridge Hospital, and a group of hospitals in western Pennsylvania with funds provided by Blue Cross through a regional hospital association. Once sufficient field experience has been attained, the EED audit and advisory staff will turn to the traditional ORAU mode of training others, both technicians and professionals, in energy management tasks.

13

University Isotope Separator-Oak Ridge

A New Model for Physics Research for the Nation

Joseph H. Hamilton*

The idea of the university isotope separator at Oak Ridge (UNISOR) was conceived at Vanderbilt University in 1969 and was initially funded in July 1971. By 1975 it had become a major international research facility. The UNISOR consortium, whose primary purpose is making and studying new, highly unstable radioactive nuclei very far from the stable ones in nature, is a unique cooperative venture among a group of public and private universities, a national laboratory, a state government, and the federal Department of Energy. To do this, the universities and the State of Tennessee purchased a magnetic isotope separator and placed it on-line to the Oak Ridge Isochronous Cyclotron (ORIC). The separator is owned by the universities and located at the Oak Ridge National Laboratory. The venture is unique because it is the first time a group of universities and a state government have collectively purchased a major piece of capital equipment for installation in a Department of Energy national laboratory and pledged to provide continuing support for its operation over an extended period. UNISOR offers a new model for physics research for the nation. Indeed, it was a forerunner of the present trend where university scientists form users groups to carry out their research at large central facilities.

In any successful program, one must not only be concerned about the work at the moment but the long-range possibilities in 5, 10, or 15 years. UNISOR resulted from just such long-range reflec-

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tions on nuclear research at Vanderbilt University and in the Southeast. In 1964-1965, physics was one of three departments at Vanderbilt that prepared a successful application to the National Science Foundation for one of the Centers of Excellence Grants. As part of the nuclear planning, the acquisition of a magnetic isotope separator was proposed. This equipment separates different isotopes of the elements according to their nuclear masses. For example, it can separate the three stable isotopes of oxygen with 16, 17, and 18 units of mass, although the latter two have abundances in our air of only 4 atoms and 20 atoms, respectively, per 10,000 atoms of oxygen with mass 16. Moreover, in a reaction between two nuclei, several radioactive nuclei not found naturally may be created. To study the decay of a particular radioactive nucleus, it must be separated from the others. The chemical properties of radioactive oxygen-14 and oxygen-15 are the same, so they cannot be separated chemically. However, they can be separated in an isotope separator because of their different masses.

In the meantime other developments were occurring. In the late 1960s, ORNL began to plan for a new accelerator which was to be involved in research that was just beginning to blossom through the use of projectiles heavier than hydrogen and helium. Oak Ridge was the world leader in heavy ion research as early as 1951 when studies were begun with beams of nitrogen-14 from a new cyclotron. However, the development of accelerators with intense beams of nitrogen-14 and oxygen-16 proceeded slowly. Beams of argon-40 (element 20) were available at only two laboratories in the world by 1968. Essentially, no nuclear physics research could be done with projectiles of the known 80 elements heavier than argon.

The new heavy ion accelerator being considered by Oak Ridge National Laboratory was to be capable of accelerating any element up through uranium. It was conceived as an accelerator for the southeastern region and not simply for ORNL. In 1968, 30 ORNL and university scientists, including representatives from essentially all the institutions in the region granting the Ph.D. degree in physics, held an information and planning meeting at Vanderbilt. A three-man university users steering committee was elected: R. K. Sheline, Florida State University; P. Riley, University of Texas at Austin; and J. H. Hamilton, Vanderbilt University. This committee helped write the ORNL proposal to the Atomic Energy Commission for the new accelerator.

Unfortunately, at this time there was an overall reduction of federal funds for basic research, and every university and national laboratory felt the pinch. The situation in the Southeast was especially critical. While national laboratories and universities in other areas of the country had secured major new facilities in the 1960s, the South had not. Facilities in the other regions had newer and considerably higher-energy tandem Van de Graaff accelerators than Oak Ridge. There were also many cyclotrons newer and better than the Oak Ridge Isochronous Cyclotron. Without at least one major new accelerator, the future of basic nuclear research in the South was in dire peril. Then the situation worsened. Many accelerators around the country, including some newer than those at ORNL, had their funding cut off and were closed. The visiting physics review committee of ORNL recommended that the ORIC accelerator be phased out in the near future.

For many university scientists in the South the situation was bleak indeed. Many southern universities had begun in the 1960s to build and strengthen nuclear physics programs. Now there were no federal funds to support such programs. Several programs were reaching the limits of their capacity for nuclear research on campus, and there were almost no federal funds for them to develop nuclear users groups that would conduct research at major facilities in other parts of the country. Many bright, energetic, young physicists were in danger of having no research possibilities while others would not even get a start.

Ways to reverse this trend were sought. A major new facility that could be used by many university scientists from different institutions was needed. Only a project with the highest scientific merit, strong regional support (both in faculty time and university money), and unusual or unique scope had any prospect of generating the federal support it must have to function. A new, heavy ion accelerator offered that possibility, but many national laboratories and major universities were sending such proposals to Washington.

While accelerators newer and larger than ORIC were built in the 1960s, the ORNL Electronuclear Division under the direction of Robert S. Livingston had pushed developing ion sources for ORIC that would give beams of particles heavier than helium. Heavy ion beams were available from ORIC in 1968 but were limited in intensity. However, with a new ion source completed in 1970, ORIC became one of the most versatile cyclotrons in the world with good beams of carbon, nitrogen, and oxygen and weaker beams of neon and argon.

UNISOR was the result of considering ways to enhance the location of a new heavy ion accelerator at Oak Ridge and to provide new areas of nuclear research for many university nuclear scientists. An isotope separator was an obvious addition to a new accelerator. Fortunately, progress on heavy ion beams at ORIC had reached a sufficiently rapid pace to show that the early acquisition of an on-line separator would open up much new research and point the way for a new accelerator. It could be moved later, if required, to be incorporated into any new accelerator. An isotope separator facility would be ideal for a large, university users group. It would be particularly convenient for many university scientists since large quantities of data could be obtained in relatively short periods (one to two days). Most data reduction and analysis could be done by the users at their home institutions. Thus, many groups could be accommodated and their time away from classes would be minimal.

Although one could show great scientific merit for such a venture and truly unique capabilities with heavy ions, even these were deemed insufficient to initiate a new project in 1969-1970 in light of all the cutbacks and elimination of accelerator programs even at major universities. Moreover, if ORNL were to acquire funds for a new accelerator, strength in the region and a desire by a large number of university scientists to use ORNL as a base of research had to be shown. It was also important to demonstrate that ORNL had the interest and the ability to accommodate large users groups. Thus, interested researchers set out to develop a large university users group which would come with a significant fraction of its own funding. Finally, strong interest from the State of Tennessee was deemed another vital ingredient in the long-range development plans.

It was anticipated that it would take three to five years to complete the building, to test the facility, and then to achieve significant scientific results. The program would have to be underwritten for a period of five years in such a fashion that any university scientist could use the facility without additional support because any new AEC or NSF grants to individual university scientists would almost certainly not be made in this initial period.

With the enthusiastic endorsement of the administration at every level, including Chancellor Alexander Heard, Vanderbilt University took the first step by pledging $15,000 in capital expense and $10,000 a year operating expenses for five years for a total of $65,000. The University of Tennessee-Knoxville quickly matched Vanderbilt's pledge. Together, Hamilton and W. M. Bugg, head of the physics department of the University of Tennessee, approached the State of Tennessee about the project. Pledges in hand from Vanderbilt University and the University of Tennessee clearly documented the educational interests in the venture. Moreover, there was the clear possibility that this project would help bring a $15 to $20 million new facility to the state. With the support of Governor Buford Ellington and the able council of S. H. Roberts, his chief administrative assistant, the State of Tennessee pledged $90,000 with the provision that the university users match this $90,000 for equipment along with funding from the AEC.

After these funds were pledged, Robert Livingston and Alex Zucker, director and associate director of the Electronuclear Division at ORNL, were approached about forming a consortium. Their endorsement was enthusiastic. In the next three years, Livingston was to work many valuable hours with the university scientists, helping lay the groundwork and making UNISOR functional.

Then came the many hours of phone conversations and trips to neighboring institutions to convince administrators of the wisdom of universities in other states spending money in Tennessee. It must be remembered that universities in this period were not only hit by cost-of-living increases and cuts in federal funds for scientific research but also by endowment reductions with the drop in the stock market. As one administrator said in discussing UNISOR, "Only this week we lost $2 million in stock, so it isn't the best time." Other universities had campus construction in progress. On the other hand, the argument that convinced so many to join was simple: For modest funds, this consortium offered the opportunity for university faculty and graduate students to participate in the forefront of nuclear science, an opportunity that no single university or even national laboratory could develop with the restricted budgets in effect. Indeed, UNISOR became the one new project at ORNL in the early 1970s while others were being cut back.

Ten universities joined with Vanderbilt University and the

University of Tennessee to form a consortium and to submit a proposal to the AEC in late 1970. The universities and the State of Tennessee pledged to provide more than 40 percent of the initial capital funds of about $550,000, the remainder being the cost of constructing an addition to the ORIC building to house the separator and associated equipment and the cost of beam lines to it from ORIC. The AEC, through ORNL, approved and funded this construction. The universities also agreed to provide 40 percent of the total (about $150,000 per year) operating funds for five years to give the project sufficient time to prove itself. The balance of funds was requested from the AEC.

UNISOR officially began in July 1971 with joint capital and operating funding from the following schools:

University of Alabama at Birmingham
Georgia Institute of Technology
Emory University
Furman University
University of Kentucky
Louisiana State University
University of Massachusetts
University of South Carolina
University of Tennessee
Tennessee Technological University
Vanderbilt University
Virginia Polytechnic Institute and State University

Oak Ridge Associated Universities, the State of Tennessee, and the AEC also provided funding. With the help of Pollard, ORAU became the fiscal agent for UNISOR. Herman Roth, AEC, Oak Ridge, and George Rogosa, AEC, Washington, provided valuable assistance in negotiating for AEC support. Pollard conducted a considerable portion of the contract negotiation with the AEC on behalf of UNISOR.

Before looking at how UNISOR has worked in practice, let us consider briefly the scientific reasons behind the venture. Of the more than 5000 isotopes theoretically predicted to exist, fewer than 2000 have been identified, and less than half of those have reasonably well-known nuclear properties. The mere existence of new isotopes alone, however, is not sufficient reason to justify the effort and expense of such a venture as UNISOR. Most of our knowledge of nuclear structure has been gained from studies of nuclei which lie in the "valley of beta stability"—that is to say, most of these nuclei are forbidden by the law of conservation of energy from emitting a beta particle and thus going from one chemical element to another. As one adds or subtracts neutrons from a stable isotope found in nature, one begins to reach nuclei with higher and higher energies available for beta decay. These high energies make beta decay easier and the half-lives for such decay go from years in the valley of stability to fractions of a second far from the valley.

In the first series of UNISOR studies, the importance of journeys to nuclei far from stability to find new phenomena not seen in the valley of beta stability was demonstrated in the clear identification of the coexistence of spherical and deformed shapes in mercury nuclei populated by previously unknown thallium isotopes of mass numbers 184, 186, and 188. These studies also documented the importance of the fact that heavy ions bring in large amounts of rotational motion (called angular momentum or spin, like the motion of a spinning top).

In its earliest conception, UNISOR was seen as a self-supporting operation without individual grant support. Thus, in the formulation of an operating budget, three ingredients were considered essential if the project were to succeed in offering all the participants opportunities for research: (1) an onsite UNISOR staff to be responsible for the separator and data acquisition facilities, (2) some travel support for faculty and students, and (3) provision for one or two summer appointments and one academic year appointment so that university personnel could spend extended periods at Oak Ridge to develop fully their use of the facility. The first requirement guarantees a working system, although researchers must select the detectors and set up the electronic system necessary for their experiments. The second point ensures that everyone in the project has support to travel to UNISOR for research. The final point ensures maximum use of the facility. With in-depth knowledge of the facility, more imaginative research will be proposed and carried out.

While formal UNISOR operation began in July 1971, university scientists began in early 1970 to meet every two or three months to make plans and lay the groundwork. By the time the funding was approved, bylaws had already been adopted and a technical committee had been at work drafting specifications for the separator, building, and associated equipment.

Successful operation of a project in which 14 institutions provide funds requires an outlook somewhat different from one for planning a personal, on-campus research program. While problems have arisen, UNISOR has shown that the problems can be overcome and a real cooperation develop. The first step was a governing body. The UNISOR executive committee, under the umbrella of ORAU, oversees all work. This committee is composed of one representative from each founding institution.

The initial plans for UNISOR were executed by technical and bylaws committees with scientific programs and scheduling committees added later. UNISOR now has three permanent staff members. A. C. Rester was the first acting director, and Eugene H. Spejewski is the current director. The cyclotron director, E. E. Gross, and the operating staff of ORIC were extremely valuable in helping UNISOR rapidly achieve its high level of operation.

UNISOR is a very successful cooperative project that is internationally recognized for its research. Already several invited papers have been given at international conferences in Europe, Asia, and the United States. This preeminence has not been easily achieved, but the problems associated with such a multiuniversity venture have been overcome to provide outstanding research opportunities for a large number of university and national laboratory scientists.

UNISOR has also fulfilled its other mission to attract to Oak Ridge a major, new heavy ion facility. Keeping the Oak Ridge Isochronous Cyclotron operating and documenting both the strong interest from universities in the region in conducting research in Oak Ridge and the ability of ORNL to accommodate a large users group were major factors in the selection of Oak Ridge as the site of the new Holifield Heavy Ion Facility. When completed, at a cost of more than $40 million, this facility will have the world's largest tandem Van de Graaff accelerator and a new cyclotron which will greatly expand the research capabilities of UNISOR. Thus, the future UNISOR separator is ideally located to accept beams from both of these new accelerators.

At dedication ceremonies in 1972, one speaker described UNISOR as a most significant step in the expansion to new heights of nuclear research in our universities, particularly in the Southeast, as well as the beginning of a major new nuclear research effort in our country and the world. Indeed, UNISOR's successes have already justified this feeling.

14

The Institute for Energy Analysis

Alvin M. Weinberg*

The idea of an institute for energy analysis was first raised by William O. Baker, president of the Bell Laboratories, with Alvin M. Weinberg early in 1973. Weinberg was then on leave from the Oak Ridge National Laboratory, which he had directed since 1955. Baker's conception was shaped by the worsening energy crisis. He argued that, if the highest levels of government had had access to systematic overall analysis of the energy problem, the country might have been spared the difficulties caused by the shortage of energy. An institute devoted to such analysis would therefore fill an important role.

A "Prospectus for the Institute for Energy Analysis" was prepared by Weinberg and later revised by H. G. MacPherson, former deputy director of ORNL and professor of nuclear engineering at the University of Tennessee. The prospectus was issued in the fall of 1973. After analyzing the energy "problematique" (that is, the interrelated complex of energy problems), the prospectus argued the advantages of an institution capable of dealing with these problems in a coherent manner. To quote from the prospectus:

> *When Government agencies address the energy problematique, they usually break it into little fragments which are then reintegrated by policy-makers in Washington. An alternative or complement to such central integration is to bring together the elements of the problem in a setting devoid of day-to-day operating pressures. The formulation of rational policy probably requires a more scholarly atmosphere than that afforded by a*

*Director, Institute for Energy Analysis, Oak Ridge Associated Universities.

> *Government office. I propose the creation of an Institute for Energy Analysis (IEA) that will provide Government with the type of coherent, long-range thinking and planning about energy that seems to have been lacking.*

The prospectus then outlined in more detail typical questions that IEA might address, as well as possible clients, sponsors, and contractors for IEA. At the time (fall 1973), the budget suggested for IEA was $1 million in the first year, increasing to $2-to-$2.5 million by the second year.

Initial Steps

Launching IEA was a task undertaken jointly by Baker and Weinberg. Baker at the time served as an adviser to the White House. His ideas for the Institute for Energy Analysis were well received in the Executive Office of the President, especially by John Sawhill, who was at the time the associate director for science, technology, and natural resources of the Office of Management and Budget. With Baker's assistance, a meeting was arranged between Sawhill and Weinberg in the fall of 1973 to discuss the establishment of an institute. Sawhill assigned James Walker of his staff to arrange for funding of IEA.

In the meantime, Weinberg, with Baker's support, promoted IEA to various government officials. He received encouragement from Guy Stever, the director of the National Science Foundation; from Elmer Staats, comptroller-general, with whom he met in late 1973, and then, with MacPherson, in early 1974; and from members of the Atomic Energy Commission, particularly its chairman, Dixy Lee Ray, and Commissioner Clarence Larson.

Originally the institute was conceived as an entity attached directly to the executive office. However, it soon became apparent that a more appropriate home for the institute would be the Atomic Energy Commission—especially in view of the expanded role in energy that was being assigned to that agency. Both Sawhill and Ray concurred in this view.

On November 16, 1973, Weinberg met with the Atomic Energy Commission to pin down plans for starting the institute. The commission gave unanimous approval for the establishment of the Institute for Energy Analysis, and General Manager Hollingsworth was directed to allocate $500,000 to start the enterprise.

The commission further asked that Oak Ridge Associated Universities be designated as contractor for IEA. This decision came after a fair amount of consideration of alternative arrangements. Indeed, Weinberg had spent several weeks visiting Argonne, Brookhaven, and Los Alamos and had received strong invitations to set up shop at each of these laboratories. The Argonne Universities Association board actually passed a resolution inviting IEA to become an adjunct of Argonne National Laboratory.

Weinberg's own inclination, after canvassing other possibilities, was to establish IEA in Oak Ridge. However, in view of the rather freewheeling, possibly unpopular lines of inquiry that IEA would follow, a private corporation such as Union Carbide Corporation did not seem an appropriate contractor. On the other hand, cooperation with Oak Ridge National Laboratory was highly desirable. Thus the Oak Ridge Associated Universities, which since its inception had cooperated with the Union Carbide installations, particularly ORNL, seemed to be a proper contracting agent. Weinberg discussed this possibility with William G. Pollard, executive director of ORAU, and with H. Willard Davis, president of ORAU. Both enthusiastically embraced the idea and brought it before an executive committee of the ORAU board of directors. In December 1973 the ORAU board approved the establishment of the Institute for Energy Analysis as a division of ORAU, and invited Weinberg to join ORAU as director of IEA.

The Washington Period

IEA officially began operation on January 1, 1974, with Weinberg as its director. The Oak Ridge National Laboratory supported the institute by lending C. C. Burwell and E. B. Richardson, members of the ORNL staff, to serve with IEA.

Meantime, the Yom Kippur war had just ended, and the Arab oil embargo had begun. Long lines were forming at the gas stations. America, for the first time in its history, felt the grip of an energy shortage.

The reaction in Washington was yet another reorganization around the energy problem: the establishment of the Federal Energy Office (FEO). William E. Simon was appointed director and John Sawhill moved from OMB to become deputy director. FEO was the forerunner of the Federal Energy Administration; at the time, it was still part of the Executive Office, with much of its rapidly expanding activity being housed in the New Executive Office Building. FEO became the manager of the energy crisis: it was responsible for allocation, particularly of oil and gas, in the short run, and for initial plans for dealing with the long-range energy problem.

On December 24, 1973, Weinberg was approached by Sawhill to head the newly formed Office of Energy Research and Development (OERD) in the Federal Energy Office. When Weinberg pointed out that he had just agreed to direct the Institute for Energy Analysis, Sawhill suggested that another director be found for IEA and that IEA serve as an extension of the OERD. Sawhill explained that OERD would actually be located in the White House complex (Old Executive Office Building) and, apparently at Baker's insistence, OERD would serve, to some degree, as an interim scientific presence in the White House during a time when there was no full-time presidential science adviser.

In early January, Weinberg agreed to come to Washington for between six months and a year, but only after H. G. MacPherson agreed to serve as director of IEA during this period. Thus IEA, just a week after it had opened for business under Weinberg's leadership, was taken over by MacPherson, and became the major technical support of the Office of Energy Research and Development. The institute, during the ensuing year, consisted of H. G. MacPherson (director), C. C. Burwell, B. L. Cohen, B. Corn, H. Davitian, L. Markel, V. Normand, A. M. Perry (ORNL), D. B. Reister, E. B. Richardson, R. M. Rotty, E. G. Silver (ORNL), C. Thomas (on leave from the University of Tennessee), C. E. Whittle, and W. G. Pollard (who had just retired as executive director of ORAU). Burwell and Richardson, who were still on loan to IEA from ORNL, worked mainly in the Washington Office of Energy Research and Development.

The establishment of OERD within the Federal Energy Office with Weinberg as director led, however, to a contract and funding crisis for ORAU. At the end of December 1973, an amendment of ORAU's prime contract with AEC had been drafted and agreed to by both parties and ORAU was authorized to proceed with the establishment of IEA under the contract. Because of the new relationship with the Federal Energy Office, however, the Office of Management and Budget decided that AEC support was no longer appropriate and directed that the AEC fund balance on March 1, 1974, be transferred to the Department of Interior and that the FEO contract with ORAU using Department of Interior contract authority. This led to a complex round of contract negotiations which kept Pollard and Paul Elza, ORAU assistant director for administration, shuttling between Washington and Oak Ridge for the next four months. The FEO had no experience in contracting and the Department of Interior had no contracts comparable to AEC's long-term prime operating contract. A contract for March-June 1974 was finally executed in late June and later extended for fiscal year 1975 as a contract with FEO's successor, the Federal Energy Administration.

During the year under MacPherson's wise direction, many of the birth pangs of IEA were allayed. Offices were provided in the ORAU library and manpower training building. Relations with the supporting administrative branches of ORAU were settled, staff was recruited, and IEA became a working entity in a surprisingly short time.

An initial meeting of an IEA preliminary board of advisers was convened at the National Academy of Sciences January 25, 1974, to discuss the organization and program of IEA. Those attending were Peter Auer, Chester Cooper, Freeman Dyson, Lincoln Gordon, Edward Gerjuoy, Hans Landsberg, Clarence Larson, Gordon MacDonald, Herbert MacPherson, Edward Schmidt, Sidney Siegel, Calvin Burwell, and Alvin Weinberg. The discussion covered such topics as funding and organization, purposes and work of the institute, a permanent board of advisers, and permanent location of the institute. Though there was little attempt to achieve a consensus, the group did believe that, while IEA was a good idea, it should be located in Washington rather than Oak Ridge; the group also felt that IEA's success would depend on its integrity, as well as the quality of its work.

In August 1974, Philip L. Johnson became executive director of ORAU, and Pollard, as he had earlier agreed with Weinberg, joined the staff of IEA for the remaining eighteen months to his retirement at age 65.

At the outset, IEA's main job was to support the Office of Energy Research and Development. This required very close exchange between OERD and IEA; MacPherson commuted to Wshington every week, both to advise Weinberg in directing the OERD, and to receive guidance about appropriate projects for IEA. Weinberg had assigned Walter Hibbard, deputy director of OERD, and Fred Weinhold of his staff as liaison and contracting officers to IEA; Weinhold visited the institute on several occasions.

The IEA staff contributed to the operation of OERD by participating in staff conferences, informally consulting with OERD staff, and criticizing papers prepared by OERD. The largest IEA undertaking was preparation of the chapter on energy research and development for the Project Independence Blueprint. In support of this work, IEA developed a simulation model which appeared as report ORAU-125 (IEA 75-1).

During the summer of 1974, MacPherson invited about a dozen faculty and students, mostly from universities associated with ORAU, to participate in the work of IEA. These visitors brought to the institute much enthusiasm and diversity of viewpoint. Since then, IEA has encouraged extended visits by faculty and students and, in this way, has gradually expanded its contacts with the academic community.

By the end of 1974, IEA was actively involved in several studies, mostly for FEA/OERD, but also for other government agencies such as the Tennessee Valley Authority, Department of the Interior, and the Atomic Energy Commission. The following partial list of report titles illustrates the range of work completed during this period: *Man's Energy and the World's Climate, Dynamics of Implementation of Nuclear Energy Centers, Methanol from Coal—Fuel and Other Applications, The IEA Long-Range Energy Simulation Model, Report on a Workshop on the Effect of Energy Consumption on the Economy, U.S. Uranium Demand and Supply.*

The Transition Period: December 1974 to June 1975

Weinberg's year in Washington ended in December 1974, and with his departure, the Office of Energy Research and Development was closed. MacPherson, who was still on leave from the University of Tennessee, returned to his professorship in March 1975, and William G. Pollard took over as acting director of IEA. Since Weinberg had headed the Office of Energy Research and Development, the bureau that had administered the IEA contract, he was disqualified from returning to IEA for at least six months, although he did consult with IEA during this period. Moreover, the Atomic Energy Commission, which had been the original source of funds for IEA (though the Federal Energy Administration had taken over its funding), no longer existed; in its stead was the new Energy Research and Development Administration.

IEA was able to survive during this period by doing short-range tasks for various sponsors, including a definitive net energy analysis of light water reactors. This study came at a time when the debate on nuclear energy had raised the question of whether nuclear reactors produced a net gain or loss of energy. The IEA study showed that the pay-back time for a light water reactor operating for 30 years was about 3 years, a result that has since been confirmed by others and is now generally accepted. This work led IEA to continuing investigations of net energy analysis. Other studies completed during this period included the *Economics of Methanol from Coal*, *Alternative Feedstocks for the Petrochemical Industry*, *Transmission of Power from the Kentucky Lake Site*, and *Comparative Performance of Solar-Thermal Systems for Electric Power Generation*.

But the future of IEA, with the government reorganization, still was not resolved. The matter was the subject of several discussions between Weinberg and Robert Seamans, who had been named administrator of the Energy Research and Development Administration (ERDA). Seamans wanted IEA to continue and to report to the administrator's office through the assistant administrator for planning and analysis, Roger LeGassie. He urged Weinberg to return as director.

The understanding between Seamans and Weinberg was spelled out in a letter to Weinberg from Roger LeGassie. The agency was prepared to make a three-year commitment to IEA at a level of about $1.5 million per year, with the understanding that, if the institute prospered, this level would increase and the commitment of support would be extended. With this agreement in hand, Weinberg agreed to return to IEA and on July 1, 1975, he once more assumed directorship.

The Washington Office

Weinberg recognized from the outset that the institute would require social scientists and policy analysts. He therefore invited Chester L. Cooper, formerly head of the social science branch of the Institute for Defense Analyses and a long-time official in the national security arm of the government, to join IEA as head of a social science group. Cooper countered with the suggestion that IEA establish a small Washington office with him in charge; the office would function as daily liaison with ERDA and other Washington-based agencies, would perform economic and other research in support of the main center in Oak Ridge, and would serve as a Washington office for ORAU. Weinberg accepted Cooper's suggestion, as did Philip L. Johnson, executive director of ORAU, and after receiving approval from ERDA—a not negligible achievement since ERDA's first reaction was unfavorable, the Washington office of IEA/ORAU was approved by the ORAU board. The office opened in August 1975 at 11 DuPont Circle. It has gradually established itself as an important element of IEA/ORAU, specializing particularly in international energy problems.

The IEA Advisory Board

From the beginning, it was realized that much of what IEA might do would evoke controversy. It was therefore decided to establish an advisory board that would meet once a year to review the IEA program, plans, and progress and, to some degree, help protect the institute's independence. The original board consisted of Howard Raiffa (chairman), Hans Landsberg, Tjalling Koopmans, Joseph Swidler, George Brown, and Walter Hibbard. It met for the first time on May 21-22, 1976, in Oak Ridge, and has since met once each year.

In addition to the IEA advisory board, the ORAU council has established a subcommittee of faculty from member universities to keep informed of and to advise IEA. The membership of this committee rotates; at present (August 1978) it consists of Joseph E. Lannuti (chairman), Florida State University; John A. Dillon, University of Louisville; Herbert O. Funsten, College of William and Mary; Manuel Gomez, University of Puerto Rico; James L. Gumnick, University of Houston; Enrique Silberman, Fisk University; Milton Stombler, Virginia Tech; Lynn Weaver, Georgia Tech; and Simon Wender, University of Oklahoma.

The ERDA Period: July 1975 to December 1977

With its new charter under ERDA, the Institute for Energy Analysis proceeded to develop and execute a work plan, as well as to recruit the necessary staff. Ernest Silver, on leave from ORNL, became the executive officer, and by April 1976, the professional staff numbered 20; of this number, 12 were permanent and 8 were on leave, either from universities or industry. In addition, there were a half-dozen consultants who participated in the institute's work.

The main task of the institute during its first year under ERDA auspices was to examine the economic and environmental implications of a nuclear moratorium between 1985 and 2010. The possibility of a nuclear moratorium had been raised in the Office of Energy Research and Development during 1974. The question had become increasingly timely because several states were considering such moratoriums, and the possibility of losing the nuclear option remained real—although an unbiased, scholarly examination of the implications of such a moratorium had yet to be made. The study was actually conducted under contract to the National Academy of Sciences' Committee of Nuclear and Alternative Energy Sources; this came about in part because ERDA did not wish to be directly associated with a study that might be regarded as taking sides in the nuclear debate.

The study was one of the first, aside from the Ford Energy Policy Project study, to project energy demands *much* lower than had previously been accepted: 101 to 126 quads by 2000, compared with 150 or more, the prevailing estimate at that time. Thus a limited nuclear moratorium, though serious, was not viewed as being quite as devastating as originally believed—at least, if the use of coal could be expanded rapidly. The report appeared in September 1976, and received a good deal of public attention. Its main impact probably was to make lower energy projections more respectable. Beyond this, its even-handed examination of the nuclear option helped remove the pro-nuclear onus that plagued IEA because of the nuclear antecedents of many of its original staff.

The moratorium study gave rise to two continuing questions: First, if a nuclear moratorium is undesirable, then how does one construct an acceptable nuclear future? And second, if the nuclear option disappears, can one construct a plausible non-nuclear, predominantly solar future? These two threads have tied together much of IEA's work and remain at the core of the largest projects being undertaken by IEA.

In addition to the work on nuclear futures and solar futures, IEA has pursued work on cost and economic analysis, on environmental and biological aspects of energy systems, and on international energy analysis. We describe these activities briefly.

Cost Analysis and Net Energy Analysis

The cost analysis was conducted in direct support of LeGassie's office. Carried on largely by Doan Phung, it aimed at establishing consistent algorithms for estimating costs of various energy options. Closely related to cost analysis has been IEA's formulation of guidelines for net energy analysis. These guidelines are in response to requirements of Public Law 93-577. They were put together by A. Perry in collaboration with R. Rotty and D. B. Reister. In addition to the general guidelines, net energy analyses for five specific energy systems have been performed by W. Devine, A. M. Perry, A. E. Cameron, G. Marland, H. Plaza, D. B. Reister, N. L. Treat, and C. E. Whittle.

Economic Analysis

The basic question here is to elucidate the relations among energy consumption, GNP, and other economic parameters. Several major reports, notably *U.S. Energy and Economic Growth, 1975-2010* by E. L. Allen, C. L. Cooper, F. C. Edmonds, J. A. Edmonds, D. B. Reister, A. M. Weinberg, C. E. Whittle, and L. W. Zelby and *A General Equilibrium Two-Sector Energy Demand Model* by D. B. Reister and J. A. Edmonds, have been issued.

Environmental and Biological Risks

Two major continuing tasks are included here. First, under the guidance of R. Rotty, IEA has played a key role in alerting the political community to the CO_2 problem—that is, the warming of the atmosphere caused by the accumulation of CO_2 produced by burning fossil fuels. This came about largely as a result of Rotty's studies, which were conveyed by Weinberg to Seamans, Frank Press, President Carter's science adviser, and to various political figures in Washington. Weinberg and Rotty have served as chairman and executive secretary, respectively, of the study group on CO_2 that was established by Seamans in 1976. This group serves as a sort of conscience for the CO_2 problem; it has been influential in mobilizing a national effort aimed at understanding the problem.

Second, under the guidance of H. Adler and then J. Totter, IEA has sought to elucidate the biological basis for standards of acceptable risk from energy-produced effluents. Much of the environment/energy impasse rests upon certain assumptions regarding the biological hazard of low-level insult. Adler and then Totter have examined these assumptions; and Totter has found evidence that cancer, far from being primarily the consequence of exogenous, man-made insults, may very likely be a response to unavoidable endogenous metabolic intermediaries. Their findings, if verified, could profoundly affect the debate about the environment and energy.

Transition to DOE

The work of IEA was reviewed by ERDA early in 1977 in preparation for the 1978 budget. The report gave IEA good marks for innovativeness, but faulted it for being insufficiently responsive to the short-term needs of its main client, ERDA's Office of Policy Analysis (OPA). Nevertheless, after some uncertainty, the OPA agreed to continue IEA funding at $850,000, a substantial reduction from its previous level. IEA was encouraged by OPA to find additional sponsors in ERDA as well as in other agencies.

This IEA proceeded to do, and by the middle of 1977 IEA was receiving funds from the following components of ERDA: planning and analysis, solar, and nuclear, as well as from the Congressional Office of Technology Assessment and the Federal Energy Administration. At about this time, Charles Whittle and Chester Cooper were appointed assistant directors of IEA.

But hovering over IEA, as indeed over all energy contractors, was another imminent reorganization and the creation of a new department: the Department of Energy. DOE was established on October 1, 1977; it was not until November 1977 that IEA discovered that its main sponsor was to be the assistant secretary for planning and analysis, who was at that time Alvin Alm. In many ways this transition was advantageous: IEA now could concern itself with energy analysis in its broadest context, not simply with energy research and development. Thus, although a home within the new department was found only after a good deal of thrashing about, the arrangement seems to be working well. Two major projects were approved: a study of nuclear siting based on expansion of existing sites and a study of an all-solar future. The first tries to point the way out of the nuclear impasse by designing a nuclear future based on existing sites, the second by estimating the practicality of a future without nuclear power.

At present (August 1978), in its fourth year of operation (the third since Weinberg returned), IEA has a rather diversified client list. Its total budget for fiscal year 1978 is $1.8 million, which is spent under six main rubrics:

Nuclear Futures and Nonproliferation

Solar Futures

Environment
- Biology
- Carbon Dioxide

International Energy Analysis

Conservation Analysis

Miscellaneous
- Fossil Fuels
- Exxon
- Office of Technology Assessment
- Data Validation
- AMTRAK

The staff of the institute, as of June 1978, consisted of 35 professionals, including consultants who spend 20 percent or more of their time at IEA.

Ed Schmidt, one of the founders of TEMPO, the General Electric analysis institute and one of the original advisers in the establishment of IEA, has said that the best work of a think tank is usually done in its first three years of existence. IEA is now almost four years old. The staff of IEA believes that the best is yet to come: that much of what IEA has accomplished in its first three years has been preparation for answering such weighty questions as: How can man live with nuclear fission? What are the real trade-offs in the soft energy path? How can environmental standards be set when they must be based on knowledge that goes beyond the limits of science? How can man live with build-up of CO_2 in the atmosphere?

IEA hopes that during the coming years it will provide plausible advice on, if not answers to, several of these questions. IEA, though the newest of ORAU's divisions, conceives of itself as a permanent arm of ORAU that will continue to make a difference in the formulation of the country's energy policy.

Appendix

Member Institutions

1946 (Charter members)
University of Alabama
Auburn University
Catholic University of America
Duke University
Emory University
Georgia Institute of Technology
University of Kentucky
Louisiana State University
University of North Carolina
University of Tennessee
University of Texas at Austin
Tulane University
Vanderbilt University
University of Virginia

1948
University of Arkansas
University of Florida
University of Georgia
University of Louisville
University of Mississippi

1949
Mississippi State University
North Carolina State University
University of Oklahoma
Rice University
Virginia Polytechnic Institute
and State University

1950
University of South Carolina
Texas A & M University

1951
Florida State University
University of Maryland
University of Puerto Rico

1952
Clemson University

1953
Southern Methodist University
Tuskegee Institute

1955
Meharry Medical College
North Texas State University

1956
University of Miami

1957
West Virginia University

1958
Fisk University

1960
Texas Woman's University

1962
Texas Christian University

1963
Virginia Commonwealth University

1966
College of William and Mary

1971
University of Alabama in Birmingham
Memphis State University

1976
University of Houston
University of New Orleans

1979
Baylor University

Officers Since Incorporation

President
Frank P. Graham, 1946-1949
Paul M. Gross, 1949-1970
H. W. Davis, 1970-1976
Oscar Touster, 1976-present

Vice President
Frederick Seitz, 1946-1949
J. W. Beams, 1949-1954
Clifford K. Beck, 1954-1956
Marten tenHoor, 1956-1957
Warren C. Johnson, 1957-1959
Louis A. Pardue, 1959-1963
Howard M. Phillips, 1963-1965
Eric Rodgers, 1965-1970
Frank Anderson, 1970-1971
Michael J. Pelczar, 1971-1974
Oscar Touster, 1974-1976
S. Y. Tyree, Jr., 1977
Ardath H. Emmons, 1978
George R. Herbert, 1979-present

Secretary (Executive Director)
William G. Pollard, 1946-1974
Philip L. Johnson, 1974-present

Treasurer
William G. Pollard, 1946-1976
Philip L. Johnson, 1976-present

Board of Directors*

W. W. Akers, 1963-1968
Frank Anderson, 1967-1973
William R. Arrowsmith, 1961-1964
Sanford S. Atwood, 1965-1971

Ronald Bamford, 1957-1964
J. W. Beams, 1946-1954, 1960-1969
Clifford K. Beck, 1953-1956
Robert B. Beckmann, 1976-present
T. W. Bonner, 1959-1962
George H. Boyd, 1952-1955
Allan D. Bromley, 1978-present
R. W. Brown, 1962-1967

Lewis W. Cochran, 1968-1970
George L. Cross, 1954-1957
Harry A. Curtis, 1957-1960

Joseph M. Dallavalle, 1955-1958
H. W. Davis, 1964-1976
Michael E. DeBakey, 1964-1967
Karl Dittmer, 1965-1966
Charles H. Douglas, 1976-1978
Earl G. Droessler, 1975-1978
Billy G. Dunavant, 1971-1977
Charles E. Dunlap, 1955-1962
John R. Dunning, 1950-1959, 1962-1968

James D. Ebert, 1967-1971
Lois T. Ellison, 1979-present 1984
Ardath H. Emmons, 1976-present

Henry J. Gomberg, 1959-1962
Mary L. Good, 1970-1976
Ernest W. Goodpasture, 1946-1952
Max Goodrich, 1971-1977
Frank P. Graham, 1946-1949
Paul M. Gross, 1946-1970

Norman Hackerman, 1975-present
T. Marshall Hahn, Jr., 1967-1969
George T. Harrell, 1954-1960, 1963-1965, 1971-1973
Leland J. Haworth, 1959-1961
Director Emeritus, 1971-1977, 1978-1979
George R. Herbert, 1971-1974, 1978-present
Roger F. Hibbs, 1969-1977
Edward G. High, 1975-present
George R. Holcomb, 1976-present
William V. Houston, 1951-1958

Robert M. Johnson, 1978-present
Warren C. Johnson, 1953-1959, 1961-1967
Edward D. Jordan, 1976-present
Billy V. Koen, 1975-1976

Robert T. Lagemann, 1958-1967
Edward N. Lambremont, 1979-present
Clarence E. Larson, 1953-1955, 1962-1969
James R. Lawson, 1967-1970
Charles T. Lester, 1962-1965
David E. Lilienthal, 1946
Samuel C. Lind, 1949-1953
Alvin R. Luedecke, 1974-1977

*New directors will be elected January 15, 1980.

Edward Mack, 1950-1952, 1954-1956
A. C. Menius, Jr., 1969-1975

Samuel M. Nabrit, 1968-1975
Hayden C. Nicholson, 1952-1955

John W. Oswald, 1967-1968
Charles G. Overberger, 1978-present

T. S. Painter, 1947-1953
Louis A. Pardue, 1950-1955, 1956-1963
George B. Pegram, 1946-1949
Michael J. Pelczar, 1966-1975
Merlin D. Peterson, 1953-1959
Carl C. Pfeiffer, 1955-1958
Howard M. Phillips, 1958-1964, 1965-1969
William G. Pollard, 1946-1948
Russell S. Poor, 1948, 1960-1962
J. Harris Purks, 1949-1950, 1954-1957

J. Wayne Reitz, 1970-1973
Eric Rodgers, 1963-1969
Wimberly C. Royster, 1978-present

S. R. Sapirie, 1973-1976
E. Leigh Secrest, 1968-1971
Frederick Seitz, 1946-1949, 1969-1971
Hilton A. Smith, 1969-1975
Arthur H. Snell, 1959-1962
Herman E. Spivey, 1965-1973
Harold W. Stoke, 1949-1951

Marten tenHoor, 1955-1962
Oscar Touster, 1970-present
S. Y. Tyree, Jr., 1973-present

E. R. VanArtsdalen, 1969-1975
Joseph H. Volker, 1973-present

James E. Webb, 1956-1960
H. Stephen Weens, 1960-1963
Alvin M. Weinberg, 1955-1959
Simon H. Wender, 1961-1966
W. Dexter Whitehead, 1975-present
Eugene P. Wigner, 1947-1948
John L. Wood, 1958-1965

Chairmen of the Council

Frank P. Graham, 1946-1949
J. Harris Purks, 1949-1950
Louis A. Pardue, 1950-1952
George H. Boyd, 1952-1955
Marten tenHoor, 1955-1958
Robert T. Lagemann, 1958-1961
Simon H. Wender, 1961-1964
H. W. Davis, 1964-1967
Frank Anderson, 1967-1970
Oscar Touster, 1970-1973
S. Y. Tyree, Jr., 1973-1976
George R. Holcomb, 1976-1979

Council Representatives

Auburn University
Russell S. Poor, 1946-1948
Fred Allison, 1949-1952
William Vann Parker, 1953-1971
Ben T. Lanham, Jr., 1972-1974
Paul F. Parks, 1975-present

Baylor University
Darden Powers, 1979-present

Catholic University of America
Karl F. Herzfeld, 1946-1953
George D. Rock, 1954-1963
F. Leo Talbott, 1964-1968
Edward D. Jordan, 1969-1976
James G. Brennan, 1977-present

Clemson University
Howard L. Hunter, 1952-1967
F. I. Brownley, Jr., 1968
A. E. Swartz, 1969
R. W. Henningson, 1970-present

College of William and Mary
Robert T. Siegel, 1966-1967
S. Y. Tyree, Jr., 1968-1976
Herbert O. Funsten, 1977-present

Duke University
Walter M. Nielsen, 1946-1959
Karl M. Wilbur, 1960-1964
Lewis Anderson, 1965-1975
Boyd R. Strain, 1976-present

Emory University
J. Harris Purks, 1946-1949
Robert T. Lagemann, 1950
J. G. Stipe, 1951-1952
H. M. Phillips, 1953-1956
Charles T. Lester, 1957 1961
Robert B. Platt, 1962-1970
Charles T. Lester, 1971-1979
John M. Palms, 1979-present

Fisk University
James R. Lawson, 1958-1966
Rutherford H. Adkins, 1967-1971

I. E. Elliott, 1972-1973
Prince Rivers, 1974
Enrique Silberman, 1975-present

Florida State University
Milton W. Carothers, 1951-1957
Werner A. Baum, 1958-1961
Russell J. Keirs, 1962-1971
J. E. Lannutti, 1972-present

Georgia Institute of Technology
Robert I. Sarbacher, 1946-1947
R. L. Sweigert, 1948-1960
Mario J. Goglia, 1961-1965
E. A. Trabant, 1966-1967
Maurice Long, 1968-1971
Lynn Weaver, 1972-present

Louisiana State University
William O. Scroggs, 1946
Richard C. Keen, 1947-1968
Max Goodrich, 1969-1971
Edward N. Lambremont, 1972-1976 and 1978
William F. Curry, 1977 (Interim)
John C. Courtney, 1979-present

Meharry Medical College
Paul F. Hahn, 1955-1959
Isaac H. Miller, 1960-1965
Edward G. High, 1966-1975
James U. Lowe, 1976-present

Memphis State University
John W. Richardson, 1971
Glen A. Peterson, 1972-present
Edmund Segner, 1977-1978 (Interim)

Mississippi State University
M. P. Etheredge, 1949-1963
E. Irl Howell, 1964-1978
J. Chester McKee, 1979
Marion T. Loftin, 1979-present

North Carolina State University
C. G. Brennecke, 1949
Clifford K. Beck, 1950-1952
C. G. Brennecke, 1953
F. Phillips Pike, 1954-1959
R. Murray, 1960-1961
A. C. Menius, 1962-1968
Walter J. Peterson, 1969-1973
Earl G. Droessler, 1974
Vivian T. Stannett, 1975-present

North Texas State University
J. C. Matthews, 1955-1957
Richard B. Escue, 1958-present

Rice University
T. W. Bonner, 1949-1958
William W. Akers, 1959-1962
Gerald C. Phillips, 1963-1975
Stephen D. Baker, 1976-present

Southern Methodist University
Wayne Rudmose, 1953-1962
John L. McCarthy, 1963-1964
William B. Stallcup, 1965
John L. McCarthy, 1966-present

Texas A & M University
C. Clement French, 1950-1951
D. H. Morgan, 1952-1954
Donald F. Weekes, 1955-1964
J. McIntyre, 1965-1970
Alvin Luedecke, 1971-1974
John D. Randall, 1975-1976
Robert R. Berg, 1977-present

Texas Christian University
Joseph Morgan, 1962-1975
C. A. Quarles, Jr., 1976-present

Texas Woman's University
John A. Guinn, 1960-1964
Kenneth A. Fry, 1965-present

Tulane University
J. C. Morris, 1946-1947
Robert T. Nieset, 1948-1960
J. C. Morris, 1961-1967
Albert J. Wetzel, 1968-1977
Frank E. Durham, 1977-present

Tuskegee Institute
R. W. Brown, 1953-1961
James H. M. Henderson, 1962-present

University of Alabama
James R. Cudworth, 1946
Marten tenHoor, 1947-1957
Eric Rodgers, 1958-1962
F. W. Conner, 1963-1965
Earl Long, 1966-1967
E. R. VanArtsdalen, 1968
Donald F. Smith, 1969-1972
Charley Scott, 1973-present

University of Alabama in Birmingham
Joseph F. Volker, 1971-1972
Robert P. Glaze, 1973-present

University of Arkansas
W. W. Grigorieff, 1948-1952
R. R. Edwards, 1953-1955
Lowell F. Bailey, 1956-1975
Aubrey Harvey, 1976
Johnnie Stokes, 1977 (Interim)
Don Ousterhout, 1977-present

University of Florida
Ronald B. Eutsler, 1948-1955
Russell S. Poor, 1956-1959
George K. Davis, 1960-1964
Billy G. Dunavant, 1965-1970
M. J. Ohanian, 1971-1975
F. E. Dunnam, 1976-present

University of Georgia
George H. Boyd, 1948-1958
Gerald B. Huff, 1959-1967
Robert A. McRorie, 1968-1970
Charles H. Douglas, 1971-1975
William R. Finnerty, 1976-present

University of Houston
James L. Gumnick, 1976-present

University of Kentucky
W. D. Funkhouser, 1946-1947
Louis A. Pardue, 1948-1949
Lyle R. Dawson, 1950-1956
Lewis W. Cochran, 1957-1958
Wendell C. DeMarcus, 1959-1973
Wimberly C. Royster, 1974-1977
Fletcher Gabbard, 1978-present

University of Louisville
Robert C. Ernst, 1948-1965
John A. Dillon, Jr., 1966-present

University of Maryland
Ronald Bamford, 1951-1956
Nathan L. Drake, 1957-1958
Michael J. Pelczar, 1959-1965
Robert B. Beckmann, 1966-1975
Robert E. Menzer, 1976-present

University of Miami
Walter O. Walker, 1956-1961
Maxwell Dauer, 1962-1969
Joseph Hirschberg, 1970-1972
Eugene H. Man, 1973-1978
Clarence G. Stuckwisch, 1979-present

University of Mississippi
J. D. Williams, 1948
P. K. McCarter, 1949-1952
Fred W. Kellogg, 1953-1954
Frank A. Anderson, 1955-1970
Joseph Sam, 1971-1972
Donald Walsh, 1973-present

University of New Orleans
Mary L. Good, 1976-1978
Joseph Murphy, 1979-present

University of North Carolina
Frank P. Graham, 1946-1948
C. D. VanCleave, 1949-1956
Arthur Roe, 1957-1958
Henry C. Thomas, 1959-1966
George R. Holcomb, 1967-present

University of Oklahoma
L. H. Snyder, 1949-1951
Simon H. Wender, 1952-1963
L. M. Rohrbaugh, 1964-1967
Carl Riggs, 1968-1970
Simon H. Wender, 1971-present

University of Puerto Rico
Facundo Bueso, 1951-1959
Juan D. Curet, 1960-1969
Ismael Almodovar, 1970-1971
Willie Ocasio Cabanas, 1972-1974
Ismael Almodovar, 1975-1977
Myriam Vargas-Cesani, 1978-present

University of South Carolina
H. Willard Davis, 1950-1966
O. F. Schuette, 1967-present

University of Tennessee
F. C. Smith, 1946-1947
E. A. Waters, 1948-1956
Hilton A. Smith, 1957-1968
P. F. Pasqua, 1969-present

University of Texas
T. S. Painter, 1946-1949
C. P. Boner, 1950-1952
Malcolm Y. Colby, 1953-1957
R. N. Little, 1958-1972
Billy V. Koen, 1973-1974
Eugene H. Wissler, 1975-present

University of Virginia
L. G. Hoxton, 1946
L. B. Snoddy, 1947-1949
John H. Yoe, 1950-1962
E. R. VanArtsdalen, 1963-1967
Lawrence Quarles, 1968-1971
W. Dexter Whitehead, 1972-1975
Dennis W. Barnes, 1976-present

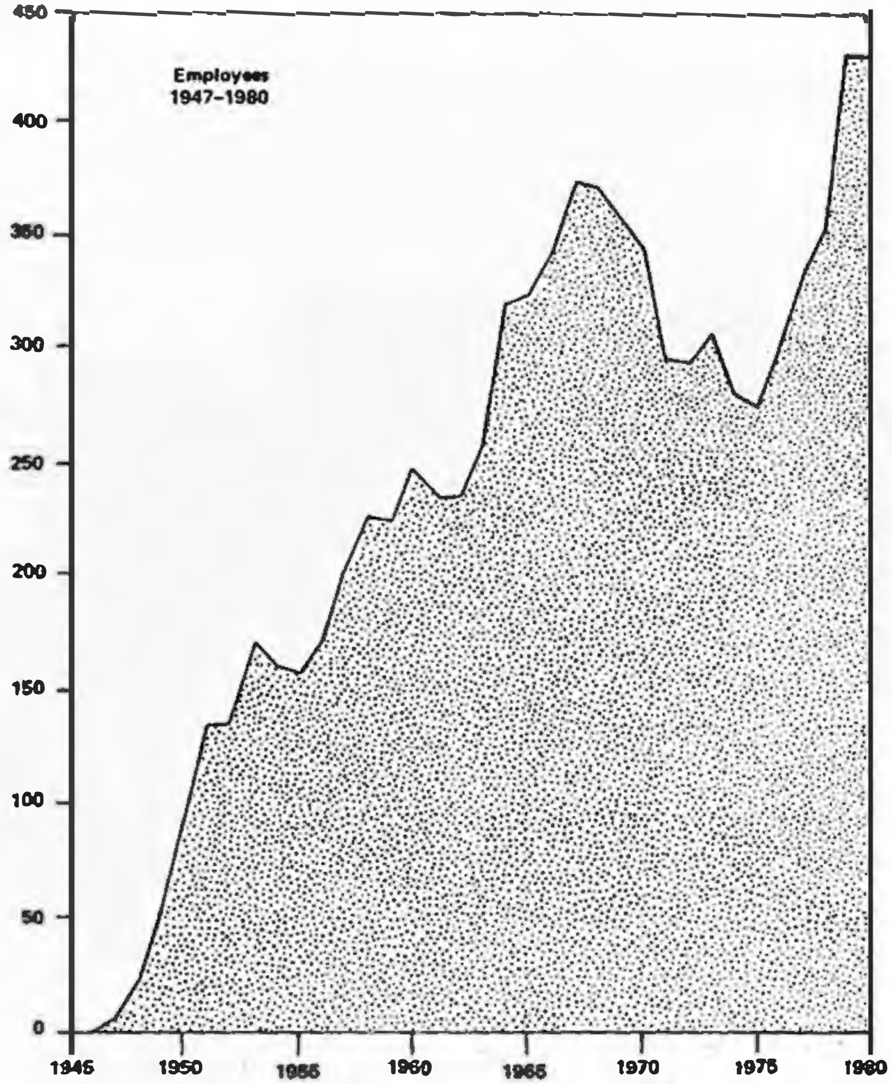
Vanderbilt University
Harvie Branscomb, 1946
Philip Davidson, 1947-1950
Merlin D. Peterson, 1951-1952
Robert T. Lagemann, 1953-1960
Leonard B. Beach, 1961
Graham DuShane, 1962
Oscar Touster, 1963-1972
Joseph H. Hamilton, 1973-present

Virginia Commonwealth University
E. Richard King, 1963
F. T. O'Foghludha, 1964-1970
Stewart Lippincott, 1971-1974
John J. Salley, 1975-present

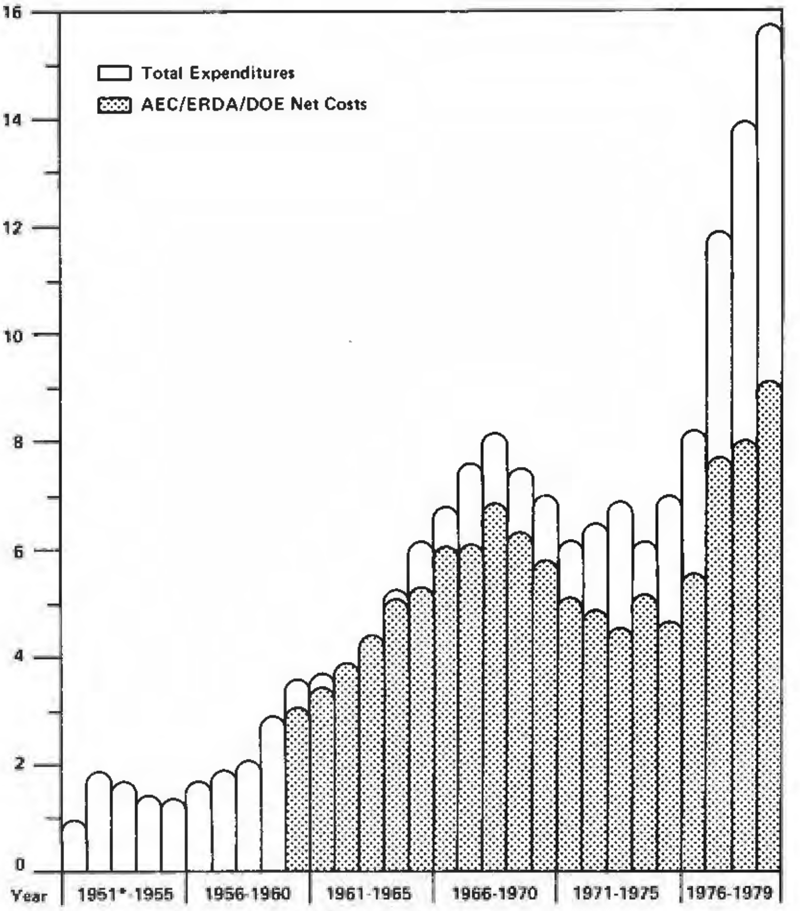
Virginia Polytechnic Institute and State University
C. Clement French, 1949
L. A. Pardue, 1950-1952
Frank C. Vilbrandt, 1953-1957
R. C. Krug, 1958-1964
Fred W. Bull, 1965-1977
Milton P. Stombler, 1977-present

West Virginia University
R. B. Dustman, 1957-1959
Walter A. Koehler, 1960
John F. Golay, 1961-1964
Robert S. Dunbar, 1965-1967
Arthur Pavlovic, 1968-1971
Knox VanDyke, 1972-1975
Mark Conner, 1976-1977
Stanley Wearden, 1978-present

ORAU Employment



Total Program Costs



*AEC/ERDA/DOE Net Costs Not Available 1951-1959.

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