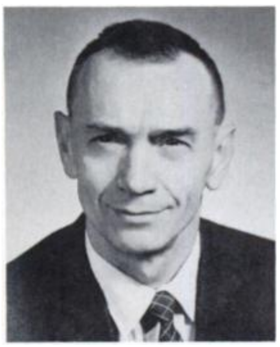
COMMENTARY

OAK RIDGE: MIDWIFE TO NUCLEAR MEDICINE

Tennessee was known to science as the home of "The Monkey Trial." Why, of all places in 1942, was its outback selected as the site for midwifery to the highest technology of the Atomic Age?



Physicists advising the new Manhattan Engineering District said that a nuclear chain reaction could be achieved; hence, an atomic bomb could be made. But it would require highly concentrated uranium-235, or maybe a new fissionable stuff called plutonium. "How do we make it today, not next week," asked Colonel (later General) Groves, head of the project. A few ways might work: a battery of cyclotrons, gas diffusion, or maybe a new sustained nuclear reaction mechanism called an Atomic Pile. "Build all three plants immediately," ordered Groves. But tremendous amounts of electricity would be needed to run cyclotrons and the massive diffusion plant necessary to make 2 or maybe 100 Kg of uranium-235 (Arthur Compton's best estimate of the required amount for one A-Bomb).

Where in the United States was there enough electric power generated to fuel such devices—and secretly of course? The Tennessee Valley Authority (TVA) had power to spare, and was in a sparsely populated region. In July of 1943, Groves had 96 square miles of Tennessee hill country fenced in to make uranium-235.

By December at the University of Chicago, operational headquarters of the Manhattan Project, Enrico Fermi built the first uranium-graphite "pile" and it worked. It produced nothing except a "proof of concept," which was sufficient for Groves to order a big copy built at his secret hideaway in Tennessee. The size of the project, the number of technicians to run the plants, and, always, the secrecy required that a fair-sized town be built. It was put on the back side of a hill which already had a name: Oak Ridge.

A Cornucopia of Radioisotopes

On November 4, 1943, the Oak Ridge Pile (officially called a "nuclear reactor") went critical. The only surprise, even to the physicists who designed it, was the diversity and the volume of radioisotopes that could be produced.

One morning in the fall of 1944, a DC3 and a C47, each with a package bound for Berkeley, CA, took off from the Knoxville, TN, airport. (They were the same model airplanes but the C47 had its passenger seats stripped out to carry Army Air Corps cargo.) The C47 cargo was a 12-inch cube that seemed quite heavy. It contained a lead pot holding a glass vial labeled "P-32," the regular monthly shipment of one curie to John Lawrence at the Berkeley cyclotron laboratory.

Lawrence had been treating leukemia patients with phosphorus-32 for almost seven years. His phosphorus-32, in millicurie amounts, came from the Berkeley cyclotrons until the Manhattan Atom Bomb Project preempted all cyclotron time for the production of the first plutonium samples. In order to keep the new work secret, John was instructed to continue his work with lots of papers and talks. The phosphorus-32 would be supplied in lavish amounts—a curie/month—from the new reactor at Oak Ridge.

The "package" that left Knoxville on the DC3 was a child with leukemia. In the absence of any other form of therapy his doctors had opted for the new radiation therapy being tried at the University of California. The child from Knoxville was treated 3,000 miles from home with phosphorus-32 made in his back yard. Except for the fact that the patient was not cured it was a successful trip. Army Security was pleased with the highly publicized deception. Lawrence, though distressed at his failure, learned that phosphorus-32 was of no use in treating childhood leukemia. The child was thrilled by his cross-country flight. The reactor scientists learned that their primary mission—plutonium—be damned; they had a cornucopia of a highly desirable (and saleable) product at hand.

Radioisotope Production on a Kitchen Table

When the Gas Diffusion Plant at Oak Ridge took over the separation of uranium-235 and the Hanford reactors in the state of Washington began making plutonium, the Oak Ridge reactor was no longer essential to the A-bomb effort. But there were thousands of unanswered questions on the chemical, physical, and especially the biologic behavior of the hundreds of radioisotopes produced with and by A-bombs. In the June 17, 1946, issue of *Science*—two months before the first anniversary of Hiroshima—an article announced the availability of radioisotopes to the scientific public. Nobody was prepared for the response. Before the end of the year a kilocurie of radioisotopes had been shipped from Oak Ridge.

No chemical engineering precedents existed for manufacturing, handling, and shipping radiochemicals on an industrial scale. Research lab procedures had to be scaled up a factor of a thousand and more. Physical facilities were nonexistent. Any space, instrument, or tool needed had to be scrounged from another job or invented on the spot. Much of the work was done in an open field on an old wooden kitchen table. Radiation safety was maintained with time-limits and distance. A health physicist with a Cutiepie and a stop watch was an ever-present fixture.

On January 1, 1947, the Atomic Energy Commission (AEC) took over the Manhattan District. The Tennessee facility changed its name to Oak Ridge National Laboratory (ORNL). It did a lot more than ship radioisotopes but this job was non-secret and bore the brunt of AEC publicity. One question bothered a few people: how many scientists knew how to handle radioisotopes? They also wondered how many scientists had the instruments, or even knew of the units of measurement. The safety record of the Manhattan Project had been remarkable, but only because a new discipline called Health Physics had been enforced. Except in the few universities already involved in AEC work, radiochemistry was a new realm in scientific technology. Somebody had to do some teaching.

ORINS Opens a Kindergarten

In 1947 an association of 12 universities in the southeastern United States was organized to make use of the nuclear science facilities at Oak Ridge. Their graduate schools could not duplicate ORNL on each campus, and the AEC needed a continuing supply of academic talent. They set up the Oak Ridge Institute of Nuclear Studies (ORINS). (Twenty years later the name was changed to Oak Ridge Associated Universities.) Even before ORINS was completely organized it got its first job. The AEC decided to offer three one-month courses during the summer months to faculty members of a few universities.

Ralph Overman, the chemist who had prepared the curie/month of phosphorus-32 shipped to Berkeley, was given leave-of-absence from ORNL to run the show (*1*). Ralph begged and borrowed equipment for about 30 laboratory benches. He set up strictly hands-on experiments: how to detect radioactivity, and how to measure the amount and its half-life; how to open a shipment and transfer it from one bottle to another; where it came from and how it was made; how to clean up a spill and how to know that you had cleaned up. His faculty, from theoretical physicists to instrument makers, usually borrowed from ORNL, gave examples of isotope use in all branches of science. This instruction was kindergarten technology but only to scientists already expert in their own field.

Knowledge of a no-nonsense cram course in techniques spread rapidly. A fourth course was given in October of 1947. With 100 applications still on hand, the AEC asked that the courses be repeated in 1949, then in 1950, and 1951 . . . and they are still going on. Mimicking the academic atmosphere of the first courses, at a final banquet each participant was awarded the academic degree of DRIP (Dabbler in RadioIsotope Procedures). Well over 7,000 DRIPs, many of professional rank, set the curriculum standards for a generation of teaching the use of "radionuclides." [This new name, suggested by T. Kohman in 1947, didn't become popular until the 1960s (*2*).] About a third of the DRIPs also had MD degrees.

The Significance of Oak Ridge

In 1946 the Isotopes Division of the AEC issued its first 100 licenses for the use of radioisotopes and ORNL shipped a kilocurie of radioisotopes to these users. Five years later 1,000 licensees received 12 kilocuries of radioisotopes and the United States monopoly was broken. The Atomic Energy Research Establishment (AERE) in England made 2,800 radioisotope shipments. ORNL's monopoly on radioisotope production had never been absolute. Robley Evans had supplied about 33 hospitals with radioiodine from the cyclotron at the Massachusetts Institute of Technology (MIT) all through the war. But cyclotron radioisotopes had cost about $15,000/curie; reactor-produced phosphorus-32 had cost $32.50/curie.

By the time it was retired from active duty in 1966, "old grandma"—the pile drivers' name for ORNL's atomic pile—was producing 1.28 megacuries/year. Over 10,000 radioisotope licensees in the United States were being supplied by five radiopharmaceutical companies. A US Public Health Service survey estimated that 526,476 radionuclide diagnostic tests and 33,743 radionuclide therapies were being done each year—plus almost 2 million cobalt-60 teletherapy patients were being treated each year.

Cobalt-60 teletherapy came out of Oak Ridge, as did medical gamma ray spectroscopy, the personnel radiation monitor, thyroid uptake standardization, practically all stable isotopes, nuclear data compilations, and many other improvements. But these pale in comparison to Oak Ridge's major contribution to the Atomic Age. ORNL was a cornucopia of radioisotopes and ORINS taught the first cadre of teachers.

Marshall H. Brucer, MD

Dr. Brucer served as the chairman of the ORINS Medical Division from 1948 until 1961, and was also president of The Society of Nuclear Medicine in 1957–1958.

References

1. Overman, RT: Oak Ridge remembered: 1944–1949. *J Nucl Med* 18:759-763, 1977

2. Kohman, TP: Proposed new word: Nuclide. *Am J Phys* 15:356-357, 1947