DOE/EH-0478

HUMAN RADIATION STUDIES: REMEMBERING THE EARLY YEARS

Oral History of Physician James S. Robertson, M.D., Ph.D.

Conducted January 20, 1995

United States Department of Energy
Office of Human Radiation Experiments
September 1995

MASTER

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FOREWORD

IN DECEMBER 1993, U.S. Secretary of Energy Hazel R. O'Leary announced her Openness Initiative. As part of this initiative, the Department of Energy undertook an effort to identify and catalog historical documents on radiation experiments that had used human subjects. The Office of Human Radiation Experiments coordinated the Department's search for records about these experiments. An enormous volume of historical records has been located. Many of these records were disorganized; often poorly cataloged, if at all; and scattered across the country in holding areas, archives, and records centers.

The Department has produced a roadmap to the large universe of pertinent information: *Human Radiation Experiments: The Department of Energy Roadmap to the Story and the Records* (DOE/EH-0445, February 1995). The collected documents are also accessible through the Internet World Wide Web under `http://www.ohre.doe.gov`. The passage of time, the state of existing records, and the fact that some decisionmaking processes were never documented in written form, caused the Department to consider other means to supplement the documentary record.

In September 1994, the Office of Human Radiation Experiments, in collaboration with Lawrence Berkeley Laboratory, began an oral history project to fulfill this goal. The project involved interviewing researchers and others with firsthand knowledge of either the human radiation experimentation that occurred during the Cold War or the institutional context in which such experimentation took place. The purpose of this project was to enrich the documentary record, provide missing information, and allow the researchers an opportunity to provide their perspective.

Thirty audiotaped interviews were conducted from September 1994 through January 1995. Interviewees were permitted to review the transcripts of their oral histories. Their comments were incorporated into the final version of the transcript if those comments supplemented, clarified, or corrected the contents of the interviews.

The Department of Energy is grateful to the scientists and researchers who agreed to participate in this project, many of whom were pioneers in the development of nuclear medicine. ❑

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DISCLAIMER

The opinions expressed by the interviewee are his own and do not necessarily reflect those of the U.S. Department of Energy. The Department neither endorses nor disagrees with such views. Moreover, the Department of Energy makes no representations as to the accuracy or completeness of the information provided by the interviewee.

ORAL HISTORY OF PHYSICIAN JAMES S. ROBERTSON, M.D., Ph.D.

The interview was conducted January 20, 1995, in Germantown, Maryland, by Michael Yuffee and Prita Pillai from the Department of Energy's Office of Human Radiation Experiments.

James S. Robertson was selected for the oral history project because of his research at Brookhaven National Laboratory, especially on Boron Neutron Capture Therapy (BNCT); his work at the United States Naval Radiological Defense Laboratory; and his work at the Atomic Energy Commission.

Short Biography

Dr. Robertson was born in Richmond, Virginia, on November 27, 1920. He received his B.S. (Premedicine and Mathematics, 1943), M.B. (Mathematics, 1944), and M.D. (1945) at the University of Minnesota, and his Ph.D. (Physiology and Medical Physics, 1949) at the University of California at Berkeley. He is married and has three children. Dr. Robertson began his career as a Medical Officer in the U.S. Navy during World War II (1945–46). Immediately following his naval service, he spent two months in private practice. After receiving his Ph.D., Dr. Robertson went to Brookhaven National Laboratory as a scientist in the Medical Research Center (1950–53). Aside from a two-year return to the Navy at the United States Navy Radiological Defense Laboratory (1953–55), Dr. Robertson remained at Brookhaven until 1975. From 1975 to 1983, Dr. Robertson practiced at the Mayo Clinic in Rochester, Minnesota. Dr. Robertson completed his career with a term of service as Director of the Human Health and Assessments Division, U.S. Department of Energy.

While serving in these positions, Dr. Robertson has held the following positions:

- Adjunct Professor, State University of New York, Stony Brook
- Adjunct Professor, City College of New York
- Member, American Physiological Society
- Member, Society of Nuclear Medicine, Medical Internal Radiation Dose Committee
- 1968 to 1971—Member, Radiation Research Society

Dr. Robertson has published many times on boron neutron capture therapy (BNCT). In addition, Dr. Robertson has also published articles on the medical follow-up of the Marshall Islanders, research on nephrotic children, and radiotherapy to treat various blood diseases.

Education

YUFFEE: Today is January 20, 1995. I'm Michael Yuffee of the Department of Energy's Office of Human Radiation Experiments. I'm here with my colleague Prita Pillai, also of the Office of Human Radiation Experiments. Today we're interviewing Dr. James Robertson, and we're in the Department of Energy office in Germantown.

Dr. Robertson, I'd like to thank you for agreeing to talk to us and, also, I'd like to start by asking you a little about your education, where you went to school, and why you chose medicine.

ROBERTSON: Well, I was brought up in Austin, Minnesota, and so it was natural to go to the University of Minnesota. Actually, I started out to be a chemical engineer, but the war was coming up and I'd taken a trip to visit different research places in the eastern U.S. and I was impressed by the applications that I hadn't known about before [of the technical and physical and chemical procedures to medical research]. With my father being a physician, this was part of the motivation for going into medicine. I was interested in research from the beginning.

PILLAI: Can you tell us [why] you went to the University of California in Berkeley [(UC Berkeley)]? Did you do some graduate work?

ROBERTSON: Okay. When I graduated from the University of Minnesota—this was during the [Second World] War—I took an internship at the U.S. Navy Hospital in Annapolis, Maryland. Then I did about a year [of] service in the Navy. Then I found out about California, and so I applied for research work in physiology[1] at the University of California in Berkeley. They pointed out that my interests were such that I should get into the medical physics program there, which was in Lawrence Radiation Laboratory[2] at the Donner Laboratory[3] in Berkeley.

So I worked for a Ph.D., which turned out to be in physiology, although my work was really in medical physics. But because my first contact had been with physiology, that's what I got the degree in. That was finished in September 1949, and I went from there to Brookhaven Laboratory[4] for my first real job.

PILLAI: Could you tell us a little about the research that you were involved with at Berkeley at the Donner Radiation Lab? Also, if you can, recall some of the researchers that you've worked with.

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1 the branch of biology dealing with the functions and activities of living organisms and their parts

2 now Lawrence Berkeley Laboratory, a National Laboratory under the U.S. Department of Energy; originally founded by Ernest Lawrence as the UC Radiation Laboratory in 1936

3 a laboratory set up at the UC Radiation Laboratory in Berkeley during the 1930s specifically to conduct experiments in medical physics. For an inside view of Donner Laboratory's role, programs, personalities, and day-to-day operations, see DOE/EH-0479, *Human Radiation Studies: Remembering the Early Years; Oral History of Donner Lab Administrator Baird G. Whaley* (September 1995).

4 Brookhaven National Laboratory (BNL) is a multiprogram research laboratory owned by the Department of Energy and located on 5,300 acres on Long Island near Upton, New York. BNL is managed and operated by a consortium of universities known as Associated Universities, Inc., under contract with DOE. BNL conducts basic and applied research in the physical, biomedical, and environmental sciences, as well as selected energy technologies.

ROBERTSON: The principal contact at Berkeley, my thesis leader, was Hardin B. Jones,[5] who is a pretty famous physiologist. Nello Pace[6] was involved, also. Then I worked with people like Will Siri.[7] Ernest[8] and Lowry Dobson,[9] Lola Kelly. John Lawrence[10] was the Director of Donner Lab at that time.

I had several projects going there. For my thesis, I used the data that we collected using a mass spectrometer[11] that had been built by Will Siri. We used it as a gas analyzer, and I used it by measuring the composition of respiratory gases to measure various aspects of the circulation—in particular, things like the cardiac output—and ended up with a thesis based on lung ventilation patterns.

I did some other work on the analysis of deuterium[12] by what was called the "falling drop method," and except for publishing the technique, nothing much ever came of that. I helped in the lab with Dr. Lawrence's work on the treatment of polycythemia [vera][13] by use of radioactive materials. There was a lot of radiation work going on at the lab, and to a certain extent all of us participated in various projects.

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5 Hardin B. Jones, M.D., was a physician who worked with John Lawrence at the Donner Laboratory, Berkeley. He was an early associate of John Lawrence's. He studied isotope applications in nuclear medicine and showed uptake of iodine-131 by human and bovine thyroids. Regarded as an excellent experimentalist, Jones became the scientific assistant director of Donner Laboratory and led a research group. He was a member of the National Advisory Committee on Radiation of the Federal Radiation Council. See "Reflections on Hardin Jones" in DOE/EH-0476, *Human Radiation Studies: Remembering the Early Years; Oral History of Physiologist Nello Pace, Ph.D.* (June 1995).

6 From 1946 to 1967, Pace served at UC Berkeley as a research associate for the Division of Medical Physics and a professor of Physiology, chairing the Department of Physiology from 1964 to 1967. He established the White Mountain Research Station near Bishop, California in 1950, where he worked from 1950 to 1977. In 1977, he became an emeritus professor of Physiology at UC Berkeley. Pace's research interests were in gravitational physiology, environmental physiology, and body composition. See DOE/EH-0476, *Human Radiation Studies: Remembering the Early Years; Oral History of Physiologist Nello Pace, Ph.D.* (June 1995).

7 William Emil Siri, (1919–), a physicist, worked on the Manhattan Project at UC Berkeley from 1943 to 1945. Afterward he conducted research at Donner Laboratory. Siri researched the application of radioisotopes to biology and medicine. He also studied high-altitude physiology, leading expeditions to the Peruvian Andes, the Himalaya Mountains, and Antarctica.

8 Ernest L. Dobson, Ph.D., was a biophysicist who was born in Beijing, China, in 1914 and became a U.S. citizen. He worked as a physiologist at the Lawrence Radiation Laboratory from 1946 until his death, conducting research on the physiology of the circulatory system.

9 R. Lowry Dobson, Ph.D., M.D., is a physician who was born in Beijing, China, in 1919 and became a U.S. citizen. He was a research fellow at Donner Laboratory and Lawrence Radiation Laboratory (at UC Berkeley) and was chief medical officer until 1958. Additionally, he was a senior scientist in the Biomedical Sciences Division at the Lawrence Livermore National Laboratory, conducting research on the health effects of exposure to environmental agents, radiation, and internal radionuclides.

10 Dr. John Lawrence, brother of Ernest O. Lawrence, was Director of the Division of Medical Physics at the University of California, Berkeley. He operated a clinic at Donner Laboratory, where he treated leukemia and polycythemia vera patients with radioactive phosphorus.

11 a device that uses deflection of ions in an electromagnetic field as a basis for identifying the elements (or elemental components) present in a substance

12 an isotope of hydrogen, having twice the mass of ordinary hydrogen (protium); "heavy hydrogen"

13 a disease characterized by overproduction of red blood cells

Research on Human Subjects at Berkeley

YUFFEE: The research you did for your Ph.D.—was it done with animals or human subjects?

ROBERTSON: This was on human subjects.

YUFFEE: And were they volunteers, or patients that were referred to you?

ROBERTSON: We call them volunteers. Some of them were "drafted."

YUFFEE: Were they drafted out of the ranks of the people who worked at the lab?

ROBERTSON: Yes.

YUFFEE: Did you ever take part in any of the research for yourself and for others?

ROBERTSON: Yes.

YUFFEE: That was obviously a common practice?

ROBERTSON: I would think so. Like, Nello Pace had a study of body composition, and this would involve getting into a chamber and breathing carbon monoxide,[14] and I was a subject for that experiment.

YUFFEE: I hope you didn't have to breathe that for too long.

ROBERTSON: Not much.

PILLAI: So, did you also work with projects with Siri on body composition, as well? Siri and Pace both did a series of experiments on body composition using isotopes, mostly tritium.[15]

ROBERTSON: Well, I knew about them and I was a subject for some, but I wasn't a participant in the sense that I would get my name on a paper.

Another physicist that I was trying to think of is Cornelius Tobias.[16] I was also acquainted with people in [Joseph] Hamilton's Lab.[17]

YUFFEE: Did you get the isotopes from [the Crocker] cyclotron?[18]

ROBERTSON: I think that was our main source. I don't remember to what extent we imported isotopes. At that time, it was just the beginning of isotopes

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[14] a colorless, odorless, poisonous gas, CO, produced when carbon burns with insufficient air

[15] a radioactive isotope of hydrogen having an atomic weight of three. The heaviest isotope of the element hydrogen, tritium gas is used in modern nuclear weapons.

[16] Tobias was a professor of medical physics and radiology at the Donner Laboratory and the University of California at Berkeley. Dr. Tobias's main research focused on the biological effects of radiation; cancer research; and space medicine. For the transcript of the interview with Tobias, see *DOE/EH-0480, Human Radiation Studies: Remembering the Early Years; Oral History of Biophysicist Cornelius A. Tobias, Ph.D.* (July 1995).

[17] Joseph Hamilton, an M.D., worked at Crocker Laboratory, then the site of a 60-inch cyclotron that he operated to produce radioisotopes in support of research and some medical diagnosis and treatment. Crocker was part of the Lawrence Radiation Laboratory.

[18] an accelerator in which particles move in spiral paths in a constant magnetic field

production; there were not a lot of commercial suppliers. It seems to me, on occasion we did get some from Oak Ridge.[19]

PILLAI: How did you end up at Brookhaven immediately after Berkeley?

ROBERTSON: When I finished my degree, there was a question of whether I should stay there or go somewhere else, and I was particularly interested in a job at Denver. The original contact would have been at University of Colorado with Ted Puck.[20] But he couldn't arrange it immediately, and he wanted to take a temporary job at the Veterans Administration; and at the moment, I didn't want to do that.

Invited to Join the New Lab at Brookhaven (1950)

ROBERTSON: Then Leo Farr[21] came out and interviewed people for jobs and invited me to visit Brookhaven. I was so impressed! At that time, Brookhaven was a very new Lab, but I was impressed by the amount of equipment and things that they had assembled and what they planned to do, and that's where I signed up.

PILLAI: And Farr was the head of the [Brookhaven] medical division?

ROBERTSON: Dr. Leo Farr was the head of the Medical Department at the time.

PILLAI: Can you talk a little about what Brookhaven was like when you first came there; the organization, as well as the research activities?

ROBERTSON: Well, Brookhaven was in the throes of getting going, and, for example, a couple of the lead people were Desmond and Marietta Kuper,[22] and one

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[19] During World War II, the Manhattan Project had built a vast complex of highly classified facilities in and near Oak Ridge, Tennessee, to process uranium for use in atomic bombs. The Atomic Energy Commission took control of these facilities upon its creation and, today, they belong to the Department of Energy. For producing weapons-grade plutonium, the reactor design installed at Oak Ridge proved to be significantly less efficient than an alternative Manhattan Project design at Hanford Site. After World War II, a decision was made to make Oak Ridge the principal source for reactor-produced radioisotopes, a mission to which the Oak Ridge Reactor was well-suited.

[20] Theodore T. Puck, D.Sc. (born 1916), a biophysicist and geneticist who was a research professor of biochemistry, biophysics, and genetics at the University of Colorado Medical Center in Denver from 1948 until his retirement. He was a member of the National Academy of Sciences and a recipient of numerous awards and medals. He developed principles of somatic cell genetics and genetic biochemistry and events leading to cancer.

[21] Leo E. Farr, M.D. (born 1907), a research physician who worked at the Rockefeller Institute Hospital (1934–40). He subsequently served as director of research at du Pont Nemour Foundation, Wilmington, Delaware (1940–42, 1946–48). He worked at the Naval Medical Research Institute (1942–46); headed the medical research center at Brookhaven (1948–62), worked at M.D. Anderson Hospital, University of Houston (1962–67); and organized emergency medical services for the State of California Department of Public Health, Berkeley (1967–73). Dr. Farr conducted research on kidney disease; nephrosis; protein metabolism; electrolyte imbalance; blood substitutes; deep-sea diving and submarine medicine; and the development of applications of nuclear science to medicine. At Brookhaven, Dr. Farr was Robertson's first supervisor and worked with Dr. William Sweet on the boron neutron capture program for treatment of brain tumors.

[22] J.B. Horner (Desmond) Kuper (born 1909), a physicist and electronics engineer who conducted research on spectrophotometer development, Geiger counters, and other radiation detection instrumentation. He served at the Radiation Laboratory, Massachusetts Institute of Technology (1941–46). Subsequently, at Brookhaven, he headed the Electronics Division; chaired the Instrumentation and Health Physics Department (1947–70);
(continued...)

of their first assignments was to figure out what their own salary should be. They didn't want to make it too high or too low, but this was a discussion.

But Brookhaven already had a research reactor[23] in operation, and the Medical Department was temporarily housed in what had been Army barracks. Brookhaven took over what had been Camp Upton in the war, and many of the buildings and some of the problems that went with them were inherited from the Army. They were in the process of building several new buildings, and actually, the medical was one of the last of the major buildings to be built.

YUFFEE: When you say "the medical," is it the hospital?

ROBERTSON: This is the medical research labs and the hospital. At that time we had started a program of research in boron neutron capture therapy [(BNCT)].[24] In the course of planning the medical facilities, they were down to point of quibbling about what locks to put on doors and things like that, and they asked Dr. Farr what additional things he might want in their complex. He said, well, he'd like to have a reactor for medical use. Well, they were tired of talking about hardware and stuff, and since this would be a million-dollar [item], they latched onto that. I helped in the design of this and was there when they got bids for the design, and participated in that phase of the planning and design of the medical [building] and the rest of the medical facility.

YUFFEE: When was the facility finally completed?

Boron Neutron Capture Therapy

ROBERTSON: If I'd known you were going to ask questions like that I would have been better prepared, but I don't know. I went there in 1950, and it must have been three or four years later. I don't know the year that medical building was finished. That's a matter of record; it could be established.

PILLAI: Since you brought up BNCT, can you talk a little about your involvement in BNCT and what you thought of the program?[25]

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22 (...continued)
served as assistant to the Laboratory Director; and served as a consultant. Marietta Kuper, administrative officer to BNL Director Leland Hayworth, was married to Desmond Kuper.

23 an apparatus in which a nuclear-fission chain reaction is sustained and controlled; research reactors are generally smaller than production-scale reactors.

24 Brain tumor patients were injected with a discrete amount of boron that was intended to deposit in the tumor. The tumor was then bombarded with a beam of neutrons that was directed to the boron in the hope of destroying the tumor.

25 From 1951 to 1961, Brookhaven conducted boron neutron capture therapy on 45 patients. All were suffering from aggressive and otherwise untreatable types of brain tumors; all had received conventional radiation treatments. The therapy was unsuccessful. Patients so-treated generally lived only as long as patients with the same types of brain tumor who were treated with conventional radiation therapies. The work was funded by the U.S. Atomic Energy Commission. Source: *Human Radiation Experiments Associated with the U.S. Department of Energy and Its Predecessors* (213 pages), DOE/EH-0491, July 1995.

ROBERTSON: Well, I was very enthusiastic about BNCT. We'd started with meetings between Dr. William Sweet[26] [and Gordon L. Brownell][27] from the Massachusetts General Hospital [in Boston]. They had the theoretical basis for thinking that boron neutron capture therapy might be workable, and Brookhaven had the reactor facility that was an attractive source for trying this. Actually, we did what turns out to be an inadequate number of animal experiments.

With this we had to do a special construction of a facility that was at the top of BNL's research reactor. By removing some of the shielding blocks, we constructed a sort of pit that a patient could be put into, and it [was] big enough that doctors could work around and establish intravenous setups and stuff like that. But then, when the actual radiation was taking place, all the personnel would get behind a shielded area, leaving the patient pretty much alone, although under television surveillance for the radiation. The first irradiation [would take] 30 minutes or so. When the reactor shut down, then we could come in and take the patient to the hospital for further studies.

One of the incidental things that I did in connection with this was to measure the patient's radioactivity as result of being exposed to the neutrons.[28] There is induced radioactivity, and it's a way of measuring the dose that he got.[29]

PILLAI: Did it initially start out as a collaboration with MIT?[30]

ROBERTSON: Yes. In particular, the principal investigators were considered to be Bill Sweet and Leo Farr.

PILLAI: Was there a lot of controversy surrounding it initially or once you had started treatment?

ROBERTSON: Well, there really wasn't a lot of controversy. We had to make it a sort of—maybe not a secret, but at least a low-publicity procedure. But somebody tipped off some science writer, who came out and made it a big splash in some popular science magazine. I forget whether it was *Popular Mechanics* or one of those. So that [project] had started getting

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26 William H. Sweet, M.D., D.Sc. (born 1910), was a neurosurgeon at Harvard University Medical School from 1940 until his retirement in the late 1970s. He conducted research on the central nervous system, brain fluids, treatment of brain tumors, mechanisms of pain, and behavior relating to brain disease. During the 1950s, Dr. Sweet conducted research using boron neutron capture therapy in conjunction with Brookhaven National Laboratory.

27 Gordon L. Brownell, Ph.D. (born 1922), conducted research on the imaging of positron-emitting radionuclides and computerized axial tomography, and the dosimetry effects of ionizing radiation. He served as a medical physicist and professor of nuclear engineering at the Massachusetts Institute of Technology. Brownell was a lecturer at Harvard Medical School. From 1950 to the present he has been a physicist at the Massachusetts General Hospital in Boston.

28 elementary particles found in the nucleus of most atoms and having no electrical charge

29 Robertson is referring to neutron activation analysis. When an element is introduced into a nuclear reactor, radioactive isotopes will be produced as neutrons are captured into the nucleus of the element's atoms. By measuring the radioactive emissions of these isotopes, scientists can more easily identify the irradiated elements.

30 Massachusetts Institute of Technology, Cambridge, Massachusetts

a fair amount of publicity before we'd really done the necessary amount of work to establish it.

So we did a series of patients at Brookhaven. In the meantime, a facility was being developed between Massachusetts Institute of Technology and the Massachusetts General Hospital. Another series that we had minimal participation in, but was related to our studies, was done in Boston at those reactors.

In these initial studies, it turns out that the theory of neutron capture therapy would be that the material that you inject, the boron compound, would be more concentrated in brain tumors,[31] in particular in glioblastoma multiforme tumors,[32] than in the normal brain. And this is true. This worked out and was determined by biopsy[33] samples and that sort of thing.

But a thing that had not really been properly considered was that, at the time of treatment, there was still a subsequential amount of boron in the circulating blood, and, although the boron was kept out of the normal brain cells, there was enough damage to the blood supply to the normal brain, that this put a very sharp limitation on the amount of neutron exposure that could be delivered.

So the results were, that the patients were really inadequately treated. I don't have all the statistics in my mind, but at the stage of glioblastoma multiforme—this [is] the fourth stage of the disease—their life expectancy was perhaps six months before treatment. Some of the patients lived longer than six months. I think the record was about 18 months, but this wasn't what you'd call a cure of brain tumors. You need five years' survival, and none of ours came close to that. So the whole project was temporarily abandoned, and we went back to doing animal research and development of better chemicals that would enter into the tumor faster and clear out of the blood faster.

PILLAI: How did you select the patients? Were there many patients with glioblastoma multiforme at the hospital?

ROBERTSON: Well, normally there weren't any at the BNL Hospital. I think everyone was brought to us from Boston. They were selected in Boston on the basis of histologic[34] diagnosis of the tumor as being this very malignant kind of tumor with a very low life expectancy.

YUFFEE: Where there other types of tumors that were used that patients had that were also good candidates for BNCT?

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[31] uncontrolled, abnormal, circumscribed growths of cells in any tissue; neoplasms

[32] brain tumors characterized by the presence of a great variety of cellular types

[33] the removal for diagnostic study of a piece of tissue from a living body

[34] relating to the study of the structure of tissue

ROBERTSON: We just treated brain tumors, and they weren't all glioblastoma multiforme. There were one or two astrocytomas tumors[35] that were treated.

YUFFEE: Were there any gliomas?

ROBERTSON: Well, these are all gliomas,[36] but multiforme is the worst kind, and so we thought if you could cure *them* you could [cure] anybody. But it turns out that we *didn't* cure them.

PILLAI: For the period of time when BNCT was originally initiated and the patients were coming and treatment was being done, was that the research activity that Brookhaven thought of as the most prominent research activity for Medical Division?

Other AEC Biomedical Programs

ROBERTSON: Well, this involved a lot of people and depends on who you talked to whether they thought that this was the most important thing. There were other projects, like the study of nephrotic[37] children. This was a big part of the hospital.

And then, as things developed, there was a Dr. Lewis Dahl,[38] in particular, [who] had medical projects, and George Cotzias[39] came and had projects. Cotzias was involved in the development of treatment for Parkinson's disease,[40] and this was a big project in the medical department. Lew Dahl was particularly interested in hypertension—high-blood-pressure studies—and in obesity. So they had hospital patients that were being studied for high blood pressure and attempts to reduce obesity.

There were also a lot of animal studies done in connection with hypertension. Dr. Dahl's group had rats bred. For example, there was one group of them that was sensitive to salt intake and the other group was indifferent to it. [Dahl and his people were] trying to resolve the role of salt as a causative, or at least as an auxiliary factor in reducing hypertension in humans.

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35 a tumor of the brain and spinal cord originating from astrocyte cells

36 tumors of the brain and spinal cord originating in tissues that form the supporting structure of nerves

37 having nephrosis, a kidney disease marked by noninflammatory degeneration of the tubular system

38 Dr. Lewis Dahl, M.D., a physician (internal medicine) who worked at the Rockefeller Institute before transferring to Brookhaven. He studied the relationship between salt metabolism and hypertension.

39 George Cotzias, M.D., son of the mayor of Athens (an anti-Nazi) during the occupation of Greece by the Germans. Educated at Harvard, Cotzias went on to work at Brookhaven circa 1952. He is noted for his work on manganese poisoning and Parkinson's disease, and for urging the use of high-dose L-dopa to help control Parkinson's.

40 a neurologic disease believed to be caused by deterioration of the brain cells that produce dopamine, occurring primarily after the age of 60, and characterized by tremors (especially of the fingers and hands), muscle rigidity, and a shuffling gait

YUFFEE: Since the initial funding for building the hospital came from the fund to build the three [Atomic Energy Commission (AEC)][41] research hospitals (the one in Brookhaven; Argonne Cancer Research Hospital[42]; and the one that became ORINS[43] down in Oak Ridge), how did [the] research program develop so that it was so widespread, including eventually trying to treat Parkinson's and studies on hypertension, and nephrotic children? How did it sort of branch out from the original [mission], aside from the cancer research that was going on?

ROBERTSON: Well, we had a very nice relationship with the Atomic Energy Commission and Charles Dunham[44] was the Director of—I forget exactly what they called his position, but it was biological and medical research, and they gave us pretty much any opportunity to develop our own research programs. That is, they didn't tell us what to do; I wasn't directed from above. It was financed from above, and of course, we had to write research protocols and get approval. But nevertheless, the ideas originated from within the Laboratory, and so it depended on the interests of the individuals that were hired to do the research, instead of a program that was dictated from above.

PILLAI: You had mentioned before about your experiments [with] the nephrotic children. I was wondering if you could talk a little more about that?

ROBERTSON: Well, Leo Farr, again, was the principal investigator in this, and my participation involved measuring the sodium and potassium turnover[45] rates and body composition of these. We had various techniques of controlling the nephrosis, and some of the children seemed to be outgrowing the disease [(nephrosis)]. The children responded to therapy [and gave us an opportunity to conduct additional studies with] the electrolytes sodium and potassium.

PILLAI: Were you involved at all with ^{131}I [(iodine-131)] studies on the nephrotic children?

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41 predecessor agency to the U.S. Department of Energy and Nuclear Regulatory Commission (NRC); established January 1, 1947

42 one of three clinical facilities created by the Atomic Energy Commission in 1948. While the AEC owned the 58-bed Chicago hospital, the University of Chicago medical school administered and staffed the facility. Patients were admitted on a selective basis: physicians chose persons whose condition best suited the hospital's research and treatment applications. The hospital admitted its first patient in January 1953. The Energy Research and Development Administration terminated Government support for Argonne and the other AEC-created research hospitals in 1974, three years after the hospital's name was changed to the Franklin McLean Institute. The facilities are now used by the university's medical school for studies in radiology and hematology.

43 Oak Ridge Institute of Nuclear Studies, established in 1946 by the Manhattan Engineer District and operated under a Manhattan Project (and later Atomic Energy Commission) contract. ORINS was responsible for training physicians and researchers in the safe handling of radioisotopes and in the development of isotope applications in medicine. In addition, ORINS was responsible for selecting both students and established scientists for fellowships and other temporary research assignments.

44 director of the AEC's Division of Biology and Medicine from 1963 to 1967, when he left to take a position at the National Academy of Medicine

45 clearance from the body and replacement by new intakes of the same materials

ROBERTSON: ^{131}I on nephrotic children . . . I don't really remember that detail. We did get involved in iodine-131 treatment of thyroid[46] in general, and we had Rulon Rawson[47] and some other people from New York City that were our advisors in the use of iodine in developing therapy and in studying iodine uptake[48] in the thyroid.[49]

PILLAI: With the nephrotic children, I know the children were at the hospital, and the parents could have been located in other areas. How involved were the parents in the treatment of the children? Was there a correspondence that took place?

ROBERTSON: The parents were frequent visitors and were kept informed, mostly by conversation. I don't remember writing letters to the parents and things like that. When they came in, we would talk to them about what we were doing and how the child was doing and try to answer their questions.

PILLAI: With all the experiments that were conducted at Brookhaven—I know that Brookhaven was one of the earliest places where actual consent forms could be seen. Were the consent forms filled out for experimental procedures or did they basically have them but they weren't filled out for particular experiments? Do you recall anything for the consent forms?

ROBERTSON: The consent forms were very primitive at that time. We had general consent forms that people would sign that didn't really spell out details of what we would be doing. I mean, they said they would agree that we would conduct certain procedures, in general terms, and the parents of the children involved or the patients themselves would sign this sort of general thing. To the other extent, the doctors would talk to patients and then make a [handwritten] recording in the patient's own record as to what was told the patient. The doctor would sign this and this was considered informed consent at that time.

YUFFEE: Were they told general information, or were they given specifics? For example, the patients with BNCT.

ROBERTSON: The patients with BNCT were very clearly told this was an experimental procedure and it might or might not work, and to a large extent, even the technical details of what was involved, which involved giving him an injection and subjecting him to external radiation and under somewhat uncomfortable conditions.

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46 an endocrine gland located at the base of the neck and secreting two hormones that regulate the rates of metabolism, growth, and development

47 Rulon W. Rawson, M.D. (born 1908), a physician and specialist in diseases and physiology of the thyroid and thyroid cancer. He served at Harvard Medical School, Massachusetts General Hospital (1938–48), Cornell University (Ithaca, New York), and Memorial Sloan-Kettering Cancer Center (1948–54). He was vice president of the College of Medicine and Dentistry of New Jersey (1958–67). His research interests were in the use of radionuclides for treatment of thyroid disease.

48 an excess assimilation of radioiodine in the thyroid, indicating abnormality

49 Radioiodine (^{131}I) is widely used to diagnose thyroid function and also is a highly effective therapy for hyperthyroidism, Graves' disease, and thyroid cancer.

YUFFEE: With situations like the nephrotic kids, in those situations were the parents given really explicit details?

ROBERTSON: The parents were given, orally, a substantial amount of information. Particularly if they asked questions. But I don't remember any very formal written things that they would sign, except as a general consent that the Laboratory would conduct certain procedures and they'd agreed.

YUFFEE: With the nephrotic kids, how did [the Laboratory] find those patients to take part in this study? Were they referrals?

ROBERTSON: They were referrals. Dr. Farr was established there as a child physician. He had a lot of contacts, and people would refer the nephrotic children to Brookhaven. They came from all over the country.

YUFFEE: I'm curious: how did that work? If Dr. Farr wanted to do a study on nephrotic kids, would he then get on the phone and call up people he knew, contacts that he knew of, or [did he know which] places these children might have been?

ROBERTSON: How did Dr. Farr recruit patients? Well, he would go to meetings and talk to his acquaintances and things like that. We didn't put ads in the paper or anything like that.

YUFFEE: So it was basically word of mouth? And this was the case with a lot of research that was being done?

ROBERTSON: Yes.

PILLAI: Can you discuss some of the other experiments or research you were involved with? You were involved with some iodine treatment for thyroid cancer?

ROBERTSON: My participation in the iodine study was quite limited to actually doing some of the technical work and calculating the dose. I was interested in the biological effects of the radiation, and so I was interested, at that time, in how to determine the radiation dose from iodine-131. But I really didn't get too much involved in the actual experiments that were conducted. If I *was,* I don't remember.

Brookhaven Human Use Committee

PILLAI: Maybe we can come back to that. May we talk about the Human Use Committee at Brookhaven? You were part of that committee on the use of isotopes on human subjects?

ROBERTSON: Well, we did, fairly early in the game, establish what is now called a Human Use Committee. The investigators that were going to be conducting experiments that would involve any radiation to humans would have written protocols; and to some extent, the informed consent procedures came into this. That would be submitted to the committee, and there would be four or five people on the committee that would review the proposal and frequently would ask for modifications, based on what somebody on the committee saw as necessary preliminary information,

before the study could be transferred to humans. There was [a] substantial amount of animal experiments going on, and some of these [protocols] would be transferred to human [studies] as they became better established. But the Human Use Committee would review and would have to agree to any human study before it was actually done.

PILLAI: Was this standard procedure to have animal experimentation before humans for all of the research which was conducted on humans prior to most experimentations?

ROBERTSON: [Certainly] for a radiation study. I think for some things, like obesity control and hypertension, studies were based on using things directly in humans, to a certain extent, without an animal basis.

YUFFEE: Why did the people at Brookhaven decide to create what became known as the Human Use Committee, when clearly, colleagues across the AEC complex did *not* have formal human use committees?

ROBERTSON: Well, I think this was suggested to us by Chuck Dunham, that we should do something of this sort.

YUFFEE: Do you know why? For example, I don't think the first human use committees at either Oak Ridge National Lab or at ORINS came about for another 10 years or so after the one at Brookhaven. Would you know why the suggestion maybe was made to Brookhaven, and not other places? Did they maybe ignore the suggestion?

ROBERTSON: No, I don't know a thing about that.

PILLAI: You were on the committee [at Brookhaven] since its inception?

ROBERTSON: I think so.

PILLAI: I've noticed that many of *your* proposals to do research went to committee, which you were a member of. How did that work out?

ROBERTSON: Well, when a person on the committee was involved, then he wasn't at the meeting where it was discussed. He might make a presentation to the committee, but he wasn't there when it was reviewed.

YUFFEE: Was it, in reality, a *pro forma* situation, or were proposals rejected even amongst members who were on that committee?

ROBERTSON: It wasn't a political sort of situation. The acceptance or rejection was based on scientific merit. Some people had more clout than others.

YUFFEE: Were there hard feelings when a proposal was shot down?

ROBERTSON: Well, I suppose, but it would be temporary. Besides, you just didn't shoot a thing down without making suggestions for how it could be remedied.

PILLAI: You were talking about tracer[50] studies. Can you tell us what the feeling was at the time, as far as safety in using tracers? I know a lot of tracer

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[50] a radioactive tag on biomolecules, used to study a biological, chemical, or physical system

experiments were done on normal subjects, and not on patients. Could you tell us what the feeling was among the researchers, including yourself, as far as safety?

ROBERTSON: Well, the tracer dose, by definition, is a small quantity of [radio]activity. We did have a certain understanding of radiation dosimetry[51] at that time. Granted there have been a lot of improvements and development of knowledge since then, but there were certain guidelines for what level of radiation was safe, and of course, we'd stay well below that.

It was considered that the tracer experiments were essentially harmless to the subject. The people that were handling radioactivity had to have extra precautions to keep from getting overexposed, because you start with a fairly high concentration of activity. Eventually, when it gets to the patient, it's down to a low level.

YUFFEE: When normal subjects were used, were they informed of the dose of the tracer dose itself? Were they given a description of what it did, and told about the standards for safety regarding using isotopes in humans?

ROBERTSON: I don't think that, at least in the early stages of this, it was spelled out technically. Some general terms, like "amounts that were considered to be generally safe," would be used, and things like that. Then [later in the explanation] I would get into how many microcuries[52] or whatever.

YUFFEE: How did you recruit healthy or normal volunteers for research that would include administering tracers to both patients and normal subjects?

ROBERTSON: I don't remember. I know that there were people from the general community [and] that one way or another they'd find out that there was an interest in this. Exactly how they were recruited, I don't remember.

YUFFEE: Were they paid? Do you know what the incentive might have been for participation?

ROBERTSON: Well, I was just trying to think. There were some of them having to travel that had certain expenses paid. I know there was some question about whether patients and subjects should be paid at all, because we didn't want that to be considered the incentive for doing that. Some of them were just doing it as their general idea of helping to advance science in their own way. [For] some others, there was somebody in the family that would have the disease, and if we could contribute to information on that, [that] was the basis of their interest in it.

YUFFEE: A lot has been said about places like Oak Ridge having such a high concentration of Ph.D.s and M.D.s and highly educated people. Did you find the community around Brookhaven to be a community like that? You know, that form a basis of a pretty highly educated population that could support research activities?

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[51] the process or method of measuring or calculating the dose of ionizing radiation, or energy absorbed per unit mass, using data from bioassay and other radiation measurements

[52] a millionth of a curie; a curie represents 37 billion radioactive decays per second.

ROBERTSON: Well, I would consider this to be a very mixed bag. The State University was developing at Stony Brook, and so there was an intellectual community there. There were engineers, particularly, that worked for the different aircraft [manufacturers] that are located on the island [(Long Island)]: Grumman [(now Northrop-Grumman)]; [Fairchild] Republic.

But we were in the middle of a farming community, and one of the big exports from Long Island was flowers [that] were being shipped to Boston and other places. Strawberries were a big thing; I think they exported three million quarts of strawberries. So there were a lot of people that were in these nonscientific enterprises that would make [up] the bulk of our contact with the community.

PILLAI: Back to the Human Use Committee. Once a proposal was approved, did it then go back to the AEC? How was the AEC involved in that, or were they not involved?

ROBERTSON: We would write, I think, quarterly reports to the AEC describing our activities, but I don't think informed consents were submitted to the AEC for their approval, at least not on a patient-by-patient basis. Perhaps the sort of general form might have been reviewed; I don't remember.

PILLAI: Were project proposals submitted to the AEC for approval, or was it just internally within the committee where it was approved or denied?

ROBERTSON: It depends on how much money was involved. A project that could be financed out of funds that were already committed to the department, without any higher-level approval, would be approved locally. But for things that would require additional funding, of course, this would have to be submitted to [AEC] Headquarters.

YUFFEE: What would happen once a project research proposal was approved that involved administering isotopes? How did the researchers go about getting the isotopes? Was Brookhaven providing them, at that point?

ROBERTSON: A lot of isotopes were made at Brookhaven, in the research reactor. It had extensive isotope production facilities, and there was a hot lab[53] associated with it. Some things, I remember, the sodium and potassium that I mentioned that we were using, were bought from Oak Ridge.

YUFFEE: They were made at the graphite reactor[54] down in Oak Ridge?

ROBERTSON: Well, however they made them.

YUFFEE: Were you aware of the process of how to get isotopes from Oak Ridge? Do you remember the procedure involved?

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[53] a heavily shielded room designed for work with radioactive materials. The technician usually stays outside of the room and manipulates the materials by remote-controlled robotic arms to process radioactive chemicals.

[54] a pilot graphite reactor and plutonium production plant at Oak Ridge, built by Du Pont. The X-10 pile was a graphite cube, 24 feet square. It had been drilled with 1,248 channels that could be loaded with uranium slugs. Large fans blew cooling air through these channels. (Source: Richard Rhodes; *The Making of the Atomic Bomb;* New York: Simon and Schuster; 1986, p. 547)

ROBERTSON: Our procedure was [that] there was an isotopes division at Brookhaven, and we told them what we wanted, and they got it for us.

YUFFEE: Did they ship it up?

ROBERTSON: How they got it from Oak Ridge, I didn't get involved in that. We'd tell them what we wanted in so many millicuries[55] or microcuries of something on a certain date, and they took care of it.

PILLAI: Do you recall if anyone from the AEC, including Dunham, ever requested that certain types of research be done?

ROBERTSON: I think, as Dr. Farr put it, "They don't tell us what to do, but we listen to their advice."

PILLAI: What was the nature of the advice?

ROBERTSON: I don't remember a lot of details of that. There were certain things that occasionally came up about, "Should we do this or should we do that?" And because they already [knew] that somebody else was doing it, they would say they weren't enthusiastic about our doing it. But, actually, I don't remember anything in particular that they told us to do. There may have been, but I don't remember.

PILLAI: Can you talk a little about the collaborations with other institutions? I know that there was some work going on with Argonne Cancer and also [the laboratories at the University of] California.

ROBERTSON: There were extensive collaborations with other laboratories, but this was largely on a basis of individual contacts: if somebody had a friend at the other place [who] was interested in the same thing, or maybe not necessarily a friend but, somehow or another, they'd got acquainted and could work together. But I don't remember any formal procedures being set up. Maybe there were [agreements] that [said,] "We're going to do this and you're going to do that and this the division of labor," and that sort of thing. I have seen these in other places. You develop a written contract. But I think we were pretty informal, at least in the early days of Brookhaven.

PILLAI: Do you recall any collaborations with any international atomic energy boards or anything outside [the United States]? I know there was one study that Brookhaven did which was a collaboration with the South Africa Atomic Energy Board.

ROBERTSON: Larry Hanks [had a collaborative project with South Africa]. I went to meetings of the IAEA[56] in Vienna.

PILLAI: Did you keep in contact with people from California, from Donner Radiation Laboratory?

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[55] thousands of a curie; a millicurie is one thousand microcuries.

[56] International Atomic Energy Agency, an organization of the United Nations headquartered in Vienna, Austria

ROBERTSON: At first it was more intense then as time went on. But, yes, we kept in touch, in particular with the Dobsons and with Hardin Jones.

PILLAI: Was there a lot of interaction between researchers at Brookhaven and researchers at the other sites that were being funded through the AEC?

ROBERTSON: Well, I personally didn't have a lot of such contact. There may have been [more contact] going on than I remember now, but there was not any law against it. We had enough going on our premises without getting too much involved in some other things. Larry Hanks's studies in South Africa were dictated by the unique patient population that would be available.

YUFFEE: Focusing on unique patient populations, did you ever play a role in the monitoring of the Marshall Islanders?[57]

ROBERTSON: Oh, yes.

YUFFEE: Could you describe that a little bit?

Castle Bravo Atomic Weapon Test (March 1, 1954)

ROBERTSON: I think it was 1953, [during] the Korean War. Having been in the Navy before, I'd been called back. I got assigned to Naval Radiological Defense Laboratory in [Hunters Point, California, near Oakland], and that is where I met Ed Alpen[58] and Victor [P.] Bond,[59] Stan Cohn,[60] and other people that were interested in radiation protection research. While I was there, on March 1, 1954, there was this accident that involved a bomb

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[57] residents of the Marshall Islands, a group of 34 atolls in the west central Pacific where the United States performed atmospheric tests of nuclear weapons in the 1950s. Since 1986 the Marshall Islands have been a self-governing area associated with the United States.

[58] Edward L. Alpen, Ph.D. (born 1922), a radiobiologist and physiologist who conducted research on radiation biology, cellular kinetics, and regulation of erythropoiesis. He served as biophysicist, division head at Hanford Laboratories, and Director of the Pacific Northwest Laboratory in Richland, Washington (1955–75), and as professor of medical physics and assistant director of the Donner Laboratory at the University of California, Berkeley (1975 until retirement). For recollections of Alpen's tenure at Donner, see DOE/EH-0479, *Human Radiation Studies: Remembering the Early Years; Oral History of Donner Lab Administrator Baird G. Whaley* (September 1995).

[59] Victor P. Bond, M.D. (1919–), was a radiation biophysicist with the Naval Radiological Defense Laboratory (1948–55) and Brookhaven National Laboratory (starting 1955). He conducted research on the biological effects of radiation. At Brookhaven, he conducted pioneering research in bone marrow transplants and served as an Associate Laboratory Director.

[60] Stanton H. Cohn, Ph.D. (born 1920), was a physiologist and chemist at Argonne National Laboratory (1946–49), a radiobiologist at the Crocker Laboratory of the University of California (1949–50) and Naval Research Laboratory (1950–70), and head of the Medical Physics Division at Brookhaven National Laboratory (1970 until his retirement). He conducted research on mineral metabolism in bone, biological distribution and effects of internally deposited radionuclides, whole-body neutron activation analysis, and whole-body counting.

test[61] at Eniwetok[62] that the fallout [63] from it fell on people that were living on the island of Rongelap,[64] in particular. There were some other islands involved, too, but the main population was out on Rongelap. When this was known, they organized us to go out and study the population that had been irradiated.

YUFFEE: Were you the first group to go?

ROBERTSON: I think I was not in the first group that went out to study them, [but the first follow-up].

YUFFEE: With Stanton Cohn?

ROBERTSON: Right, [also Dr. Robert Conard[65] and Dr. Victor Bond. Later studies were organized by Dr. Conard at BNL]. We had developed a whole-body counter,[66] and, maybe not on the very first study, but at least on the six-month follow-up, we arranged to transport [to the Marshall Islands] this whole-body counter, which was in a lead-lined room built at BNL that was the size of this area that we're in right here.

YUFFEE: Probably about six [feet by four feet].

ROBERTSON: The bill of lading called it a "building." [Because of all the heavy metal shielding,] this weighed about 30 tons, and it was lifted by a 20-ton crane; there was some question about putting it onto the ship. But, it got transported onto the island and that was a shielding for the first whole-body counter that we used to determine the radioactive content of the Marshall Island people on Rongelap.

YUFFEE: Did you go to Rongelap?

ROBERTSON: I went to Rongelap later. On the first study that we went on, the people that had been living on Rongelap had been moved to Majuro, and we studied them on Majuro. Later they were moved back to Rongelap.

YUFFEE: After the island wasn't [radioactively] "hot"?

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61 A hydrogen bomb test, Bravo was the first shot in the Castle Series. Detonated March 1, 1954, the size of the blast and amount of radiation produced was said by the AEC to have been far greater than planned. Test personnel, Marshallese islanders, and the crew of a Japanese fishing vessel received fallout from the Bravo Test. Source: DOE/EH-0445, *Human Radiation Experiments: The Department of Energy Roadmap to the Story and the Records* (February 1995).

62 an atoll in the Marshall Islands, a group of 34 atolls in the west central Pacific where the United States performed atmospheric tests of nuclear weapons in the 1950s

63 radioactive debris from a nuclear detonation or other source. Fallout is usually deposited from airborne particles.

64 For a researcher's account of the field trip to assess the fallout effect on the Rongelap islanders, see "Cleanup of the Nevada Test Site and Marshall Islanders" in DOE/EH-0463, *Human Radiation Studies: Remembering the Early Years; Oral History of Health Physicist William J. Bair, Ph.D.* (June 1995).

65 Robert A. Conard, M.D. (born 1913), was a medical scientist with the U.S. Navy and the Naval Radiological Defense Laboratory (1941–56) and Brookhaven National Laboratory (1956–79). He conducted environmental health studies among the Marshallese exposed to radioactive fallout.

66 an apparatus that measures radionuclides in man using shielded detectors and multichannel energy analyzers

ROBERTSON: Well, it was relatively "cool," but [the Islanders] wanted very badly to be back, and the activity had subsided to acceptable levels. With these whole-body studies, we were able to determine the body content of a number of the radioactive isotopes that they had ingested. In particular, cesium content was an easy one to detect, and we would measure the cesium peak in its [radioemissions] spectrum.

YUFFEE: Was the monitoring basically just measuring the level of exposure, or were there any other activities?

ROBERTSON: Well, we couldn't really measure the [external] radiation exposure because the external gamma rays don't leave any residual radioactivity. So that had to be determined by more indirect methods. But what we *could* measure was the radioactivity that had gotten into the body from their ingesting contaminated food. We had a gamma ray[67] spectrometer[68] that could distinguish the [emissions] peaks, and we could tell, to a certain extent, what was what [(what peaks were signatures of what elements)]; and we made records of this.

YUFFEE: This may be a foolish question, but is it possible to determine what was inhaled as opposed to ingested by food?

ROBERTSON: No. You could tell what was in the body without being able to tell how it got there. One of the things that they were told not to eat was some of the land crabs that had a high strontium content. Strontium is a beta emitter,[69] but there are ways of detecting the strontium in the body, the strontium-to-yttrium decay. We could tell which of them had been cheating and eating crab when they weren't supposed to.

Studies on Marshallese at Brookhaven

YUFFEE: When was the first group [of Marshall Islanders] brought to Brookhaven for the first studies there? Or, if you can't remember, what was the purpose for bringing them to Brookhaven?

ROBERTSON: Well, for some of these body measurements, we wanted to [establish absolute values by calibrating them with other instruments]. Actually, they stopped at Argonne [National Laboratory outside of Chicago] and they were measured there before they were at Brookhaven. There were more sophisticated ways to measure things in the laboratory than what we could take with us to the island. I don't know all the motives for doing it. I think the main thing was to get a better quality of data.

I don't know if you know what [the] atoll looks like, but there's a lagoon that is maybe 20 miles or so across. Then there is this little string of islands that are maybe a quarter of a mile wide [around the lagoon,] that

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[67] a highly penetrating photon of high frequency, usually 10^{19} Hz or more, emitted by an atomic nucleus

[68] an optical device for measuring wavelengths, deviation of refracted rays, and angles between faces of a prism

[69] a radioactive substance that emits electrons or positrons during radioactive decay

make what is called the atoll. The people live on an island that is five miles long and a quarter of a mile wide, and that is their idea of land.

So when they came to the U.S., [except for a Jeep] they'd never seen real automobiles, elevators, tall buildings. Almost everything that we are used to, seemed strange to them. But they took it in stride, of course. The ones that we brought either spoke English or could speak through one of them who did speak English. So they saw San Francisco and they saw Chicago and they saw Boston and they saw Brookhaven. Then they, of course, went back to Rongelap.

On a later trip, there was one that we called John that was a leader, and I asked him, "What did you tell the people that the U.S. was like? What did you tell them?" He said, "I told them that it was a big atoll."

PILLAI: Were any studies done on the people [who] came from the Marshall Islands? Any tracer studies or anything of that nature?

ROBERTSON: I don't think so. Some of them that were brought back were developing thyroid problems, and this was studied, but I wasn't directly involved in that. Again, the main thing that we were interested in was calibrating different instruments that were involved in the field and in the laboratories, using [the islanders] as standard subjects and cross-calibrating between what Argonne would determine as the body content and what Brookhaven would determine as the body content. We had physical sources that we could do this with, but things are somewhat different when you're measuring things in humans, and the whole-body counting technique that [they] had at Argonne was not exactly like the one we had at Brookhaven. So you want to [do] cross-correlation of the results that you get from these different kinds of equipment.

YUFFEE: Whose decision was it to continue the follow-up studies on the Marshall Islands? Was it the AEC's decision?

ROBERTSON: I think AEC was strongly involved in promoting the follow-up. The very initial things were under the military, but then, Brookhaven followed up [and] after the first year [the studies were coordinated through Brookhaven].

YUFFEE: As a personal observation, what was the feeling amongst the Islanders for having been exposed in such a way?

ROBERTSON: This is a mixed sort of a thing. They resented having been moved off of the island more than anything else, and to the extent that some of them were actually injured by the radiation, of course, that didn't go over too well.

But there were some things that we did that made them think we were real great. They depended on a supply ship that would come periodically and deliver rice to them. On one of our trips we asked John, the leader, how the people were doing, and he said they were very unhappy that they hadn't received their load of rice for a long time. The next day after we got there, the ship came and, not knowing how we do things, they

thought we had something to do with that. So, we got credit for being able to bring them their supplies from the outside.

Otherwise, we got along with them very well. After we'd been there the first time, when they knew we were coming they arranged to have a sort of a party for us. They would supply the local foods that they'd grow, and we would supply the ice cream. We had makings for things like that. And so, a good time was had by all at sort of a reception we had when we first got there.

YUFFEE: They willingly participated in being studied?

ROBERTSON: Oh, yes. [For] the whole-body counting studies that we did, they would have to be in the counting room for 20 or 30 minutes, and we had a record of Hawaiian music. I didn't need a clock; I could tell, by where we were in the music, when the time was up. I got tired of hearing "Sweet Lalani." But anyway, this was a way of keeping them entertained while we did that. They were organized, and they would come one at a time. They were somewhat docile, as a matter of a fact.

The children were very interesting. The main thing they were interested in [with regard to] what we were doing was whether we were going to show a movie that night. It didn't matter what we showed. One time we showed a Tarzan picture and the reels got out of order. It didn't bother them. There were three reels, and I think they showed the third reel when they should have been showing the second reel. That was okay.

PILLAI: Did the studies on the Marshall Islanders or the involvement with the Marshall Island follow-ups, did that lead to studies on fallout or other types of studies on fallout?

ROBERTSON: There were lots of studies of fallout going on concurrently. We were involved in the study of humans, but there were other people that were involved with physical measurements and studying the chemistry of the situation and all sorts of things that I only had very indirect information about.

PILLAI: How about as far as leading to studies [that] were administered that related to fallout? Or tracers or whole-body counting that was done with things like that?

ROBERTSON: Well, Stan Cohn had a study going where we were looking for cesium and other isotopes in normal humans,[70] and to some extent, this was correlated with what was known about fallout. Although fallout wasn't a big problem on Long Island, there was some. It was a global problem.

PILLAI: Can you talk a little about that?

ROBERTSON: I told you what I know.

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[70] See BNL-34, "Study of the Metabolism of Cesium-137," in *Human Radiation Experiments Associated with the U.S. Department of Energy and Its Predecessors* (213 pages), DOE/EH-0491, July 1995.

YUFFEE: It's very interesting that you just said that fallout wasn't a big problem on Long Island, but it was a worldwide problem.

ROBERTSON: The worldwide problem was sort of a low-level thing. There were people making a bigger study in the nature of where there were bomb tests. In the local vicinity, there was much more of a problem than there was in a remote location.

YUFFEE: In regard to research proposals or research ideas, was that something that was taken into an account, whether or not it was a regional issue for Long Island. For example, this is just a correlation, but apparently, there is a high rate of cancer on Long Island, and people have thought that might be in regard to EMR (electromagnetic field radiation) as opposed to ionizing radiation. But, whether or not that's true—do you see what I'm saying, a local issue? Were there other research ideas that came about because of them being local in nature or of local concerns?

ROBERTSON: Well, first, I don't know where you got the idea that there is a high cancer rate on Long Island.

YUFFEE: I guess there was something in the news recently.

PILLAI: Breast cancer is what I think he's talking about, the breast cancer rate in Suffolk County[, New York].

ROBERTSON: It's high?

PILLAI: It's one of the highest counties in the nation, and actually, I think Brookhaven is doing some studies on that right now.

ROBERTSON: I see. That is more recent information than I'm familiar with. Actually, when I was there, the leukemia rate on Long Island was pretty low. A couple of cases came up, and it turned out that they were people who had recently moved to Long Island. So, if there was radiation involved in causing leukemia, then they got their exposure from somewhere else.

Breast cancer is a complicated thing. It depends on fat metabolism and exposure to sunlight and hormone balances and all sorts of things. I don't know what problem there would be on Long Island.

YUFFEE: Would there [be] facilities at Brookhaven to treat leukemia[71] patients? Was that a common place to get treatment for leukemia?

ROBERTSON: No.

YUFFEE: They would pretty much be sent someplace else?

PILLAI: Which types of research [at] Brookhaven led to radiation diagnostic and therapeutic procedures that became standard practice or breakthroughs?

ROBERTSON: I don't really know. In the Parkinson's studies, the radioactive studies were just incidental to other nonradioactive studies that were going on.

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[71] any of several cancers of the bone marrow characterized by an abnormal increase of white blood cells in the tissues, resulting in anemia, increased susceptibility to infection, and impaired blood clotting

But the use of L-dopa[72] was somewhat generally accepted, although I think other people have discounted it relative to certain other drugs. But for a while, L-dopa was established at Brookhaven and was adopted at other places.

Modern BNCT Treatment

PILLAI: What's your opinion abut BNCT now, because they just started treating patients again?[73]

ROBERTSON: In-between these early studies that we discussed and this very recent one at Brookhaven, I had spent 10 years at the Mayo Clinic [(Rochester, Minnesota)] in entirely different areas, and then came to the Department of Energy Headquarters here, and we were supporting research in medical areas and nuclear medicine,[74] in particular.

We got a proposal from Idaho [National Engineering Laboratory (INEL)][75] to use the PBF [(Power Burst Facility)] [76] reactor to revive treatment of glioblastoma. The argument for this was that this was a reactor that could deliver a pulse, whereas with the Brookhaven reactor, the exposure has to be spread out over quite a long time. There was some advantage in giving a pulse: you could time things which you wanted better by giving a pulse of neutrons.

In the meantime, a lot of chemical work had been done. There were new compounds. I can't remember the exact name of the compound that was developed by Soloway[77] in Boston [(at Massachusetts General Hospital). This was being used by Dr. Hatanaka[78] in Tokyo.] Between Boston and Ohio, there were a lot of people involved in things that led to improvements during this intermediate time, and there was a certain amount of political influence in promoting the development at Idaho.

We had design studies for how to convert the Idaho reactor into clinical facilities, but in the meantime, we were supporting animal work there. They treated a series of dogs, and showed that BNCT could be used and

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72 a chemical converted in the brain to dopamine: used in synthetic form to treat Parkinson's disease

73 Advances in technology that deliver higher concentrations of boron to tumor tissues for potentially improved therapy have brought about the return of boron neutron capture therapy. As a result, Brookhaven is currently involved in BNCT research and clinical trials.

74 diagnostic and therapeutic medical techniques using radionuclides or radioisotopes

75 Created in 1949 as the National Reactor Testing Station (NRTS), INEL has served as the test site for prototypes of many reactor designs in wide use today. INEL now operates the Advanced Test Reactor (ATR) for engineering studies, and focuses on waste disposal and remediation technology.

76 an experimental reactor built at the National Reactor Testing Station near Idaho Falls, Idaho. Its original purpose was to simulate extreme operating conditions and to aid in the study of reactor physics.

77 Arthur Soloway, Ph.D., was a chemist from Massachusetts General Hospital who synthesized the boron cage used to deliver boron atoms to brain tumors during early studies on boron neutron capture therapy at Brookhaven.

78 Hiroshi Hatanaka, M.D, a Japanese physician who conducted pioneering work in boron neutron capture therapy for brain cancer

give satisfactory results and cures of larger animals, getting away from mice and rats. I think dogs were the largest animal that they used. In the meantime, there were continued animal studies going on at Brookhaven.

There have been at least three, maybe four or five international conferences on neutron capture therapy. I went to one in Tokyo. There is sort of an international agreement that, until certain things were better established, that neutron capture therapy wouldn't be revived on a clinical basis. But things are coming along.

I don't know exactly why they did it at Brookhaven. I don't know if "humanitarian" was the word they used, but there was a lot of pressure on them to do this one patient. So—somewhat reluctantly, to my understanding—the people at Brookhaven were persuaded to go ahead and do the study. Fortunately, it's been working out quite well, from the information I've got. Maybe you've got something newer. I thought the patient was doing very well, but I think, by and large, we still consider it premature to develop a wide-scale clinical program.

There's a lot more they want to know about the mechanisms and the localization, the turnover rate of boron compounds in the tumor. It would be very desirable to have, say, a boron-labeled antibody that would go specifically to the tumor that you are interested in. But the problem there has been that if you load antibody too heavily with boron, it will not work anymore. So the problem is to sort of shield the boron in a chemical cage so that it can be used to label antibodies and deliver a higher quantity of boron into the tumor before it is exposed to neutrons.

So they think there are a lot of chemical and physiological things that should be studied before the clinical studies get too heavily underway. I think the word they used for this one patient they did at Brookhaven was "compassion" study.[79]

PILLAI: For the recent one?

ROBERTSON: The recent one, yes. I don't think they plan to do any more right away. Have you been up there, and what did they say?[80]

PILLAI: Basically what *you* said: that they were hesitant to do this one patient.

YUFFEE: They have gained some big pretty big press about it. A lot of publicity, which may, unfortunately or fortunately, cause them to put pressure on them to kick it into high gear.

ROBERTSON: There has been a tremendous amount of improvement in the knowledge of what goes on since our early studies. Maybe what we're afraid of is that if there's another study done with any sizable number of people, and it turns out to be another failure, that would doom BNCT for many more

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[79] New treatment modalities may be attempted on the basis of emergency or "compassionate" need. Food and Drug Administration approval is needed for further clinical trials after an application has been accepted for an "investigational new drug" (IND), radiopharmaceutical, or procedure.

[80] The current plan is to test BNCT on a series of about 20 brain tumor patients.

years. They want to be more sure, based on animal and theoretical studies, that it is going to work this time, before they get too heavily involved.

You'd be surprised—or maybe you know—how much of an international interest there is in this. At these international meetings that I've been to, there are some countries—Russia, Germany, England, and Japan—that have reactors and other ways of delivering neutrons, that are directly interested [in a BNCT study], in that they would be participants in it. But there are other countries—and you would wonder how they get in[to the conferences] at all—[that] are [simply] doing computer studies and are interested in it without having any facilities for actually doing it. But there is interest in this.

PILLAI: I have a proposal here for something that you were involved with, the use of radiopalladium and cancer therapy. Do you recall anything about that?

ROBERTSON: With a doctor from New York City. There was this surgeon in New York City.

PILLAI: Was it Dr. Ariel?

ROBERTSON: Irving Ariel.[81] He was promoting some sort of mixed therapy, a combination of chemical therapy and radiation therapy for these tumors. He would bring patients out to Brookhaven, and he did the treatment. We got involved in measuring the activity in the palladium, and things like that.

PILLAI: Was it for a particular type of cancer?

ROBERTSON: I don't remember.

PILLAI: You can't tell from the proposal. It has your name on it as principal investigator.

ROBERTSON: From Brookhaven's standpoint that is true, because Ariel wasn't officially at Brookhaven. But it was really his experiment.

PILLAI: Were you involved with any other type of cancer therapy?

ROBERTSON: I should have read through this [*curriculum vitae*] more carefully before I did this, [to have refreshed my memory]. One I thought was interesting was with Harold Atkins.[82] We got involved in using californium-252 for studying the effects of radiation on human skin. We used pigskin as a model. Pigskin is almost like human skin. One of these papers was [prepared by] me, with Atkins. It says, "Comparison of Radiation of Californium-252 and Radium on the Skin of Swine."

There were several reasons for being interested in californium-252, because it's a neutron emitter; and it *could* be that at one time we

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[81] Irving Ariel, M.D., a physician at the Memorial Hospital (Memorial Sloan-Kettering Cancer Center) in New York City who was interested in combinations of radiation and surgery for treating abdominal cancers. He collaborated with Brookhaven scientists to develop palladium for irradiation after surgery.

[82] Harold L. Atkins, M.D. (born 1926), a physician in nuclear medicine at the State University of New York, Stony Brook. Atkins collaborated in radiation research with the medical department at Brookhaven National Laboratory.

thought that perhaps—getting back to neutron capture therapy—that californium could be the neutron source. That was developed to some extent, but it turns out that you need a pretty large roomful of californium to have enough neutrons to be used for neutron capture therapy. But we did study these effects on the skin.

YUFFEE: What was the neutron source used for BNCT?

ROBERTSON: The neutron source was the reactor. The thing is, neutrons in a reactor are born [having] high energy, and to keep the reactor going, they have to go through different energy-reduction reactions with the graphite [moderator] in the reactor. To a large extent, the neutron content of the graphite reactor and the medical research reactor is thermal neutrons; but it's far from being pure thermal.

Since the boron neutron capture cross-section is highest in the thermal region,[83] it seemed logical that we would want a thermal beam. But it turns out that thermal neutrons don't have good penetrating ability through human tissue, or any other tissue.

So, after we got started on this, it turned out that it would be better to have what is called an epithermal beam,[84] so that the shutter and the design for bringing the neutrons out of the reactor and directing them toward the patient was designed such that it didn't completely thermalize the neutrons. They were in the epithermal, a little bit above the thermal energies. But then, this thing also had to be heavily shielded against the gamma component and other stray radiations that would be part of it, so it's not a pure beam that comes out; it's quite a spectrum. We try to avoid having real high-energy neutrons, which are very destructive, but it's sort of tricky to get an epithermal beam.

Insofar as reactor sources are concerned, it starts with uranium or plutonium fusion or fission, and they start as high-energy neutrons and have to get down to epithermal or thermal. Californium[-252, a radioisotope that emits neutrons,] would be a direct source of high-energy neutrons; of course, they would have to be epithermalized before they'd be used for this.

YUFFEE: You just would need too big a source of californium?

ROBERTSON: Well, at least according to our original calculations. If it could be somewhat more concentrated than the sources that are available to us, that would be different. But the amount of californium activity per gram of what we were using wasn't high enough to be practical.

PILLAI: Were the californium studies on humans?

ROBERTSON: No, pigs.

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[83] thermal neutrons—neutrons that have slowed down by energy loss (collisions) to about 0.025 to 0.04 electron-volt at room temperature

[84] epithermal neutrons—neutrons that have slowed by energy loss to energies above the thermal level (1 to 100 electron-volts)

PILLAI: Only on pigs?

ROBERTSON: We didn't use californium on any humans.

PILLAI: Why was that?

ROBERTSON: Why *would* we? If there's a potential therapy it might have been considered, but in the pig studies, we were looking at the comparative effects of neutrons as compared to other kinds of radiation; radium[85] gamma rays, in particular.

YUFFEE: Was that type of knowledge in comparative studies—would that have been common to take place involving human subjects? You just said "Why *would* we?" because you didn't see any reason for it, in terms of trying to develop a therapy. Was a therapy always the reason why you would use a human subject?

ROBERTSON: Well, the bulk of studies, at least that I've been involved in, with human subjects have been tracer studies. In these, you try to avoid any effects.

There was another series of experiments that we haven't mentioned: that early in the history of neutron therapy, Dr. Stone,[86] at the University of California, had used high-energy neutrons to treat certain kinds of tumors in human patients. They got very poor results. I don't know the exact year, but pretty early.

YUFFEE: Pretty early on?

ROBERTSON: Yes pretty early.

YUFFEE: I thought they were using phosphorus as one of the things they used.

ROBERTSON: Well, that is different.

YUFFEE: That would be a different treatment?

ROBERTSON: Phosphorus is a pure beta emitter. Dr. Stone had a cyclotron as a source of high-energy neutrons, and the reason for the high biological effectiveness of neutrons had to be worked out. It's related to the oxygen; that is what is called the oxygen enhancement factor in some radiation effects;

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[85] a radioactive, luminous white, metallic element that occurs in very small quantities in combination with minerals. Radium had been used in treating cancer. At that time, no radioisotope had been more thoroughly characterized for its biomedical effects.

[86] A pioneer in radiation therapy, Robert Stone, M.D., had conducted human radiation studies before World War II. He was an early researcher at the Lawrence Radiation Laboratory and became a major figure in radiobiology research. When Joseph Hamilton began operating his 60-inch cyclotron at Crocker Laboratory, Stone requested that fission products be made on the cyclotron and that their fate in mammals be systematically studied in small animals. That information would be used for radiation protection proposes. In 1942, while chairing the Department of Radiology at UC San Francisco's medical school, Stone was recruited to lead the Medical Division of the Manhattan Project, overseeing all biological, medical, and radiological protection research. Accordingly, he moved to the University of Chicago, where he served as Associate Director for Health under Arthur Compton. In the 1950s, after serving in the Atomic Energy Commission, Stone returned to his post at the UC San Francisco as head of the Department of Radiology. Under Stone, UCSF acquired a 70-MeV synchrotron for conducting therapeutic research.

and the high-energy neutrons have a higher linear energy transfer coefficient than the intermediate-energy ones.

But the reasons for why irradiation with high-energy neutrons had [such a] different effect from lower-energy ones—the mechanisms of these—were of interest. And this is where the californium study came into it. This was an alternative source of high-energy neutrons that could be manipulated.

Leaves Brookhaven for the Mayo Clinic (1975)

PILLAI: Talk a little bit about why you left Brookhaven.

ROBERTSON: I was drafted back into the Navy. We didn't consider it leaving. I was still considered "on leave" from Brookhaven, and I came back to my same job.

YUFFEE: The second time, when you finally left?

ROBERTSON: When I left after 25 years? [In the early years,] there was more freedom as to what experiments we could do. But toward the later years, there was more pressure on the Medical Department to actually do clinical work,[87] and not so [many] animal studies and other basic studies. There was more and more pressure to do certain clinical kinds of study that were of interest to what had become [the Energy Research and Development Administration (ERDA)].[88]

Insofar as the nuclear medicine program was concerned, I thought that I'd gotten away from my clinical training too much to really do research in nuclear medicine on a clinical basis. So I discussed this with them, and it seemed to be a good idea if I would go some place where there was clinical nuclear medicine underway.

For me, it was logical to go to the Mayo Clinic, because my home had been in Minnesota when I went through high school [and college]. So I contacted the Mayo Clinic, and they said they would be glad to have me come there.

At that time, I was partly being paid by Brookhaven and partly by the Mayo Clinic, on a one-year basis. That is, Brookhaven would have paid my full salary for six months, but to stay [in Rochester, Minnesota] for a year at half-salary, I got additional support from Mayo.

I got there and got involved in a study comparing the use of iodine-123 for doing thyroid uptake studies instead of iodine-131, which has more general health hazards associated with it. There was already a study underway, and they were getting a discrepancy between [various forms of] the iodine-123. If they gave a *liquid* iodine-123, they got a different timing of uptake than if they gave it as [a] capsule. I established that the

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[87] treatment and observation of living patients, as distinguished from research

[88] ERDA succeeded the AEC in the early '70s, and in turn was replaced by the DOE in 1977.

basis for this was that they weren't getting the proper uptake using capsules because iodine wasn't being absorbed. [The capsule filler] was not dissolving, not being digested. [It was passing through the gastrointestinal tract and being excreted, together with the iodine.]

Dr. Warner said that he liked the way I did things, and they offered me a more permanent job there. So I went back to Brookhaven for a while, but then we negotiated that I would take the job in Rochester. I wasn't ready to retire, and there wasn't any big problem. I was just going to greener pastures.

YUFFEE: Why did you leave the Mayo Clinic [in 1983]?

ROBERTSON: By that time, they had a mandatory retirement at age 65, and I was pushing 65. I didn't want to quit working, because what was I going to do afterwards? So I discussed it with them, and they didn't have an answer. I think they've relaxed [their mandatory-retirement rule] since then, but at that time I was going to retire. So actually, I jumped the gun, a bit less than a year ahead of time. I had asked questions, and a man [from] the FDA [(Food and Drug Administration)], Peter Paris, alerted me that there was a possible opening in the DOE in Nuclear Medicine,[89] and so it sounded like the perfect thing to jump into if I was going to get out of laboratory work and clinical work altogether. So I applied for and got the job here.

YUFFEE: What type of work did you do here?

Joins the Department of Energy (1983)

ROBERTSON: Well, this gets complicated. I was put in charge of what was, at that time, called the Human Health and Assessments Division. The Human Health part involved research support. There were not actual studies [conducted] here, because there was no laboratory. But we'd give grants to researchers in medically related areas, and [at first] this also included epidemiology.[90] There is a big difference between the research in epidemiology and research in chemistry laboratories [on the one hand] and in clinical laboratories that are looking for mechanisms of effects and things in humans [on the other].

The other thing we haven't touched on was the development of this positron[91] detection equipment[92] that I was involved in at Brookhaven,

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89 The Nuclear Medicine Program Office was part of the office of Health and Environmental Research at DOE.

90 the branch of medicine dealing with the statistics of incidence and prevalence of disease in large populations and with detection of the source and cause of epidemics; *also:* the factors contributing to the presence of absence of a disease

91 a particle with the mass of the electron but with a positive electric charge

92 positron emission tomography (PET) scanner—a device that produces computerized three-dimensional images of biochemical activity in the brain or other organ through use of radioactive tracers that emit positrons and twin 0.511-MeV gamma rays; the detectors measured the accompanying 0.511-Mev gamma rays emitted during positron decay.

and then back again in supporting research at the DOE. As part of the human applications, the proposed neutron capture therapy program at Idaho became a big thing. There were other places that were getting support for neutron capture therapy; there were institutions in Boston and Ohio and some others scattered around the country.

I had about 100 research grants, different proposals that were being supported. I would really need a list of them to tell you what we were supporting, but mainly the ones we were doing were pretty directly related to medical applications. Some [were projects] like isotopes development at Los Alamos [National Laboratory]. You'd think Los Alamos[93] would be funded by the chemistry or nuclear reactor physics [programs of DOE], but they were getting money from the medical program for developing and improving the way that they separate medically useful isotopes. They were using a linear accelerator[94] as a way of isotope production.

PILLAI: Do you want to talk about the positron emitter?

ROBERTSON: Well.

PILLAI: You've just mentioned it.

ROBERTSON: Again, to a certain extent, the inspiration for trying to detect positrons came when Gordon Brownell from Massachusetts [Institute of Technology and Mass General Hospital] came and contacted the Medical Department, and we got the Instrumentation Department at Brookhaven in on it, to have a way of scanning with a positron detector.

The advantage of positrons is that you know [that when they collide with electrons] they annihilate, [producing] gamma rays that go 180 degrees apart. So by having two detectors, if something happens in the path in-between them you can localize where the source of activity is better than you can with just straight gamma emission. So, by what is called coincidence counting,[95] [Dr. Brownell] had a pair of detectors that would mechanically move, and he thought that if we could have [several pairs], you could scan more efficiently.

We got into a discussion, and I don't know who actually suggested it—I sort of attribute it to Willie Higginbottom—who was Director of the Instrumentation Division at Brookhaven at the time. He said, "Instead of pairing them, why not have everything look at everything? Coincidences between 'this' and 'this'; and then, somehow or another, you unscramble this data and you get a mapping of this distribution." So that's what we started working on.

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[93] Los Alamos Scientific Laboratory was a key research and development center for the Manhattan Project. Nuclear bombs were assembled there before and during the Cold War. It has been a research and development center for nuclear weapon designs. Renamed Los Alamos National Laboratory, it is now a part of the U.S. Department of Energy, operated by the University of California.

[94] an accelerator that accelerates particles in a straight line, often miles long, instead of in a closed loop

[95] use of a special radiation detector that matches two simultaneous emissions from a single radioactive decay

Then things bogged down, because [at that time we didn't have an adequate mathematical algorithm for reconstructing the activity distribution]. So things sort of lumbered along by approximations and one thing or another, and we developed this [device] that was called the "head shrinker," with many detectors and [associated equipment]. So this was a crude beginning.

Then, later, some people unearthed some image-analysis programs that had been developed in connection with the space program, and these could be applied to what we were doing. They got so, that instead of just using these little scintillation-counter[96] detectors, they're using gamma cameras[97] and doing coincidence counting with gamma cameras. But Brookhaven didn't have too much interest in that aspect of things, and it was developed in other places, in particular at St. Louis [at the Mallinckrodt Institute], and then at UCLA [(University of California at Los Angeles)].

There was the development of using gamma cameras as positron detectors and coincidence counting. Eventually, things developed into where they got real nice, clinically useful pictures. Fortunately, it was developed at other places. Now PET [(positron-emission tomography)] scanning is a well-established procedure.

PILLAI: They are doing PET scanning at Brookhaven now?

ROBERTSON: Well, now they've got gamma cameras, and we've got scans with sophisticated equipment. The early thing that we developed was pretty crude. To a certain extent we could localize, but it's not anywhere near as good as what you get with PET gammas.

Eventually, people developed these image reconstruction procedures and what is called SPECT,[98] single-photon imaging, [which] is very competitive with PET. It's easier to use in a more general situation that doesn't have to be a research laboratory. The isotopes that are involved are easier to obtain than the positron-emitting isotopes. So SPECT is becoming the big thing in general clinical nuclear medicine. Although, there are some places [such as the University of Tennessee at Knoxville] that are doing PET scans on a clinical basis for the patients who aren't [subjects of] research studies; they are doing it as a hospital service.

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96 a device that measures radioactivity by registering the number of scintillations (ionizations of a phosphor struck by a photon or energetic particle) it produces

97 Anger cameras, large, flat circular crystals of thallium-activated sodium iodide, backed with photomultiplier tubes arranged in honeycomb geometry, for obtaining an image of gamma emitting pharmaceutical in the patient; named for its inventor, Hal Anger, of the University of California at Berkeley. The cameras are still widely used in modern nuclear medicine clinics to image gamma-emitting radiopharmaceuticals used in the diagnosis of cancer and other diseases.

98 Single Photon Emission Computed Tomography (SPECT)—a detector system resembling a gamma camera that rotates around a central axis; computer algorithms generate a two-dimensional image by analyzing photon attenuations from a radioactive source material distributed nonuniformity in the patient.

YUFFEE: One of the people that we have talked to, Karl Hubner,[99] has been pretty involved in PET recently.

Work at the Naval Radiological Defense Laboratory (1953–55)

PILLAI: Can we talk a little bit about the [(U.S. Naval)] Radiological Defense Laboratory [near Oakland, Califonia]? You worked there for a while, right?

ROBERTSON: I was there for 18 months.

PILLAI: Were you involved in any research projects there collaborating with the AEC?

ROBERTSON: Before the Marshall Islanders came up, we had teams of people that worked on different things. Ed Alpen was interested in the correlations between thermal injury and radiation injuries in tissues. I actually got mostly closely involved with Stan Cohn, and he was studying strontium metabolism. I participated in studies involving giving rats doses of strontium and studying what happened to it in the body. You mentioned Pat Durbin;[100] she was interested in strontium studies, too, at one time. Did she go into that?

PILLAI: I didn't do that interview.

YUFFEE: I think she did talk about that, because that was one of the things they wanted to ask her.

ROBERTSON: Well, I was interested in tritium, and we did some tritium studies at NRDL.

PILLAI: In what context?

ROBERTSON: You could use tritium to measure total body water. So, under different conditions—again, working with laboratory animals—we measured total body water with tritium. I've forgotten the details now, but there was something we were involved in regarding the relative ability of the stomach to secrete the different halogens. You know it secretes iodine, but then, bromine and other halogens are also affected. I know we were doing studies in that vicinity, but now I don't remember what they were about.

PILLAI: This was all at NRDL?

ROBERTSON: Yes. Unfortunately, after I had left NRDL and gone back to Brookhaven, there were a lot of things going on there that could have been

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[99] For the transcript of the December 30, 1994, interview with Hubner, see DOE/EH-0470, *Human Radiation Studies: Remembering the Early Years; Oral History of Hematologist Karl F. Hubner, M.D.* (September 1995).

[100] From 1951 to 1977, Durbin worked as a chemist and radiobiologist at the Crocker Laboratory of the Lawrence Radiation Laboratory (Lawrence Berkeley Laboratory). For the transcript of the November 11, 1994, interview with Durbin, see DOE/EH-0458, *Human Radiation Studies: Remembering the Early Years; Oral History of Dr. Patricia Wallace Durbin, Ph.D.* (June 1995). Durbin discusses her strontium research in three sections of her interview: "Potential Influences of Monkey Studies in Strontium Metabolism in Humans," "Human Strontium Injection Studies," and "Study of Calcium and Strontium Metabolism in Human Infants."

long-range studies, but they shut the lab down and padlocked the doors. That was it. NRDL was a mixture of military people and civilians. I was, at heart, a civilian, but I was there on a military basis.

YUFFEE: Able to appeal to both sides.

ROBERTSON: In the Navy, you know, we wore black neckties all the time. On St. Patrick's Day, I wore a real dark green one and almost no one noticed it, but Captain [A.] Behnke noticed it.

YUFFEE: Did you get into trouble?

ROBERTSON: No, but he commented, letting me know that I wasn't really getting away with it. Behnke was interested in [finding ways to help Navy frogmen avert the bends while resurfacing from] diving.

PILLAI: Siri worked on the experiments as well, didn't he?

ROBERTSON: Siri was at the Donner Laboratory. He wasn't involved in NRDL, I don't think.

PILLAI: But he was involved in all the tritium studies on body composition, and there were a couple of studies where Behnke and Siri were contacting each other.[101]

ROBERTSON: Well, see, I wasn't really involved at that time. A thing that I *was* involved in with Behnke, as a sort of follow-up thing, was that I knew he was interested in deep sea diving, and I was interested in gas exchange problems. As a Navy Reserve activity, from time to time I had gone from Brookhaven to the submarine base at New London, Connecticut, then Groton[, Connecticut]. While I was up there, the subject of gas exchange in deep sea diving came up.

I developed a computer program for bringing sailors up from a deep sea dive. [The standard procedure is that] they come up in 10-foot stages, and the problem is that while you're decompressing one kind of tissue, at this stage, another is still being exposed and it is still increasing its [nitrogen] content. The slower-turnover tissues are still gaining nitrogen, which is what causes the problem in diving [called] the bends.[102] Well, not just bends: you can get lung embolisms[103] and brain embolisms. But bends are embolisms that affect the joints, and they are very painful, and they get a lot of publicity.

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[101] From 1958 to 1959, scientists at the U.S. Naval Radiological Defense Laboratory and at UC Berkeley's Donner Laboratory collaborated in a study of lean-body weight and skeletal size in humans. The purpose of this study was to determine reference values for normal, healthy individuals. Thirty-one healthy Navy personnel served as subjects for a study of lean-body weight, total-body water, and skeletal size. See LBL-75, "Estimates of Lean-Body Weight and Skeletal Size Using Tritium and X-Rays," in *Human Radiation Experiments Associated with the U.S. Department of Energy and Its Predecessors* (213 pages), DOE/EH-0491, July 1995.

[102] The bends are caused by tiny air bubbles released into tissue by a too-rapid decrease in air pressure after staying in a compressed atmosphere, such as the too-rapid ascent of a diver from deep in the sea to normal atmosphere at sea level. It is potentially fatal.

[103] the blocking of a blood vessel by a clump of tissue, a bubble, fat globule, or other substance that has lodged in a blood vessel

So they use a [breathing] mixture of oxygen and nitrogen and noble gases—argon, in particular—and helium. As you come up, you have to maintain a certain effective pressure of oxygen, and this is why the Navy diving tables [prescribing how fast a diver should ascend] were in these 10-foot stages, so that the relative gas mixture could be readjusted at each level. But in the meantime, while you're getting rid of it in the high-turnover tissues, it's still accumulating in the low-turnover-rate tissues.

The thing that is desirable is to have a continuous way of coming up [rather than have to stop every 10 feet to readjust your breathing mixture]. So in connection with people up there [in Connecticut], I developed a continuous method of coming up from depths on a continuous gas. By "continuous," I mean that you are constantly changing the composition of these mixtures so that the oxygen level can keep [increasing]. By the time you reach the surface you have [the normal air percentage of] 20 percent oxygen, whereas when you are at very high pressures, it may only be one percent, or so, of the mixture. That gives you the equivalent oxygen tension that you get at sea level. So Behnke was the inspiration for being interested in deep sea diving and that sort of thing.

PILLAI: Did you actually test this out on divers, using tritium?

ROBERTSON: Not with tritium. The only place that we could test it was at the Navy research place in the Washington[, D.C.] area [(the Naval Research Laboratory, Bethesda, Maryland)].

PILLAI: So as far as you know, it was never tested?

ROBERTSON: That's right.

PILLAI: Is Behnke an M.D., is he a physician?

ROBERTSON: I think he was a physician. He died, you know, so we can't ask him.

PILLAI: Maybe going back to Brookhaven a little bit: You've mentioned Farr and Dahl. Can you recall other people, like [Eugene] Cronkite?[104] What was his involvement?

ROBERTSON: Dr. Cronkite is a hematologist. I did work with Cronkite. A thing that he got me involved with was effects of radiation on the survival of red blood cells. You asked if we treated leukemia at Brookhaven, and I'd forgotten about this. A possible way of treating leukemia was by what they call extracorporeal irradiation of the blood. So what you tried to do was, you send the blood through this machine that had a radiation source in it. I designed the radiation source for his extracorporeal irradiation machine. The idea was to irradiate the blood so that you'd kill the white cells, which are very susceptible, but then you'd also damage the red cells.

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[104] Eugene P. Cronkite, M.D. (born 1914), a physician and hematologist at the Naval Medical Research Institute (1946–54) and Brookhaven National Laboratory (1954–79). He conducted research on control of hemopoiesis in health and disease conditions.

So to a certain extent, a study that I got involved in was a dose-and-effects [study] on the red cells in connection extracorporeal irradiation. I don't think extracorporeal irradiation ever developed outside of the research laboratory into a treatment for leukemia, but it was an idea.

YUFFEE: Was it tested on humans?

ROBERTSON: Oh, yes.

YUFFEE: Without much success?

ROBERTSON: Well, there was success of a sort, in that it would decrease the lymphocyte[105] population without too much red cell damage. But the thing is, the red cells then are being regenerated at such a rapid rate that it didn't have any permanent effect.

YUFFEE: Were there specific types of leukemia that were treated?

ROBERTSON: I suppose, but I don't remember what they were. They were acute leukemias.[106]

YUFFEE: They were acute as opposed to chronic?[107]

ROBERTSON: As opposed to chronic, yes.

PILLAI: Any other researchers or people that you can think of?

ROBERTSON: Any other people? No.

PILLAI: Or research activities that you can think of that you would like to discuss?

ROBERTSON: *(scanning his* curriculum vitae*)* I've been involved in the MIRD committee. This is the Medical Internal Radiation Dose Committee of the Society of Nuclear Medicine. I just happen to see here (on my *curriculim vitae*) that one of the things that I worked on out there was the dosimetry from internal distribution of iron. Now, however, radioactive iron was used in studying polycythemia and other red-blood-cell–related problems, and iron was used for studies. It has to be fairly big doses of iron to get results.

The question is, are we talking about dangerous concentrations of iron? So, one of my studies for the MIRD Committee was on the radiation doses of the different iron isotopes: iron-52, iron-55, and iron-59[108] as used to study ferrokinetics [(iron transport)]. So, I developed a model for it.

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[105] a type of white blood cell important in the production of antibodies

[106] Acute lymphoblastic leukemia comprises 90 percent of childhood leukemia, but is uncommon in adults. It is manifested by elevated white blood cell counts and blasts in circulation, and causes fatigue, bone pain, bleeding, and easy bruising.

[107] for example, chronic lymphocytic leukemia, an accumulation of immunologically incompetent lymphocytes in the circulatory system, leading to enlarged spleen, fatigue, increased susceptibility to infections, and conversion to high-grade lymphoma

[108] Iron-55 has a half-life of 2.94 years; iron-59, 45.1 days. Unlike iron-55, iron-59 emits beta and gamma radiation.

This gets awfully complicated, because it depends upon what the disease is. [For example,] anemia is entirely different from polycythemia, and the iron kinetics are very different. So, you just can't give one number and say that for a certain amount of activity that you give, the bone marrow, say, is going to get a certain radiation dose, because it depends upon which disease you are talking about. I don't remember all the details to try to discuss it here, but it's in the paper.

PILLAI: So the iron studies are mostly for polycythemia vera, as far as you recall?

ROBERTSON: No, polycythemia is one of the studies that it's used for, but there are other kinds of [blood disease]. There are the anemias. Polycythemia and anemia are the main iron studies in humans.

PILLAI: Were any iron studies done on the nephrotic children?

ROBERTSON: I think we did only sodium and potassium and body water.

Controversial Treatments and the "Crackpot File"

YUFFEE: Can you recall research proposals that you would turn down because you disagreed wholeheartedly with the procedure, as opposed to when you just thought that it needed a bit more refining, that you may have been faced with?

ROBERTSON: Well, if your talking about proposals that people at Brookhaven proposed, no.

YUFFEE: Or other places?

ROBERTSON: Every so often somebody would send me something that somebody had mailed in and say that we ought to do it. For example, one guy from Italy: [his] idea was to make radioactive wires that you could knit into a sort of basket and put that around the tumor, and then he had some way that he thought the radiation would focus in on the tumor. The whole idea was just a little too farfetched, because it's based on the assumption that radiation comes out perpendicular to the surface, so that you shape this thing and have it focused on the tumor. Well, it doesn't work that way at all: [it's a field, so] it goes in all directions. So his basic premises were no good.

So we put things like that in the "Crackpot File." That one came to Brookhaven.

While I was at the DOE, a guy had a more elaborate proposal. This was from a guy who had been trained as an aeronautical engineer, but his grandmother lived in Africa, and she had this African palm oil, which [allegedly] had curative effects for many things. He had a proposal [to study] whether it would protect you against radiation. He had this "very modest proposal" that he wanted us to [support]: he needed palm oil—that was cheap; a fire extinguisher to deliver it; some timers; and then, a "small atomic bomb"!

The idea was that we would set off the bomb; his radiation detectors would detect the radiation, and it would start the timer going, and it would squirt this palm oil onto patients; and then we would see if it protected them from the radiation! This was too much, and so that went into the unfunded files.

But we were talking about proposals at Brookhaven. I don't remember any that were rejected so completely that they were just squelched because they were too crazy or anything like that. No.

YUFFEE: There have been types of treatments used in treating cancer that have caused controversy. We mentioned BNCT that led to a little bit of controversy. The total-body irradiation studies were also controversial.

ROBERTSON: Total-body irradiation studies were done only at Oak Ridge, so far as I know.

YUFFEE: Were you familiar with those?

ROBERTSON: Only to the extent that I reviewed them when I was at the DOE.

YUFFEE: Were you familiar with the history of it down there, from the 1950s through the 1960s, and NASA's involvement?[109]

ROBERTSON: I wouldn't say I'm real familiar with that.

YUFFEE: Do you [have] general thoughts about the notion of low-exposure[-rate] total-body irradiation or medium-exposure[-rate] as a form of treating chronic leukemia?

ROBERTSON: In hindsight, it's not, generally, a good idea. The main thing in some of these things is to get localized radiation. Avoid general body radiation; and I wouldn't lend a whole lot of credibility to whole-body irradiation now. There were some good arguments for it at the time that Lushbaugh did the studies.[110]

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[109] The National Aeronautics and Space Administration (NASA) sought to determine whether astronauts should be protected from the radiation flux in the Van Allen belts and from radiation in space in the event of a highly energetic stellar event (such as a supernova). Such exposures, NASA calculated, would amount to about 1.5 roentgens (R) per hour. Some LETBI patients would receive similar rates of exposure for days at a time, as astronauts might. Accordingly, NASA paid ORINS to report on the effects of such exposure on patients in order to develop techniques that could be used to diagnose whether an astronaut was developing radiation sickness. The funding led to charges that NASA was dictating the exposure rates that the LETBI staff administered to patients. See "NASA Support for LETBI Research" in the Vodopick transcript (DOE/EH-0482, August 1995), and "NASA-Sponsored Studies" and "Questioning the Propriety of NASA-Funded Studies" in the Lushbaugh transcript (DOE/EH-0453, April 1995).

[110] Clarence Lushbaugh directed the Low-Exposure-Rate Total Body Irradiator (LETBI) facility. For contrasting views on the medical ethics of those studies, see DOE/EH-0475, *Human Radiation Studies: Remembering the Early Years; Oral History of Health Physicist Karl Z. Morgan, Ph.D.* (June 1995) and DOE/EH-0453, *Human Radiation Studies: Remembering the Early Years; Oral History of Pathologist Clarence Lushbaugh, M.D.* (April 1995).

YUFFEE: Do you think maybe part of the problem was the poor bone marrow[111] transplantation aspect to it, so that they couldn't regenerate the blood quick enough?[112]

ROBERTSON: I don't think it's worthwhile to do general body irradiation. Theoretically, it would be a way of getting a [knowledge of the] metastatic distribution,[113] where you can't pinpoint every one [(metastasic tumor)]. But I think that the general development of labeled antibodies, if you're going to use radiation, is better than just a broadcast of whole body irradiation.

PILLAI: Were there research activities that did not have proposals or didn't go through the proposals procedure of getting approval in the Human Use Committee? Did all of it go through this process?

ROBERTSON: It was pretty hard to keep secrets in a small place like Brookhaven.

PILLAI: I meant more, as far as, administratively. Was it pretty stringent, as far as everything going through this process for all the research that went on there?

ROBERTSON: I would not say "strict." If anything was being done systematically, it would get attention. But every so often, somebody could sneak in one study or something without an elaborate protocol, and sometimes I know this was done.

PILLAI: Were those studies published?

ROBERTSON: They wouldn't publish it. But out of curiosity, somebody might do some not-totally-authorized experiment. There certainly wasn't very much of that. I did one.

PILLAI: Would you like to tell us about it?

ROBERTSON: We had a patient referred to us at Brookhaven from the Army. He had spent his entire Army career in hospitals. He would come in and say he was feeling awfully sick, and they would measure his blood chemistry. Consistently, when he had these spells, he would be very low on chlorine in the blood. So, he was referred to Brookhaven because Dr. Dahl was interested in some of these electrolytes, and in particular sodium and chlorine. Dahl asked us to get involved.

With radioactive sodium studies, we found that if you gave him salt, he would excrete more sodium than he did chlorine. They were just out of balance. I first got my insight into it at seminar that Dr. Dahl gave, where he presented the results of these studies that showed an inconsistency between intake and output of chlorine. I realize that the main place

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[111] the soft, fatty, vascular tissue in the cavities of bones; it is a major site of blood-cell production.

[112] For a discussion of the Oak Ridge bone-marrow transplant research, see DOE/EH-0453, *Human Radiation Studies: Remembering the Early Years; Oral History of Pathologist Clarence Lushbaugh, M.D.* (April 1995).

[113] relating to metastasis, the spread of disease-producing organisms or of malignant or cancerous cells to other parts of the body by way of the blood or lymphatic vessels or membranous surfaces

in the body where sodium and chlorine are separated was by secretion of chlorine as hydrochloric acid in the stomach.

So actually, with some connivance with Dr. Farr, we rigged up a Geiger counter[114] in the lavatory that this patient would use, and had the nurses keep notes as to when he would go to the lavatory. Dr. Dahl was convinced that this was such a nice guy that he wouldn't be lying to us [about] throwing up, which [is] a way of getting rid of gastric juices. He denied doing any such thing.

What I did was give him a tracer dose of bromine, which is also secreted by the stomach. I don't know why we couldn't use radioactive chlorine, but it was more convenient to use just a little bit of radioactive bromine. So we surreptitiously slipped the bromine to him, had the nurses keep track of when he went to the bathroom, and all of a sudden there was detectable amounts of activity in the trap in the lavatory.

We took this as evidence that he'd caused himself to throw up, and we confronted him. Now, malingering is a court-marshall offense; it's not [just] a medical diagnosis. We had enough on the guy that we sent him back to the Army and told them what was going on. I don't know what became it. It was up to them to determine how to handle it.

YUFFEE: *(smiling)*I never heard of someone trying to throw up their way out of the Army.

ROBERTSON: *(smiling)* I considered this my contribution to medical detective work.

YUFFEE: Was there any question that we didn't ask you, that we should have?

ROBERTSON: I don't know. What else did we get into? For some reason we were involved with Los Alamos in pi meson therapy,[115] but I don't remember enough about that.

YUFFEE: Was this with human subjects?

ROBERTSON: This would have to involve [human] subjects, but I don't know if they ever actually did any in humans. We were looking at the theoretical aspects of it; it was related to the theory that we had for the neutron capture therapy. That is, with neutron capture therapy, you are setting off a little explosion within the tumor. Whereas with pi mesons, the general theory was that the mesons would penetrate—they're very penetrating—but you'd arrange the energy such that at the end of the track, they would react with whatever and give a big dose. Theoretically, that had appeal as a possible potential treatment, but I don't think it ever came to very much.

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[114] a portable instrument for detecting ionizing radiation and measuring dose rate

[115] Pi mesons (or pions) are subatomic particles responsible for the strong interactions between protons and neutrons in atomic nuclei. Mesons occur in pairs, and are liberated during the high-energy bombardment in accelerators. They have very high energy (140 MeV to 10,000 MeV) and are short-lived. Researchers have used pi mesons for cancer therapy with some success. See "Pion Irradiation Therapy at Los Alamos (1974)" in the Voelz transcript (DOE/EH-0454), May 1995. and "Grilly's Comments on Negative Perceptions of Los Alamos and of Radiation Research" in the Julie Langham Grilly transcript (DOE/EH-0469, September 1995).

YUFFEE: I think we've wrapped up all the questions we had for you. We appreciate your taking the time to talk with us. You've been very helpful and it's been really interesting.

PILLAI: It's been very interesting.

ROBERTSON: I should have reviewed my own history to better answer some of these questions.

YUFFEE: It's been a wealth of information, and we appreciate your taking the time talk with us. Thank you.

PILLAI: Thank you very much. ❑