The Role of the Los Alamos Laboratory in the Human Plutonium Injection Experiments, 1944-1947

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Abstract

In 1945-1947, at the end of World War II and the start of the cold war, medical scientists in our Nation's nuclear weapons program secretly injected 18 U. S. citizens with trace amounts of plutonium to study the metabolism of plutonium in the human body. Scientists from the Los Alamos Laboratory (now the Los Alamos National Laboratory) of the University of California played a pioneer role in 12 of the 18 human injection experiments because of their sincere concern for the health and safety of the workers who were fabricating the plutonium parts for the first atomic bombs. Even though these scientists established the elements of a responsible *health and safety ethic* to protect their plutonium workers, they did not extend this *ethic* to the citizens who were secretly injected.

I. Openness Initiative

In November, 1993, *The Albuquerque Tribune* published a Pulitzer Prize winning series of articles (Welsome, 1993) about radiation experiments performed secretly on 18 U. S. citizens -- without their knowledge or informed consent -- in 1945-1947. These experiments, which involved intravenous injections of trace amounts of plutonium into humans, were done by medical researchers of the Manhattan Project to obtain information about the behavior of plutonium in the human body. This information was needed to protect the health of the workers who were fabricating the plutonium parts for the first atomic bombs at the Los Alamos Laboratory in 1945.

Because of the information revealed in the articles of *The Albuquerque Tribune,* Hazel O'Leary, the Secretary of the Department of Energy, launched in December 1993 an "Openness Initiative" to cause the Department of

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* 50th anniversary of the start (October 16, 1945) of the 11 human plutonium experiments at Rochester in the joint Los Alamos/Univ. of Rochester series.

Energy to declassify and release to the public all documents related to these human plutonium experiments (Newsweek, 1993). O'Leary also released preliminary information related to many other human radiation experiments involving hundreds and hundreds of veterans, retarded children, and pregnant women.

The release of this preliminary information caused a flood of news reports concerning the unethical nature of these human experiments, such as lack of informed consent and experimentation on the more vulnerable and disadvantaged members of our society (New Mexican, 1994). Some reporters compared these experiments to the grim medical tests of the Nazis that were disclosed during the Nuremberg war crime trials (Udall, 1994) following World War II. The victims of these experiments were described (Science, 1994) as "nuclear guinea pigs."

On the other hand, some medical and nuclear scientists defended these human experiments as justifiable in the context of World War II and the urgent cold war situation following the war. This urgency "drove investigators to expedite their experiments with humans, even though it meant that 'informed consent' would be abridged . . ." (Rosen, 1994)

As a result of the new Openness Initiative of the Department of Energy, the Los Alamos National Laboratory (LANL) announced on January 10, 1994 the establishment of a Human Studies Project Team (HSPT) that would search for and release to the public copies of all LANL records concerning the human plutonium injection experiments and other human radiation experiments.

This team released a total of 1569 documents between January and November 1994, which included technical reports and papers, memoranda, telegrams, and letters dating from the early days of the Manhattan Project (i.e., 1943) to the present.

Discussions of the health and safety, ethical, and legal issues involving the civilian and military employees who worked with plutonium while fabricating the first atomic bombs at Los Alamos are found throughout the documents released by the HSPT.

Even though most of these documents had been declassified earlier, they were not readily available to members of the public until now. (The fact that a document had been declassified does not mean that its existence becomes known -- i.e., what has been secret tends to remain secret.)

II. The Human Plutonium Injection Experiments

A. The *Health and Safety Ethic of 1945* at Los Alamos

The documents released by the HSPT (and other documents at Los Alamos) show that the scientists at the Los Alamos Laboratory -- and elsewhere within the Army's Manhattan Engineer District (MED) -- understood by 1945 their health and safety, ethical, and legal obligations and responsibilities to their employees who worked with plutonium.

Health and Safety: The development of the atomic bomb during World War II required the processing and handling of kilogram quantities of plutonium, an artificially produced radioactive element that was discovered in 1941. An atomic bomb would contain about 6 to 8 kilograms of plutonium (Serber, 1992; Grace, 1994; Broad, 1994).

The concern over the possible damaging effects of plutonium on humans was first raised in January 1944, 18 months prior to the testing of the first bomb. On January 5, 1944, Glenn Seaborg, who discovered the element plutonium in 1941 and was co-winner of the Nobel prize in chemistry in 1951, wrote a memorandum (HSPT-365) to R. S. Stone, Medical Director of the Metallurgical Laboratory at Chicago, in which he expressed his concerns about possible hazards of plutonium:

> "the physiological hazards of working with plutonium and its compound may be very great. Due to the alpha radiation and long life it may be that the permanent location in the body of even very small amounts, say one milligram or less, may be very harmful. . . In the handling of the relatively large amounts soon to begin here and at Site Y [i.e., Los Alamos], there are many conceivable methods by which amounts of this order might be taken in unless the greatest care is exercised."

The medical researchers of the MED believed that plutonium would metabolize in the human body in a manner similar to radium, which is an extremely toxic natural radioactive material. By the late 1920's, it was known that as little as 2 to 10 micrograms of radium absorbed in the human skeleton was fatal (Evans, 1933, p. 903).

This understanding of the very damaging effects of radium on humans had been obtained from studies of individuals (mostly women) who painted luminous watch and instrument dials using radium from World War I until about 1925. In order to paint the small numerals on dials, the dial painters obtained a fine point on their brushes by drawing the brush between their lips. In doing so, they

swallowed small quantities of luminous paint, which was a mixture of zinc sulfide and enough radium to give the required fluorescence -- about 1 part of radium to 40,000 of paint (Evans, 1933, p. 901). A significant number of the dial painters died of cancer caused by the radium they ingested (Stannard, 1988, Chapter 1).

By studying the tragic deaths of these dial painters -- and other individuals exposed to radium, such as those that took radium "activated" waters for health -- scientists had establish by 1941 that a "safe" tolerance level of radium to humans was 0.1 microgram fixed in the body (Langham, 1945a, p. 2).

On Feb. 11, 1944, J. Robert Oppenheimer, the director of the Los Alamos Laboratory sent a telegram (HSPT-897) to Arthur Compton at Chicago requesting help in understanding the hazards to the workers at Los Alamos who would be fabricating the plutonium components for the first atomic bombs:

> "WE ARE CONCERNED ABOUT IMMEDIATE BIOLOGICAL PROGRAM ON HAZARDS OF FORTY NINE [i.e., plutonium] AS THEY AFFECT PROCEDURES IN THIS LABORATORY. SHOULD LIKE TO HAVE HEMPELMANN DISCUSS PROGRAM AND PROBLEMS WITH HAMILTON UNLESS YOU HAVE OBJECTION TO THIS AND UNLESS THERE ARE OTHER WORKERS OR LABORATORIES WHO WOULD BE MORE APPROPRIATE FOR THE UNDERTAKING. . . WE ARE NOT EQUIPPED FOR BIOLOGICAL EXPERIMENTS."

In this telegram, Oppenheimer mentioned an early policy of his that medical or biological research would not be done at the Los Alamos Laboratory (he changed this policy in August 1944, as explained later in this report). Oppenheimer wanted at Los Alamos only those people who were directly concerned with designing and building the bomb (see HSPT-108). Also, because Los Alamos did not have the hospital facilities for medical research, Oppenheimer felt that any research needed to protect the health of the plutonium workers at Los Alamos would have to be done at medical research hospitals and laboratories elsewhere, such as at Berkeley, Chicago, and Rochester.

Dr. Louis H. Hempelmann, mentioned in the above telegram, was the leader of the Health Group at Los Alamos, and Dr. Joseph Hamilton, also mentioned, was a medical researcher at the Radiation Laboratory of the University of California at Berkeley, who was studying the metabolism and toxicity of plutonium in laboratory animals.

On Feb. 15, 1944, Oppenheimer sent a memorandum (HSPT-880) to General Leslie Groves, head of the MED, expressing his concerns about the hazards due to inhalation of plutonium and requesting approval to allow Hempelmann to consult with Hamilton at Berkeley about the biological research program:

> "SHOULD LIKE AUTHORIZATION TO SEND HEMPELMANN TO BERKELEY FOR CONSULTATION WITH HAMILTON ON BIOLOGICAL RESEARCH PROGRAM ON RADIOACTIVE EFFECTS OF X10 [i.e., Oak Ridge Laboratory] PRODUCTS AND OF POLONIUM. BECAUSE OF THE NATURE OF TESTS WHICH WE WILL BE CARRYING OUT HERE WE ARE PARTICULARLY CONCERNED ABOUT INHALATION OF THESE MATERIALS. I DISCUSSED THE QUESTION OF BIOLOGICAL PROGRAM WITH COMPTON AND STONE, AND THEY RECOMMEND ASKING HAMILTON TO CARRY OUT WORK SPECIFICALLY FOR PROBLEMS OF THIS LABORATORY."

By knowing the tolerance level for radium (i.e., 0.1 microgram), and by studying how plutonium is metabolized in laboratory animals, medical researchers of the MED were able to make reasonable estimates of the tolerance level of the human body to plutonium. By the spring, 1945, the medical researchers at Los Alamos adopted a tolerance level of 1.0 microgram of plutonium (Langham, 1945a, p. 2), which they believed to be a conservative one (Langham, 1945e). In 1950, this level was reduced to 0.5 microgram (LA-1151, p. 9).

Ethics: On Feb. 24, 1944, Cyril S. Smith, leader of the plutonium metallurgy group at Los Alamos, wrote a memorandum to J. W. Kennedy, leader of the plutonium recovery group, about his concerns over the lack of adequate medical insurance coverage for the Los Alamos plutonium workers (HSPT-1558). Copies of this memorandum were sent to Oppenheimer and Hempelmann.

> "Some of the men in the metallurgy group are rather worried over the apparent lack of coverage provided by the standard extra-hazardous insurance policy. This policy . . . provides absolutely no coverage for the real hazard involved in our work, namely radioactive poisoning from inhaled or ingested plutonium, the symptoms of which may be years in developing.
>
> "It seems to me that it is **inhumane, unethical, and unfair** to ask our men to work with a material as hazardous as this unless they are given assurance that their families will not have to bear the expense of prolonged hospitalization, repeated operations, and expensive treatment by physicians at some future time when their connection with the project has ceased. [emphasis added]

> "I would like you to bring this matter before the governing board at their next meeting, and endeavor to obtain some action that will reassure the men and remove any reluctance to handle this very dangerous substance." (HSPT-1558)

The Governing Board was one of two committees (the other was called the Coordinating Council) that were advisory panels (Hoddeson, et. al, 1993, p. 247) to Oppenheimer during World War II. The minutes of the Governing Board meeting of March 23, 1944 indicate that Oppenheimer addressed these concerns about the lack of hazardous insurance coverage:

> "Mr. Oppenheimer reported a new arrangement. The prime contract will contain a clause in which **the government offers to reimburse the university for payments it makes at any time for claims due to injuries during this work.** The clause refers to a secret letter listing the hazards. It is planned to write to the university a letter stating that we understand that **since the university will be reimbursed, it will meet all presumptive claims.** [emphasis added]
>
> "In addition, a broad policy will be available on which the individual will pay the part of the premium covering normal hazards, and the government the part covering special hazards." (Governing Board, 1944, p. 2)

Even though this Feb. 24, 1944 memo of Smith is the only document released by the HSPT that explicitly mentions ethics, it clearly indicates that senior Los Alamos scientists (such as Smith, Kennedy, Hempelmann, Oppenheimer, and others on the Governing Board) had a keen understanding that it would be unethical to expose individuals to plutonium without keeping track of their health in the future and without providing medical treatment when necessary.

Legal: In April, 1946, Hempelmann wrote a report, *History of the Health Group (A-6), March 1943-November 1945,* in which he indicated that the primary function of the health group was "protecting personnel against the unusual hazards of this project (HSPT-105, p. 1)," and

> "**The secondary function of the Health Group has been the protection of the legal interests of (a) the individual on this project (including those not involved in hazardous work) and (b) of the contractor** (1) by keeping records of hazards, exposures, accidents, tests for overexposure to the various toxic agents, etc. and (2) by obtaining pre-employment examinations on all employees and (3) by taking histories and performing complete examinations (including all

necessary tests) on every person leaving the project." (HSPT-105, p. 2) [emphasis added]

References are also made to "medico-legal" issues in several other HSPT documents (e.g., Langham, 1945e; HSPT-559).

The above examples found in the documents released by the HSPT indicate that senior scientists at the Los Alamos Laboratory had a clear understanding in 1944-1945 of the health and safety, ethical, and legal obligations of the Laboratory to its employees (both civilian and military) who worked with plutonium. A summary of these obligations, which can be thought of as the *health and safety ethic of 1945,* includes:

1. Ensure that exposures to the plutonium workers are kept below the conservative tolerance standard of 1.0 microgram of plutonium in the body,

2. Protect the legal interests of the plutonium workers (and the Laboratory) by keeping accurate exposure and medical records,

3. Follow the health of the plutonium workers in the future and provide medical treatment for any adverse health effects caused by the exposure to plutonium.

It is thus clear from the documents released by the HSPT that by 1945 the scientists at Los Alamos understood and adopted a very responsible *health and safety ethic* for their workers who were exposed to plutonium (and also for workers exposed to other forms of radiation and other hazards).

B. Reasons for Biological Research at Los Alamos

Even though Oppenheimer originally did not want medical or biological research done at Los Alamos because he wanted only personnel at Los Alamos who would be directly involved in designing and building the bomb, he did authorized the start of a medical and biological research program in August 1944. His reasons for approving this research are found in the HSPT documents and are described below:

By August 1944, workers at Los Alamos had become alarmed about the potential hazards of working with plutonium because of an accident involving the explosion (chemical, not nuclear) of ten milligrams of plutonium in an employee's face, and about the lack of a method of detecting plutonium in the

human body. On August 16, 1944 Hempelmann wrote Oppenheimer (HSPT-174):

> "**A great deal of concern has been expressed during the past two weeks by members of the Chemistry Division about the inability of the Medical Group to detect dangerous amounts of plutonium in the body.** This concern was occasioned by the accidental explosion of 10 milligrams of plutonium in Don Mastick's face with the subsequent ingestion of an unknown amount of this material. [emphasis added]
>
> "The present medical knowledge of the hazards of plutonium is derived entirely from tracer studies of the metabolism of this element in the rat and from calculation of tissue ionization produced by alpha radiation. Interpretation of Dr. Hamilton's data on rats in terms of humans indicates that 50-100 micrograms of plutonium in the skeletal system is the lethal dose. . . Dangerous amounts of plutonium in the body should be detectable by finding plutonium in the excreta. . . As yet no satisfactory method of assaying excreta has been devised. . .
>
> "[W]e have discussed the advisability of giving a higher priority to the medical problems related to plutonium. . . It seemed to us that the following medical problems are the ones to which answers are urgently needed:
>
> "1. Development of methods of detection of plutonium in the excreta.
> "2. **Determination of the factor by which the amount of plutonium in the excreta must be multiplied to ascertain the amount in the body** [emphasis added].
> "3. Development of methods of detection of plutonium in the lung.
> "4. Further and more complete animal experimentation."

In explaining the urgent medical problem stated in item (2.) above -- determination of the factor by which the amount of plutonium in the excreta must be multiplied to establish the amount in the body -- Hempelmann comes very close to suggesting a human experiment, but he does not explicitly state it. It is hard to imagine how this factor could be obtained other than through experiments on human beings.

Hempelmann wrote a history of the Health Group in April 1946, and in this history he explained the reason that Los Alamos started its own biological research program in August 1944 was because it was not getting the help it

needed from medical and biological research laboratories located elsewhere (HSPT-105):

> "The original policy of this project toward biologic and physics research related to health problems required us to depend entirely on information gained from health research groups elsewhere. As it became obvious that reliance on other research groups did not always give us the proper data in time to establish safe operating procedures . . . in August of 1944 . . . biologic research was started by a section of the Health Group.
>
> "In August 1944 following an accident in which a number of milligrams of plutonium blew up in the face of Donald F. Mastick, dissatisfaction was expressed by the members of CM Division and by the Health Group with the progress of biological research on the toxicology on plutonium at other projects. Accordingly, permission was obtained from Mr. Oppenheimer to undertake a research program of our own to study biological problems of special interest to this project . . . **The research program was aimed primarily at developing tests for detecting overdosage of personnel with plutonium.** A satisfactory test for determining the amount of plutonium excreted daily in the urine was difficult to develop because of the small quantities of plutonium excreted from the body . . . A successful method of analyzing urine was developed in January 1945 but could not be used as a routine test for overexposure of personnel until a contamination free laboratory (ML building) was ready for use in February 1945. . . **It was not until the first human tracer experiment had been performed in April 1945 (with the help of the medical section of the Manhattan district) that the above tests could be evaluated with any degree of certainty.** [emphasis added]
>
> "In addition to urine assays on exposed personnel, **the biochemical section of the health group undertook human tracer experiments and certain animal studies to help evaluate the above test.**" [emphasis added] (HSPT-105, pp. 2-8)

These reasons for starting the medical or biological research program were also discussed in a 1948 document (HSPT-1560) by Dr. T. L. Shipman, who became the leader of the Health Division at Los Alamos in January 1949:

> "During the war there was no intention that Los Alamos should ever become a permanent installation. Los Alamos Scientific Laboratory, moreover, had but a single objective, namely, to develop an atomic weapon suitable for use by the military establishment at the earliest

possible moment. Excellent medical care was provided by Army physicians, but little attempt could be made to build up organizations concerned with industrial hygiene and similar refinements. For these reasons no attempt of any sort was made to establish a program of biomedical research, even though the presence in Los Alamos of an outstanding group of physicists, chemists, and other top ranking scientists, together with their equipment, made this a very logical place to carry out some experimental programs in the fields of biology and medicine.

"At first there was actually a feeling on the part of the Laboratory's director that such experimental programs should not be carried out at Los Alamos. It was assumed that laboratories in Chicago, Berkeley and elsewhere could easily do whatever research chores might become necessary along with the rest of their work. Perhaps fortunately, this proved to be fallacious. It was realized from the outset that a number of workers at Los Alamos would be engaged in handling plutonium in one form or another. Methods had to be developed quickly for establishing permissible concentrations of this material in air, of carrying out air sampling procedures, and of **determining in some way the amount of this material which a worker might actually have taken into his system. Laboratories in other parts of the country did not seem to be too interested in providing the answers.** [emphasis added]

"There were a number of reasons for this lack of interest. In the first place, the other laboratories already had work of their own which they felt was just as important as anything else. In the second place, the cloak of secrecy which surrounded the work at Los Alamos during the war years made it well nigh impossible to communicate to other laboratories the sense of urgency, or even some of the basic facts. Because of the difficulty of getting the necessary information from other sources, Dr. Louis H. Hempelmann persuaded Dr. Oppenheimer to let him assign some chemists from the Los Alamos staff to this very essential work. The answers were forthcoming in short order, and the newly devised methods were put to work eight months before any other laboratory was prepared to commit itself on the subject. **This was the birth of biomedical research at Los Alamos, and from this small beginning has grown an organization with just cause for pride in its accomplishments.** [emphasis added]

"It should be borne in mind that the situation just described existed in the war years of 1944 and 1945." (HSPT-1560, pp. 1-2)

Shipman repeated these arguments in September 1949 in a letter (HSPT-1504) to Dr. Shields Warren, Director, Division of Biology and Medicine of the Atomic Energy Commission (AEC):

> "Actually the original plan for carrying out these activities [medical and biological research] was that the work should be done in other existing Laboratories. This was tried and found to be unsatisfactory. The principal difficulty was that other Laboratories were working on a set program which could not repeatedly be interrupted. In addition, work which was completed at other Laboratories did not always yield itself to the purposes which were desired at Los Alamos. **Gradually, therefore, and of necessity, Los Alamos was forced into rolling up its sleeves and doing the work right here.** This arrangement has shown itself to be most satisfactory and has received the commendation of all who have given the matter careful consideration. [emphasis added]
>
> "The Medical Research laboratory here in Los Alamos **has done the pioneer work in studies of the toxicity and toxicology of plutonium, polonium, americium, tritium, and other materials.** It has worked out methods and techniques whereby workers handling these materials may be more adequately safeguarded." [emphasis added] (HSPT-1504, pp. 1 and 2)

In a 1958 report, *Human Experiences with Plutonium* (HSPT-618), Wright H. Langham of Los Alamos explained why the medical researchers at Los Alamos and other laboratories initiated the human plutonium injection experiments:

> "[I]n the fall of 1944, radiobiologists at the Metallurgical Laboratory of Chicago, the Crocker Laboratory of the University of California, and the Los Alamos Scientific Laboratory reported that small amounts of plutonium, like radium, produced osteogenic sarcoma in experimental animals. These findings made it imperative that the psysiology and toxicology of plutonium in man be investigated. **In the spring of 1945, the Los Alamos, California, and Chicago groups initiated studies in terminal human patients to determine whether small doses of plutonium were acutely toxic and to establish the urinary excretion rate to provide a more accurate base line from which to determine the body burden of exposed workers.** The plutonium was administered intravenously. In all, **15 cases were studied, the majority of them through arrangements with the Los Alamos group."** (HSPT-618, p. 3) [emphasis added]

In a 1972 journal article Langham reiterated that human tracer experiments were initiated by Los Alamos, Chicago, and Berkeley laboratories to establish the human urinary excretion rate (Langham, 1972, p. 947):

> "By the first of March 1945, urine assays were being applied both at Chicago and Los Alamos in attempts to estimate exposure of personnel to plutonium. Body burden was estimated on the assumption that the excretion rate in man was the same as that for the rat and rabbit and, at about 20 days after exposure, reached a steady state at 0.01% of the body burden per 24 hr. **In April, tracer studies in hopelessly ill subjects were initiated through both the Chicago and Los Alamos laboratories (and a little later at the Radiation Laboratory at Berkeley) to establish the human urinary excretion rate.**" [emphasis added]

It is very clear from the above examples written by senior Los Alamos medical researchers Hempelmann, Shipman, and Langham (1) that the researchers at the Los Alamos Laboratory felt they had to get involved in medical and biological research because they were not getting the help they needed from other research laboratories and (2) that they played a major role -- in parallel with other research laboratories -- in the human plutonium injection experiments. These human injection experiments were necessary to help the researchers understand the metabolism of plutonium in the human body so they could protect the health of the plutonium workers. It is also clear that the Los Alamos medical researchers recognized their pioneer role in these experiments and took considerable pride in their technical achievements.

C. Need for Experiments on Humans

On August 16, 1944, Oppenheimer responded (HSPT-176) to Hempelmann's concerns (i.e., HSPT- 174) about the lack of appropriate biological information by authorizing health related research at Los Alamos:

> "In answer to your memorandum on the health hazards of plutonium and in confirmation of our conversation, I should like herewith to authorize you to undertake two programs: (a) the development of methods of detection of plutonium in the excreta; (b) the development of methods of detection of plutonium in the lung.
>
> "We both agree that if this program is to be effective it must be prosecuted with rather high priority.

> "As for the biological sides of the work, which may involve animal or **even human experimentation**, I feel that it is desirable if these can in any way be handled elsewhere not to undertake them here." [emphasis added]

This is the earliest mention in the information released by the HSPT of the possibility of plutonium experiments on humans.

Oppenheimer's desire of doing the human experiments somewhere other than Los Alamos comes from his concern that "we are not equipped for biological experiments (HSPT-897)" -- probably because of the lack of adequate medical facilities and personnel at Los Alamos in 1944 and because he did not want people at Los Alamos who were not directly contributing to building the bomb. For example, for a nostalgic speech in 1969, Shipman wrote (HSPT-108, p. 5):

> "To understand what was going on in those days [i.e., World War II] we must keep in mind the facts that we were operating under a wartime philosophy and that all 'services' were provided by the military. Robert Oppenheimer wanted no one on his staff who wasn't contributing directly to attaining the Laboratory's single goal. He did not want, for example, anyone engaging in biological research. If chores of that sort were needed, they could be provided by other institutions such as the University of Chicago. It was not until 1944 that Dr. Hempelmann prevailed on him to approve the assignment of a very small group to studying the problems arising from exposures to plutonium."

In response to Oppenheimer's memorandum of August 16, 1944, which authorized biomedical research, Hempelmann immediately started the research program. In a memorandum (HSPT-177) dated August 23, 1944, probably written by Hempelmann, but the name of the author is obliterated by declassification markings of 1959, the author writes:

> "Following Dr. Oppenheimer's directive of 16 August 1944, we have launched upon the two programs mentioned therein:
>
> "a. The development of methods of detection of plutonium in the excreta.
> "b. The development of methods of detection of plutonium in the lung."

On August 29, 1944, Hempelmann summarized the directions and goals of this new medical research program at Los Alamos for Oppenheimer (HSPT-178):

"Colonel Warren has suggested that I summarize the biological research program which was agreed upon in our conference with you and Mr. Kennedy on 25 August 1944. This program which will be pursued with a relatively high priority will consist of three parts:

"1. **The development of chemical methods of determining plutonium in the excreta** and in tissues and of ionization methods of detecting plutonium in the lungs. [emphasis added]

"2. Animal experimentation to check the methods described above.

"3. Tracer experiments on humans to determine the percentage of plutonium excreted daily. [emphasis added]

"When satisfactory analytical methods have been developed in this laboratory the problem of carrying out further metabolic studies will be turned over to another medical group, presumably the Rochester group."

Col. Warren, mentioned in this summary, was Dr. Stafford L. Warren, who was Chief of the Medical Section of the MED, Oak Ridge. Mr. J. W. Kennedy was head of the plutonium recovery group at Los Alamos.

Thus, by the end of August, 1944, tracer experiments on humans with plutonium had become a priority for the Los Alamos Laboratory, and these experiments would be carried out at medical facilities outside Los Alamos. As mentioned above, the human experiments were needed to allow medical scientists to calculate the amount of plutonium in the bodies of the plutonium workers from measurements of the amount of plutonium found in their urine.

The term "tracer" in the context of the proposed human experiments in the above memorandum suggests the use of small amounts of plutonium -- large enough to allow the experiments to be done adequately, but small enough to put the individuals in as low a risk as practical.

On December 2, 1944, Col. Warren, wrote a memorandum to file (HSPT-373) summarizing responsibilities and priorities in the overall MED experimental medical program on plutonium:

"The following data are urgently needed in order to get for the M.E.D. operating program which is based on something more than the present assumptions and calculations:

"a. An acute (within 30 days) LD 50 for radium and product following a single intravenous injection in rats (to be done by Dr. Cole of the Chicago Area, and Dr. Bale of the Rochester Area).

"b. The establishment of the ratios of blood level to urine and fecal excretion following a single intravenous injection of radium and product [i.e., plutonium] in rats (Dr. Cole, Dr. Bale, Dr. Hamilton (tracer) and Dr. Hempelmann.)

"**c. Tracer experiments on humans like b. above so that the comparison . . . can be made between the rat data and human data** (Dr. Bale, **Dr. Hempelmann**, and Dr. Cole)." [emphasis added]

In addition, in this memorandum, Col. Warren also emphasized that a "correlation of all these data should be made and a practical working tolerance level set as soon as possible (March 1945)." This date of March 1945 for the completion of the correlation of all the data and setting a tolerance level for humans to plutonium was important because kilogram quantities of plutonium would begin to become available from the nuclear production reactors at Hanford, Washington for fabrication at Los Alamos into bomb components by the spring, 1945.

Dr. Bale, mentioned in the above memorandum, was a medical researcher at the University of Chicago, and Dr. Cole was a researcher at Rochester. It is clear from this memorandum that Hempelmann of Los Alamos is a major player in the tracer experiments on humans using plutonium.

D. The First Human Injection Experiment (Los Alamos/Oak Ridge)

On March 26, 1945, Hempelmann wrote Oppenheimer (HSPT-188) a memorandum summarizing a meeting on March 23, 1945 with Lt. Col. Hymer Friedell, MED, Oak Ridge, who was a deputy to Col. Warren, to discuss the medical concerns associated with the handling of plutonium at Los Alamos. Los Alamos requested the following help from the MED:

"The Manhattan District is asked to help make arrangements for **a human tracer experiment to determine the percentage of plutonium excreted daily in the urine and feces.** It is suggested that **a hospital patient at either Rochester or Chicago** be chosen for injection of from one to ten micrograms of material and that **the excreta be sent to this laboratory for analysis.**" [emphasis added]

In addition, Hempelmann also expresses in this memorandum his desire that Los Alamos establish a more satisfactory relationship "with the Medical Program of the Manhattan District so that the facilities of the Manhattan District be available for the solution of our problems."

Three days later, on March 29, 1945, Oppenheimer wrote to Col. Warren (HSPT-189) at MED, Oak Ridge, and endorsed the requests to Lt. Col. Friedell detailed by Hempelmann in the above memorandum:

> "We are inclosing (sic) a record of discussions held here a few days ago during the visit of Colonel Friedell.
>
> "**I should like to add my personal indorsement** (sic) **to the requests outlined in the accompanying memorandum**. We all have the feeling that at the present time the hazards of workers at Site Y [i.e., Los Alamos] are probably very much more serious than those at any other branch of the Project, and that it would be appropriate that the medical program of the Manhattan District consider some of our problems rather more intensively than they have in the past. [emphasis added]
>
> "I believe that the order of priority outlined in the accompanying memorandum is a wise one. Although we would have some ideas of how to pursue all of the topics mentioned, **we have, as you know, neither the personnel nor the facilities which would be involved in this.** [emphasis added]
>
> "It was our impression that if other workers on the medical program were better informed about what was important from our point of view they would probably be glad to help us out."

It is clear from this letter that Oppenheimer supports the need for the tracer experiments on humans, and he is also not happy about the lack of help Los Alamos has been getting from the medical program of the MED.

The reasons why Los Alamos medical researchers needed to understand the metabolism of plutonium in humans were repeated by Langham in May 1945 (HSPT-206, p. 27):

> "The primary interest of our health department is the immediate development of a method of monitoring personnel for internal body contamination with plutonium. The obvious purpose of a monitoring plan is to enable us to retire individuals from further contact with the material before they have absorbed harmful amounts. The execution of such a plan depends on the establishment of a number of factors among which are the following:
>
> > "1) The development of a method of determining exceedingly small amounts of plutonium in some body fluid or excrement;

> "2) **The establishment of the relationship between the body fluid or excrement and the amount of plutonium contained in the human body**; [emphasis added]
>
> "3) The development of a sampling system which excludes the possibility of external contamination of the sample."

Los Alamos researchers devoted much effort to understanding these three factors, all of which were needed to protect the health of the plutonium workers. The second factor is, of course, the one that led to the human experiments. In addition, Los Alamos medical researchers -- as well as other researchers in the MED -- devoted significant effort in establishing a reasonable estimate for the tolerance level of plutonium in humans (i.e., 1.0 microgram).

On April 4, 1945, less than a week after Oppenheimer endorsed the human injection experiment, Langham sent Lt. Col. Friedell (1) a vial containing 5 milligrams of plutonium for the experiment and (2) detailed directions for preparing the plutonium solution, procedures for injecting the patient, and instructions for collecting the urine and feces samples. Langham wrote (Langham, 1945c):

> "The enclosed vial contains approximately 5 milligrams of 49 plus 4 nitrate. If the following directions for preparing the solution are carried out it will give the desired amount (5 gamma) of 49 in 0.25 ml. of solution. . .
>
> "Using a Tuberculin Syringe inject exactly 0.25 ml. (5 micrograms) of the complex solution. . .
>
> "Submit the remainder of the 25 ml. of citrate solution for 49 assay by plating directly and taking an alpha count. Save the remainder of both the stock solution and the citrate complex solution and return them to this site for further assay. . .
>
> "Collect and bottle each voiding of urine separately for the first 36 hour period. After 36 hours collect 24 hour specimens; bottle in a suitable glass container; seal carefully; pack and ship to this site. . . If it is possible to collect feces samples collect each stooling separately during the first 36 hours; place in a Mason fruit jar; preserve with 40% formaldehyde; pack and ship. . . Collections should continue for the next 30 days."

Two days later, on April 6, 1945, Langham sent Lt. Col. Friedell additional directions for performing the first human injection experiment (Langham, 1945d):

> "Although we sent you directions for the 49 experiment along with the material we feel that we should write you more detail. . .
>
> "The point about which I am most concerned is the calibration of the Tuberculin syringe in order that we will know actually how much 49 the subject did get from the injection. My experience has been that a syringe always delivers 5-10% less than indicated by the graduations. There is also the problem of 49 absorption by ground glass surfaces. It seems to me the best way to overcome these difficulties is to calibrate the syringe against the 49 solution itself.
>
> "This is how I would like to see it done. . ."

And Langham continues with detailed instructions on how to establish the amount of plutonium that was injected into the patient. He further states:

> "After the injection and assayings are complete, please return both the stock solution and the remainder of your injecting solution to this site and I will have both re-assayed as a check.
>
> "Please call me if you would like to have more detail on any phase of the experiment."

On April 10, 1945, which is less than two weeks after Oppenheimer had endorsed Hempelmann's request for a human tracer experiment and less than a week after Langham had sent the vial of plutonium and instructions to Lt. Col. Friedell, the first human plutonium tracer experiment was initiated at the U. S. Army's Manhattan Engineer District Hospital in Oak Ridge, Tenn.

Dr. Joseph W. Howland, who did the actual injection of the plutonium solution into the first patient, was interviewed in 1974 about this experiment. Howland was an army medical doctor at the time and reported directly to Lt. Col. Friedell. A summary of the interview with Howland stated that (Weyzen, 1974):

> "In April 1945, a patient . . . was admitted to the Oak Ridge Hospital with multiple fractures resulting from an automobile accident. Dr. Hymer Friedell informed Dr. Howland that he considered the patient to be a suitable candidate for the human plutonium experiment. Dr. Howland indicated that he did not agree with Dr. Friedell. Subsequently, Friedell

ordered Dr. Howland to inject the patient with plutonium. Howland complies after receiving a written military form stating that he (Friedell) ordered Howland to inject the patient.

"Dr. Howland emphatically stated that no consent was obtained from the patient at any time . . ."

This patient was injected intravenously with 4.7 microgram of plutonium, which was about five times larger than the tolerance level for plutonium workers at Los Alamos at that time (i.e., 1.0 microgram).

The purpose of this experiment was to determine the "relation between the amount of plutonium in the human system and that excreted in the urine per 24 hours (HSPT- 206, pp. 28-29)." Excreta (urinary and fecal) were collected from this individual for a period of 58 days (HSPT-013, or LA-1151, or HP-1980).

On April 11, 1945, the day after the injection, Lt. Col. Friedell wrote Hempelmann (Friedell, 1945a):

"Inclosed (sic) is a protocol of the clinical experiment as we intend to carry it out. A copy of this was inclosed (sic) with the material which we sent back for Mr. Langham's analyses. **Everything went very smoothly, and I think that we will have some very valuable information for you.** We will try to get the specimens back as soon as we can, but it is likely they will be returned regularly about once a week. [emphasis added]

"I think that we will have access to considerable clinical material here, and we hope to do a number of subjects. At such time as we line up several patients I think we will make an effort to have Mr. Langham here to review our setup." [emphasis added]

The single page "Protocol of Clinical Experiment" that was attached to this letter summarized the procedures used by the physicians at Oak Ridge in (1) preparing and injecting the plutonium solution, (2) collecting the specimens of urine and feces, and (3) shipping the samples. This protocol closely followed the directions written by Langham on April 4 and April 6, 1945. The protocol also noted how the injection was done:

"The left median cubital vein of subject was entered with a sterile 20 gauge needle and the 0.25 cc of P 49 injected. Care was taken to avoid any leakage."

The results for the first 18 days of this human experiment were reported by Langham at the Conference on Plutonium, held May 14 -15, 1945 (two months before the first atomic bomb test at Alamogordo) in Chicago (HSPT- 206, p. 29):

> "The subject was an elderly male [53 years old] whose age and general health was such that there is little or no possibility that the injection can have any effect on the normal course of his life. The patient might not have been an ideal subject in that his kidney function may not have been completely normal at the time of injection as indicated by slight albuminuria and a low urine specific gravity."

At this conference, Langham reports a preliminary relationship between the amount of plutonium in the 24 hour excretion (urine) rate of humans and the total amount of plutonium in the body (HSPT- 206, p. 29):

> "the leveling off point seems to be about 0.02 per cent . . ."

A copy of the original graph showing the daily measured excretion rate as given by Langham in the report of the Conference on Plutonium (HSPT-206, p. 33) is shown in Fig. 1. The identity of the human patient is given in Fig. 1 as "E. C." In all other documents related to the human plutonium experiments, this patient is identified as "HP-12."

The identity of this patient was established by *The Albuquerque Tribune* in the spring of 1994. He was Ebeneezer Cade, who had been injured in a head-on traffic accident (Albq. Journal, 1994). Cade died of natural causes (heart failure) in April 1953 -- eight years after the injection.

By measuring the amount of plutonium in the urine, the medical researchers could then estimate the amount of plutonium in the human body. Langham established that the human excretes about 0.02%, or 1/5000, of the plutonium contained in the body each day. This number was the conversion factor that was so desperately needed to protect the plutonium workers at Los Alamos. This conversion factor was soon changed to 0.01% per day (Langham, 1945a, p. 2), and eventually (i.e., 1950) described by a mathematical expression that related the urinary excretion rate to the time in days after exposure (HSPT-013).

Following this Conference on Plutonium, Langham wrote a letter to Lt. Col. Friedell on May 21, 1945 in which he discussed the urgent need for additional

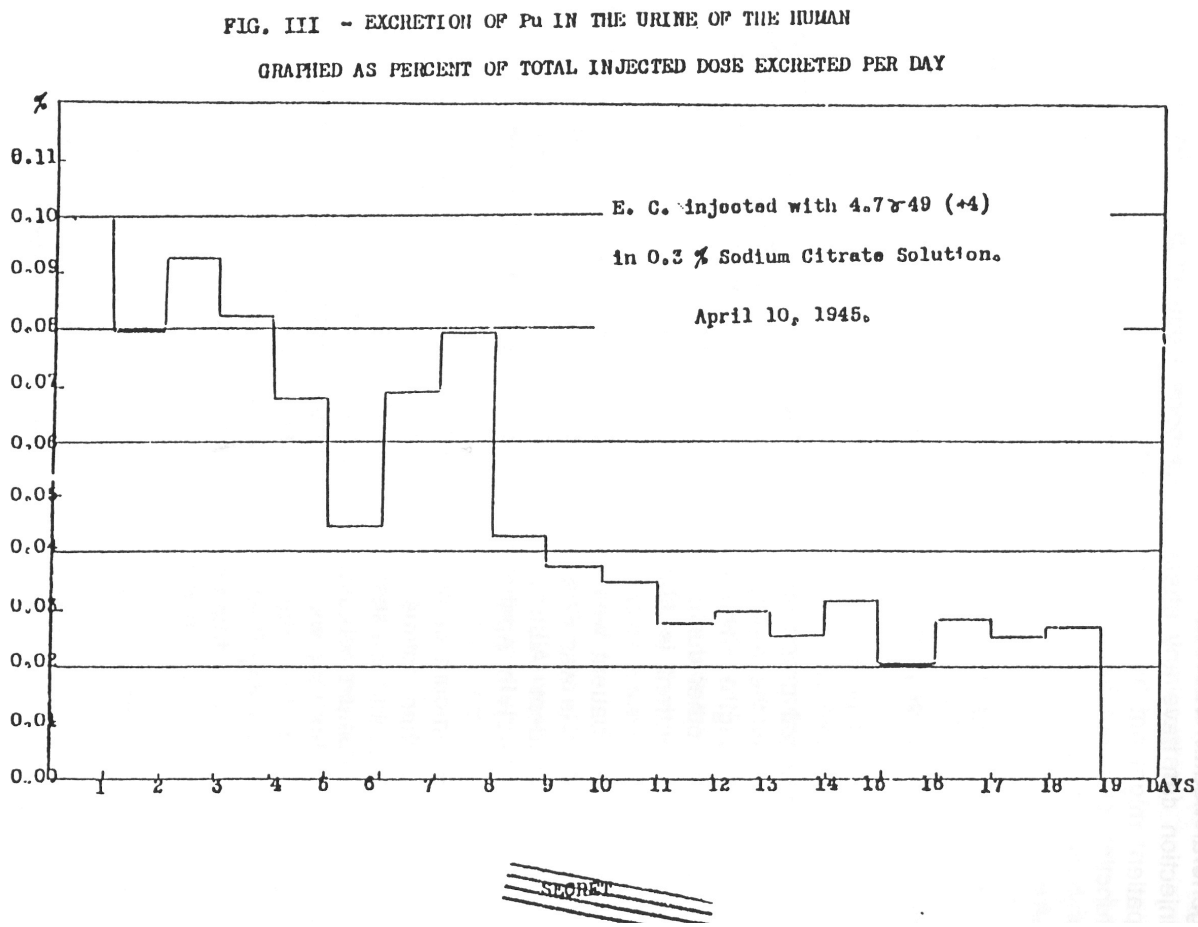

Fig. 1. The measured excretion rate of plutonium from the first human experiment. The vertical axis is the percent of the amount of plutonium in the individual's body that is excreted in urine per day. This is a copy of the original graph given by Langham at the Conference on Plutonium in Chicago, May 15-16, 1945.

human experiments to establish "an accurate, unquestionable method of monitoring personnel." Langham wrote (Langham, 1945e):

> "Since the Chicago Meeting, I am somewhat lost as to what our program should be in the future. I am still sure however, that our primary concern here should be, (1) to establish an accurate anunquestionable method of monitoring our personnel and proceed to do so as fast and as often as facilities will permit, (2) to adopt a conservative arbitrary limit for the maximum tolerance dose and remove all people from further contact with material when they have reached that limit. I favor adopting one microgram as this limit. I agree with you that this is probably much too low. The urgent need however, for a working basis and the failure of the Chicago Meeting to establish a limit seems to make it imperative that we adopt a conservative value and go ahead. I think it quite likely that further work on the part of other groups will eventually establish a legal tolerance limit of at least one microgram. If in the meantime we have consistently retired personnel below the limit eventually established, the medico-legal aspect will have been taken care of and of still greater importance, we will have taken a relatively small chance of poisoning someone in case the material proves to be more toxic than one would normally expect.
>
> "In order that we may establish an accurate, unquestionable method of monitoring personnel, I feel we should arrange to do the following:
>
> "1. Repeat our human study carefully on an individual whose kidney function has been established as normal beyond question.
>
> "2. Inject two other individuals; one with 5 gamma of uncomplexed plus 4 product and the other with uncomplexed plus 6. (an ideal setup would be to try plus 3 also)"

Langham also described two series of experiments with rats that he would like to see done to "substantiate our recent work showing that the percent of an injected dose excreted per day is independent of the size of the dose" and to "establish whether or not the excretion and metabolism of a set amount of product [plutonium] is the same when administered by a single or by multiple injections."

In addition, Langham discussed the need to continue collecting urine samples from Ebeneezer Cade:

> "Continue to collect 24 hour urine samples from [Cade] - collecting on every third day as long as he is available in order to, (a) test whether or not one is justified in extrapolating the excretion time curve and, (b) to give us actual samples with which to try to develop a simpler method of assaying."

Langham also suggests that if further human experiments are done, he would like to send a Los Alamos employee to Oak Ridge to supervise the experiments:

> "In keeping with a suggestion that I made to Lt. Howland and Lt. Goldring, in case we do continue with human studies I would like to have Miss Ann Perley of our group go to Oak Ridge to help you. She is one of the most capable and industrious workers I have ever worked with. She has had 14 years experience in hospital laboratory work, much of it in studying kidney function and metabolism. She could supervise the collecting of samples and do the laboratory tests of kidney function and the clinical chemistry. She has worked with Lt. Goldring and I am sure he shares my opinion of her."

On June 2, 1945, Lt. Col. Friedell responded to the letter from Langham (Friedell, 1945b):

> "In reference to your letter of 21 May 1945 addressed to Lt. Col. Friedell of this office, the following comments are pertinent. The program submitted has been discussed in detail and the following conclusions reached.
>
> "In reference to Item 1. in your letter **it is planned to repeat two additional studies on humans,** using the complexed plus 4 citrate as submitted by you. **Careful kidney function tests will be conducted prior to the injection of product.** Sufficient spacing will be planned between experiments to avoid burdening of your laboratory facilities. . . [emphasis added]
>
> "The present program on [Cade] will be carried out as planned."

A second human plutonium experiment (identified as "CHI-1") -- which did not involve Los Alamos -- was started by medical researchers at the University of Chicago on April 26, 1945, and the results were also presented at the Conference on Plutonium in Chicago by E. R. Russell (HSPT-206, pp. 34-45). This patient was injected with 6.5 micrograms of plutonium. The daily urinary excretion rate of plutonium found in this experiment was similar to that found in the first experiment reported by Langham.

A third injection experiment ("CAL-1") -- which also did not involve Los Alamos -- was started at the University of California Hospital at San Francisco on May 14, 1945 (Crowley, 1946).

These three human plutonium injection experiments (i.e., Los Alamos/Oak Ridge, Chicago, San Francisco) were the only ones done before the test of the first atomic bomb, "The Gadget" -- which was a plutonium bomb -- at Alamogordo, NM on July 16, 1945, and the Hiroshima (uranium bomb) and Nagasaki (plutonium bomb) bombings on August 6 and August 9, 1945, respectively.

E. The Joint Los Alamos/University of Rochester Experiments

Additional human injection experiments were not done at Oak Ridge as suggested in the above letters by Langham and Lt. Col. Friedell. However, two months after the end of the war with Japan, a series of human plutonium injection experiments (HSPT-013, p. 10) began on October 16, 1945 in a "joint project of the Los Alamos Scientific Laboratory of the University of California and the Atomic Energy Project of the University of Rochester School of Medicine and Dentistry." Eleven more human injection experiments were done -- cases identified as "HP-1" through "HP-11" -- in this joint Los Alamos/Rochester project.

The injection experiment done earlier on Ebeneezer Cade at Oak Ridge was considered to be a part of this joint Los Alamos/Rochester experimental series, and it was given the identification, "HP-12." Thus, a total of 12 experiments were done in the joint project -- 11 at Rochester and one at Oak Ridge. The final experiment in this joint project began on July 16, 1946 (HSPT-013, p. 15), and the patient was followed for 30 days.

Wright Langham of Los Alamos and Dr. Samuel H. Bassett of Rochester were the principal investigators of this joint project.

The joint nature of these experiments was described by Langham in the "Revised Plan of 'Product' Part of Rochester Experiment" (Langham, 1945b). In the introduction to this 18 page detailed experimental plan for the human experiments, which would be done at the medical school of the University of Rochester, Langham writes:

> "At the request of Col. S[tafford L.]. Warren a meeting was held in Rochester, N.Y., Sept. 5, 1945, to work out a detailed plan for a 'product' tracer study. **The study is to be a cooperative work between the**

> Rochester and Santa Fe Groups. This report is the revised plan resulting from the meeting. . . [emphasis added]
>
> "The plan is by no means set. It is merely a result of the meeting in Rochester and of numerous conversations with Col. Warren, Col. Friedell, and Dr. L. H. Hempelmann. The plan is subject to change by any of the persons concerned.
>
> "Much of the responsibility for details falls entirely upon the Rochester group. These details are not given in this report."

Langham explains that the purpose of the human injection experiments to be done at Rochester was to:

> "establish on a statistical number of subjects the relationships existing among such factors as the amount of product in the body, the level of product in the blood, the amount excreted in the urine, the amount excreted in the feces, and the variations of the above with time. This information will greatly increase our knowledge of the metabolism by the human of this hazardous and important material. It will also afford us a statistical basis for diagnosing body internal contamination from the analysis of urine or feces, the obvious purpose of which is to retire workers before they have received harmful amounts of the material." (Langham, 1945b, pp. 1-2)

The "Revised Plan" written by Langham indicates the plutonium solution to be injected into the patients will be supplied by Los Alamos (i.e., the Santa Fe Group):

> "At the close of the control period each subject is to receive a single intravenous injection of 'product'. The next 24 days after the injection will constitute the experimental period. . .
>
> "The stock [plutonium] solution will be prepared at Santa Fe by W. Langham. . .
>
> "The solution to be injected is to be prepared by Dr. Fink [of the University of Rochester]. . .
>
> "Trial preparations of this solution will be made at Santa Fe before the stock solution is sent to Rochester. These trial solutions will be assayed for 'product' and the pH will be determined. It would seem desirable to make such trial dilutions and tests at Rochester before the preparation of

> the actual injection solution. Enough stock solution will be sent to allow for such trials.
>
> "The injections are to be performed by the Rochester group. Col. Warren proposed Lt. Valentine as the one to do the injections. Dr. Fink is to be present at all injections to supervise the calibration tests . . ." (Langham, 1945b, pp. 5-7)

A draft of the final report of the joint Los Alamos/Rochester project confirms that the plutonium solution was actually provided by Los Alamos (Rochester, n.d., p. 5):

> "The standard solution of Pu for use in human tracer studies was obtained from Dr. Wright Langham of Los Alamos and consisted of 5 mg of Pu as nitrate dissolved in 2N-NHO_3, valence +4. The material was received in a volume of one ml in a sealed glass ampoule."

In the "Revised Plan," Langham mentions that the Rochester Group can make any "clinical chemistry tests" on the patients that "are of interest to the Rochester Group (Langham, 1945b, p. 8)," but "No chemical investigations should be proposed which will interfere with the delivery of urine and feces samples to the Santa Fe group." (Langham, 1945b, p. 9)

Even though Langham gives very detailed information about how the human injection experiments are to be done, he is silent in the "Revised Plan" about informing the patients of the nature of the experiments or obtaining their consent. He is also silent about the importance of follow-up checks on the patients to see if they have developed any long-term health problems from the plutonium.

On February 18, 1947, Dr. Andrew H. Dowdy, Director, Manhattan Department -- who was in charge of the Rochester Atomic Energy Project, MED (and AEC), and had been deputy to Stafford Warren, chief medical officer of MED (Marks, 1974, p. 6) -- wrote a letter to Norris E. Bradbury, the new director of the Los Alamos Scientific Laboratory, about the distribution of the technical report of the joint Los Alamos/Rochester project. In his letter Dowdy writes:

> "Dr. Wright Langham and Dr. Samuel Bassett were discussing with me today the technical details relative to writing the report of the cooperative study which has been carried out at Los Alamos and at Rochester under their direction. . .

> "There is one limitation which I should like to impose on the report which will emanate from the Los Alamos Laboratory and that is that it not be declassified for general distribution outside the Atomic Energy Commission without our foreknowledge. **I make this suggestion because of possible unfavorable public relations and in an attempt to protect Dr. Bassett from any possible legal entanglements. . ."** (Dowdy, 1947) [emphasis added]

Dowdy's concerns about (1) unfavorable public relations and (2) legal liabilities suggest reasons -- in addition to (or other than) national security -- why the final report of the Los Alamos/Rochester project (LA-1151) was classified.

All of the human experiments in the joint Los Alamos/Rochester project were done using injections of 4.6 to 6.5 micrograms of plutonium (HSPT-013, p. 15), which were about five times larger than the human tolerance standard of the time of 1.0 microgram. However, there was discussion between Langham and Bassett of doing a human experiment using a much larger dose, particularly 50 micrograms, which would be 50 times larger than the tolerance standard.

In a letter to Bassett, dated March 13, 1946, Langham writes (Langham, 1946):

> "In case you should decide to do another terminal case, I suggest you use 50 micrograms instead of 5. This would permit the analysis of much smaller samples and would make my work considerably easier. I have just received word that Chicago is performing two terminal experiments using 95 micrograms each. I feel reasonably certain there would be no harm in using the larger amounts of material if you are sure the case is a terminal one."

Langham's mention in this letter of the "terminal case" refers to the injection experiment on the patient identified as "HP-11," who lived for only 6 days after the injection.

Bassett responds to Langham's suggestion of a 50 microgram injection experiment on March 17, 1946 (Bassett, 1946):

> "The larger doses that you mention, particularly 50 micrograms, might be given if a suitable opportunity occurred and if you are very anxious that I should carry it through, I will see what can be done."

Langham and Bassett never initiated this larger dose experiment.

The final results of the joint Los Alamos/Rochester experiments were published in 1950 in a classified Los Alamos Scientific Laboratory report (LA-1151). Langham and Bassett were the principal authors of this report.

F. Additional Chicago and San Francisco Experiments

Two more human injection experiments were done at Chicago, and two more at San Francisco (HSPT-011), for a grand total of 18 experiments.

The final human experiment began on July 18, 1947 at the University of California Hospital in San Francisco on a 36 year old man, who had bone cancer in his left knee. Trace amounts of plutonium were injected into his left leg, and the leg was later amputated to keep the bone cancer from spreading. There is a handwritten record of informed consent of this patient (CHR, 1977; Welsome, 1993, p. 29):

> "The experimental nature of the intramuscular injection of the radioactive tracer sample was explained to the patient, who agreed on the procedure. The pat. was in fully oriented and in sane mind."

The record was signed by the three medical doctors and the nurse that assisted in the injection procedure, but not by the patient. This is the only record of informed consent in the 18 human experiments.

This patient lived for 44 years after the injection, to the age of 80.

In addition to these 18 intravenous injection experiments, six individuals orally ingested plutonium solutions in an experiment at the University of Chicago on May 13, 1946 (Russell, 1946):

> "In order that one might gain some idea as to the rate of intestinal elimination, it was thought advisable to conduct experiments with humans whereby approximately 400 alpha c/m were ingested and the elimination rate followed."

G. AEC Guidance on Human Experiments in 1947

On January 1, 1947 the responsibilities of the Army's Manhattan Engineer District were transferred (Lilienthal, 1964, pp. 126-127) to the new civilian Atomic Energy Commission (AEC).

Dr. Stafford L. Warren, who had been the Chief of the Medical Section of the MED, became chairman of an Interim Medical Advisory Board of the AEC, which

was chartered "to resurvey the medical research programs now being conducted, and to determine which programs and budgets should be kept active in order to safeguard the interests of the Atomic Energy Commission during this interim period." (HSPT-559)

In a letter of April 7, 1947 to Carroll L. Wilson, who was the General Manager of the new AEC, Warren outlined the research priorities of this Interim Medical Advisory Board (HSPT-559):

> "The priority for the research in the university laboratories and in certain sites [e.g., Los Alamos] has been carefully weighed and is based upon the urgency of the need for information, the number of people probably exposed, the probability of great toxicity resulting from an occasional exposure, and the apparent helplesness (sic) of our therapeutic armamentarium in the presence of a definite injury."

Warren recommends that the AEC should fund medical research projects at five universities, including the University of Rochester, and also at the Los Alamos site:

> "The extend of the medical and health physics research program at Los Alamos is controlled by special and local problems of vital interest to the area, and is strongly recommended."

Wilson responded to Warren's recommendations on April 30, 1947. In his letter he describes new procedures which the medical researchers must follow when obtaining medical data on humans (HSPT-560):

> "**It is understood that your Committee has recommended a program for obtaining medical data of interest to the Commission in the course of treatment of patients, which may involve clinical testing.** The Commission wishes to make clear to your Committee its understanding of the program which is being approved. The Commission understands that in the course of the approved program: [emphasis added]
>
> > "a. **treatment (which may involve clinical testing) will be administered to a patient only when there is expectation that it may have therapeutic effect;** [emphases added]
> >
> > "b. the decision as to the advisability of the treatment will be made by the doctor concerned.

"The commission does not intend to influence in any way the exercise of judgment by the doctor as to the administration of any particular treatment authorised (sic) under the approved program. Indeed, from the discussion at the meeting of April 3-5, it seemed to me that doctors would not allow their judgment on this matter to be influenced by anyone.

"In any such clinical testing, the Commission continues to request that the same procedure be followed which was agreed upon early in March. That procedure contemplated that it should be susceptible of proof from official records that, **prior to treatment, each individual patient, being in an understanding state of mind, was clearly informed of the nature of the treatment and its possible effects, and expressed his willingness to receive the treatment.** In view of your recommendation, the Commission does not request that written releases be obtained in such cases, but it does request that in every case at least two doctors should certify in writing (made part of an official record) to the patient's understanding state of mind, to the explanation furnished him, and to his willingness to accept the treatment." [emphasis added]

Thus, by early 1947 the new Atomic Energy Commission (1) had approved human experimentation only for cases that involve treatment for therapeutic reasons and (2) required that the patients be informed of the nature of the treatment before treatment began. These new procedures came out only nine months after the completion of the final human injection experiment in the joint Los Alamos/Rochester project, which began on July 16, 1946.

H. Follow Up on the Rochester Patients

Even though the patients in the Los Alamos/Rochester experiments were selected "such that survival for ten years was highly improbable" (HSPT-618), five of the 12 patients lived for more than 10 years (see Table I) after the injections. Six of these patients were still alive in 1952 when Hempelmann began his study of the long-term health of 27 of the Los Alamos plutonium workers (discussed later in this report) -- a study that continues today.

Table I. History of the Los Alamos/Rochester patients
(Welsome, 1993, pp. 24-25; LA-1151, Table 6, p. 24)

Patient I.D.	Injection date	Observation period (days)	Date of death
HP-1	Oct. 16, 1945	25	Jan. 12, 1960
HP-2	Oct. 23, 1945	34	April 4, 1948

HP-3	Nov. 27, 1945	23	Jan. 24, 1983
HP-4	Nov. 27, 1945	27	April 29, 1947
HP-5	Nov. 30, 1945	22	April 29, 1946
HP-6	Feb. 1, 1946	22	May 6, 1984
HP-7	Feb. 8, 1946	37	Oct. 27, 1946
HP-8	March 9, 1946	65	Nov. 22, 1975
HP-9	April 3, 1946	36	July 2, 1947
HP-10	July 16, 1946	30	June 2, 1957
HP-11	Feb. 20, 1946	(no urine data)	Feb. 26, 1946
HP-12	April 10, 1945	58	April 13, 1953

J. Newell Stannard, author of the massive 2000 page book, *Radioactivity and Health: A History,* commented about the survival of the "terminally ill" patients (Stannard, 1988, p. 350) used in the human injection experiments:

> "Since most patients were selected because they had a short life expectancy, some died moderately soon, and tissue samples were analyzed as were excreta. Others lived for many years, even long enough to cast doubt on the validity of the original medical opinion or to confirm the resiliency of the human organism."

In 1958 -- 12 years after the injections -- Langham and Harris of Los Alamos reported on the status of the Los Alamos/Rochester patients (HSPT-618, Table I). However, their report contained many errors. For example, they incorrectly believed that both HP-1 and HP-6, who were still alive in 1958, had died within 5 years of their injections, and that HP-12 might still be alive, but he had actually died in 1953. They indicated that the "deaths" of both HP-1 and HP-6 were "unrelated to Pu exposure." (HSPT-618, Table I)

In a 1962 journal article, the Los Alamos medical researchers summarized Los Alamos' experience with plutonium in man (Langham, 1962). In this article, the authors studied 16 of the 18 patients who had been injected with plutonium in 1945-1947, which included the 12 in the joint Los Alamos/Rochester project, the three in the Chicago experiments, and one in the San Francisco experiments (see LA-1151, p. 24). The Los Alamos authors incorrectly stated that:

> "many of them [the patients] died within 30 days **(only three lived the full 138-day observation period), which seriously limited the period of observation.**" (Langham, 1958, p. 755) [emphasis added]

In fact, 11 of the 12 patients in the Los Alamos/Rochester experiments lived more than 138 days (HP-11 -- the "terminal case" -- died in 6 days), as can be seen from Table I. In addition, three of the four patients in the Chicago and San Francisco experiments also lived more than 138 days (Welsome, 1993, pp. 24-25). As shown in Table I, the observation periods (i.e., the lengths of time excretion samples were obtained) of the Los Alamos/Rochester patients ranged from 22 to 65 days, whereas the observation periods of two of the Chicago patients and the San Francisco patient did extend to 138 days (see LA-1151, p. 25). The observation periods of the Los Alamos/Rochester patients were thus not limited by early deaths, as stated by the Los Alamos medical researchers.

It thus appears that the Los Alamos researchers neither kept accurate track of what had happened to the Los Alamos/Rochester patients nor carefully followed their medical conditions. Apparently Los Alamos' interest in these patients was short term only; i.e., to obtain information to be able "to retire [the Los Alamos plutonium] workers before they have received harmful amounts of the material." (Langham, 1945b, pp. 1-2)

Three of the Los Alamos/Rochester patients (HP-3, HP-6, HP-8) and one of the San Francisco patients were still alive in the late 1960's when their existence was "rediscovered" by a medical researcher at the Lawrence Berkeley Laboratory (Durbin, 1969).

In March, 1946, while the joint Los Alamos/Rochester human experiments were still in progress, Langham stressed the need for longer observation periods, i.e., longer than the 24 days suggested in the "Revised Plan" (Langham, 1945b). In a letter to Bassett on March 13, 1946, Langham wrote (Langham, 1946):

> "The work here is coming along nicely. I went over some of our data with our medical physicist. We tried to extrapolate our excretion curves and derive a mathematical expression for calculating the amount of material remaining in the body at ten and fifteen years. **He was alarmed and disappointed that we had not followed the excretion further in each case.** It is his opinion that the result should be followed to 244 days in order that an accurate mathematical interpretation can be made. **This emphasizes to me the necessity of our trying to get each patient back into the hospital for an occasional study if it is possible from your point of view."** [emphases added]

However, as can be seen from Table I, most of the patients in the joint Los Alamos/Rochester project were actually followed for less than 37 days, and two were followed longer (58 days and 65 days).

In 1950, Langham did try to get additional urine samples from the surviving patients to strengthen the analysis for the final report of the joint Los Alamos/Rochester project (LA-1151) -- a report that he characterized as going to "be the last word on the plutonium situation (HSPT-868)." On March 20, 1950, Langham wrote (HSPT-867):

> "I have spent the last three months working over all of the human excretion data available. It looks as if the half-time of excretion of plutonium is of the order of hundreds of years and the excretion curve seems to be composed of a number of exponentials. The excretion constants of three of the exponentials can be determined from the data available. Undoubtedly a fourth exponential exists and represents the excretion rate from the major body storage of plutonium. **It is highly important that we get a few results at the end of a very long time in order that we may determine the excretion constant for this fourth storage depot. I think this is sufficiently important that we should spare no effort to obtain additional samples.**" [emphasis added]

The final report of the joint Los Alamos/Rochester project -- *Distribution and Excretion of Plutonium Administered Intravenously to Man* -- was issued on September 20, 1950 as the Los Alamos Scientific Laboratory report LA-1151. Langham and Bassett were the primary authors.

On October 2, 1950 Langham sent Dr. Joseph W. Howland (now at the University of Rochester) his suggestions on how to obtain addition medical data and urine samples from two of the Los Alamos/Rochester patients (Langham, 1950):

> "I am very glad to hear that you will manage to get follow-ups on the two subjects. **The x-rays seem to be the all important thing, but please get them in a completely routine manner. Do not make the examination look unusual in any way.** [emphasis added]
>
> "Judging from the recent observations that Robley Evans has made, a generalized osteitis with rarefaction of the bones of the feet, the jaw and the heads of the long bones with coarsening of the trabeculae are the most likely symptoms.
>
> "I think we might as well dispense with the idea of collecting any more fecal samples since their content is below our present methods of detection. We do, however, need three or four urine samples on both of them."

Langham's recommendation in this letter that the x-rays of these patients be obtained "in a completely routine manner" and that Howland should "not make the examination look unusual in any way" suggests he was colluding with Howland in keeping the nature of the experiments secret from the patients.

Langham eventually got additional urine samples (HSPT-013) from two of the Los Alamos/Rochester patients (HP-3 and HP-6); however, it is not clear if he made much use of this data (HSPT-046).

Apparently, these were the last urine samples obtained from any of the patients involved in the human plutonium experiments until the surviving few were rediscovered (Durbin, 1969) in the late 1960's and remeasured (Rundo, 1979) in the 1970's.

In the mid-1970's, nearly 30 years after the secret injections, the AEC did follow up on the four patients that were still alive (three from the joint Los Alamos/Rochester project; i.e., HP-3, HP-6, HP-8) to inform them of the details of the experiments. In addition, the bodies of a few of the patients that had died (HP-4, HP-9) were exhumed for autoradiographic studies of plutonium distribution in bone (Welsome, 1993, pp. 24-25, 44-45).

Because of their failure to follow up on the Los Alamos/Rochester patients, it is obvious that the Los Alamos medical researchers failed to acquire important long-term scientific information.

I. Follow Up on the Los Alamos Plutonium Workers

Even though there was little or no follow up on the health of the Los Alamos/Rochester patients, the medical researchers at Los Alamos have consistently followed for decades the health of the workers that were exposed to plutonium during the construction of atomic bombs at Los Alamos during World War II.

In December 1952, the AEC funded a project for Hempelmann (who was then at the University of Rochester) to periodically conduct long-term medical examinations of the Los Alamos plutonium workers who had "absorbed significant amounts of plutonium in the past (HSPT-397, p. 1)." The project was administered by the University of Rochester with the Los Alamos Scientific Laboratory participating in the project (LA-1537). The purpose of the study was "to collect additional information to support the choice of a maximum permissible dose of plutonium." Examinations have been conducted every few

years from 1953 until the present (Hempelmann, 1973; Voelz, 1979; Voelz, 1985; Voelz, 1991).

In the *Los Alamos Health Division Progress Report, May 20-June 20, 1953* (HSPT-397), a summary of the results of the first examinations of these men was reported:

> "Dr. Hempelmann has now completed the survey of those past and present Laboratory workers who are known or assumed to have absorbed significant amounts of plutonium in the past. There are 27 individuals in the entire group . . . All of the exposures occurred in the 1945-46 period. Dr. Hempelmann's report has not yet been completed but it can be stated with assurance that every individual in the group studied is in normal good health without evidence of injury from the plutonium. . . The study unquestionably should be repeated in a slightly streamlined form every two or three years. The body burdens of plutonium involved in these cases are of the general order of 0.5 to 1.0 micrograms." (HSPT-397, pp. 1-2)

The *Annual Report of the Biomedical Research Group* for 1952 (LA-1537, pp. 8-9) indicates that three of the plutonium workers had amounts of plutonium in their bodies (i.e., body burden) in excess of 1.0 microgram (ranging from 1.2 to 1.3 micrograms), three had 1.0 micrograms, and 21 were below 1.0 microgram (ranging from 0.1 to 0.8 micrograms).

These early estimates of body burdens are about five to 50 times lower than the amounts in the bodies of the 12 patients injected with plutonium in the joint Los Alamos/Rochester experiments (which also includes the Oak Ridge patient, Ebeneezer Cade).

Later medical examinations on these plutonium workers indicated that some body burdens were higher and some were lower than those determined in the first examination in 1953. In 1977, the estimates ranged from 0.1 to 3.8 micrograms.

No adverse health effects have been found in these men because of their exposures to plutonium:

> "the mortality experience of these Pu-exposed men has not been excessive for the first 42 y after exposure. Periodic clinical examinations have not revealed findings that are unusual or unexpected for men in their age group." (Voelz, 1991, p. 187).

19 of these men were still alive in 1995 (Voelz, 1995).

The Los Alamos medical researchers have stressed the importance of following the health of the plutonium workers (HSPT-679; Voelz, 1991, p. 181). They have also demonstrated their personal concern and interest in these men. In a report issued in 1973, which summarized the results of the 27-year study of these plutonium workers, the Los Alamos researchers said:

> "[I]t is worthwhile to point our that there is concern and interest for these subjects [i.e., the Los Alamos plutonium workers] even though many years have passed since they worked with plutonium." (Hempelmann, 1973, p. 29)

These researchers also noted in this report that because Langham personally cared for the Los Alamos plutonium workers, he organized an exclusive "club" -- called the "UPPU Club" -- for them. Membership in this exclusive club was limited to those "whose eligibility requirements could only be met by the early, heavily-exposed plutonium workers (Atom, 1973, p. 5)." Langham, who was known "as one of the if not *the* world's authority on plutonium biochemistry and toxicity" (Hempelmann, 1973, p. iii), was intensely concerned about the toxicity of plutonium in humans, and

> "he organized the UPPU club composed of the subjects of this study. He kept in close touch with the Club members by periodic circulation of friendly UPPU Newsletters. It was undoubtedly the humor and enthusiasm expressed in these Newsletters that has been responsible for the excellent cooperation of the UPPU Club members in this study." (Hempelmann, 1973, p. iii)

Photographs of Hempelmann (and the other authors of the 27-year study) and Langham at a social event with members of the UPPU Club, who were in Los Alamos in 1972 for medical examinations, are shown in the April 1973 issue of *The Atom,* which was a monthly magazine for families of employees of the Los Alamos Scientific Laboratory (Atom, 1973, pp. 4-5).

Unfortunately, similar care, concern, periodic medical examinations, and UPPU Club membership were not extended to the surviving patients in the joint Los Alamos/Rochester project (or the patients at Chicago and San Francisco) -- who had higher exposures than the Los Alamos plutonium workers and who never knew they had been used as subjects in the injection experiments.

In 1950, Hempelmann, who initiated the follow-up studies on the Los Alamos plutonium workers (e.g., Hempelmann, 1973), became a professor of

experimental radiology at the University of Rochester and also became a consultant to the Los Alamos Scientific Laboratory. Oddly, he made no follow-up studies on the surviving Los Alamos/Rochester patients even though he was involved in 1945 in planning the joint Los Alamos/ Rochester project (Langham, 1945b) and was associated with both research institutions for several decades. Six of the patients were still alive in 1952 (see Table I) when the long-term study of the plutonium workers began, and three were still alive in the early 1970's when the 27-year follow-up study of the Los Alamos plutonium workers was done.

III. Discussion

A review of the documents released by the Human Studies Project Team reveals that Los Alamos Laboratory research scientists played a pioneer role in the studies of the metabolism of plutonium in humans. The 12 human plutonium injection experiments done in 1945-1946 as a joint project between the Los Alamos Laboratory and the University of Rochester were a critical part of these studies. The medical researchers at Los Alamos believed it was only through such experiments on humans that the "factor by which the amount of plutonium in the excreta must be multiplied to ascertain the amount in the body" (HSPT-174) could be obtained.

The medical researchers at Los Alamos took responsibility for the metabolic studies only after other research institutions failed to provide, in a timely manner, the information needed to protect the health of the plutonium workers at Los Alamos who were fabricating the components for the first atomic bombs. J. Robert Oppenheimer, director of the Los Alamos Laboratory, approved biomedical research at Los Alamos in August 1944 (HSPT-176). The human experiments were done at research hospitals outside of Los Alamos because Los Alamos did not have the medical "personnel nor the facilities which would be involved in this." (HSPT-189)

The Los Alamos medical researchers (1) initiating the first human injection experiment "with the help of the medical section of the Manhattan district" (HSPT-105, p. 8), (2) jointly participated with the University of Rochester in eleven more human experiments (HSPT-013), supplied the plutonium for the 12 experiments (Langham, 1945c; Rochester, n.d., p. 5) in the joint Los Alamos/Rochester project, and (4) took pride in their pioneer role and accomplishments (HSPT-1560, p. 2).

The documents indicate that the 12 patients in the joint Los Alamos/ Rochester project were unaware they had been used in these injection experiments (Durbin, 1971; Weyzen, 1974); i.e., no consent was obtained from the patients.

The medical researchers at Los Alamos in 1944-1945 had a keen understanding of their health and safety, ethical, and legal obligations to the civilian and military employees who worked with plutonium. These obligations, which can be thought of as the elements of a mature *health and safety ethic of 1945,* include:

1. Ensure that exposures of the plutonium workers are kept below the conservative tolerance standard of 1.0 microgram of plutonium in the body,

2. Protect the legal interests of the plutonium workers (and the Laboratory) by keeping accurate exposure and medical records,

3. Follow the health of the plutonium workers in the future and provide medical treatment for any adverse health effects caused by the exposure to plutonium.

The Los Alamos medical researchers did established a conservative tolerance standard (1.0 microgram) and were successful in keeping the exposures of the 27 plutonium workers at levels that were near or below this standard. In addition, the Los Alamos researchers have followed the health of these workers for the past 50 years. No adverse health effects have been found (19 are still alive in 1995).

What is missing in the documentation, however, is any mention or suggestion that the *health and safety ethic,* which applied to the Los Alamos plutonium workers, should also be extended to the surviving patients of the joint Los Alamos/Rochester injection experiments.

The Los Alamos researchers neither kept accurate track of what had happened to the Los Alamos/Rochester patients nor carefully followed their medical conditions. Los Alamos' interest in these patients was short term only; i.e., to obtain information to be able "to retire [the Los Alamos plutonium] workers before they have received harmful amounts of the material." (Langham, 1945b, pp. 1-2)

Also, because of their failure to follow up on the Los Alamos/Rochester patients, the Los Alamos medical researchers lost the opportunity to obtain important long-term scientific information about these patients.

The reason for the failure of Los Alamos, Rochester, and Manhattan Engineer District medical researchers to extend the *health and safety ethic* to the surviving patients is unclear.

Because the patients in the joint Los Alamos/Rochester project lived near Rochester, New York (or Oak Ridge) rather than Los Alamos, New Mexico does not relieve the Los Alamos researchers of their obligations to these patients. The documents -- for example, Langham's detailed "Revised Plan" for the experiments at Rochester (Langham, 1945b) or his directions for the experiment at Oak Ridge (Langham, 1945c,d) -- show that the Los Alamos medical researchers had significant influence and control over the scientific and technical aspects of the experiments at both Rochester and Oak Ridge, but they were silent about the ethical and legal aspects.

Only one of the joint Los Alamos/Rochester human injection experiments (i.e., the Oak Ridge experiment done on Ebeneezer Cade) was done before the end of World War II, and thus the national security concerns would be quite different for the remaining 11 experiments done at Rochester. As early as June, 1947 -- less than a year after the completion of the joint Los Alamos/Rochester human injection experiments -- Los Alamos medical researchers wrote articles, which were published in the open literature, that described methods of determining the amount of plutonium in urine and feces (Carritt, 1947; Maxwell, 1948). The connection of plutonium with human excreta was thus not secret by mid-1947.

The letter (Dowdy, 1947) from Dr. Andrew H. Dowdy, Rochester Atomic Energy Project (AEC), to Norris E. Bradbury, the new director of the Los Alamos Scientific Laboratory, in February 1947 requesting that Los Alamos not declassify the joint Langham/Bassett authored technical report (LA-1151) without informing Rochester because of "possible unfavorable public relations" and "to protect Dr. Bassett from any possible legal entanglements" perhaps provides insight into why the surviving patients were treated differently from the Los Alamos plutonium workers.

Thus, concerns over unfavorable public relations and legal liabilities, rather than national security, may have governed why the Los Alamos/ Rochester patients were never told they had been used in the injection experiments and why the *health and safety ethic* was not extended to them.

However, because the Los Alamos plutonium workers knew they were working with plutonium, they were in a position to speak of their concerns. And the medical researchers took steps (HSPT-1558) to "reassure the men and remove any reluctance to handle this very dangerous substance."

The Los Alamos/Rochester patients, on the other hand, did not know they had been injected with plutonium, and this fact was kept secret from them.

Sadly, no one spoke for them.

IV. Epilogue

In December 1971, Dr. Patricia W. Durbin of the Lawrence Berkeley Laboratory, the researcher who had rediscovered in the late 1960's the existence of the few surviving patients, talked to Wright Langham at Los Alamos about the importance of obtaining urine samples from these survivors more than 25 years after the injections. Below are excerpts from a summary of her discussion with Langham (Durbin, 1971):

> "Dr. Wright Langham of the Los Alamos Scientific Laboratory was the biochemist who performed the Pu analyses of the excreta and other samples obtained from the first Pu-injected person, HP-12. . . [He also] analysed (sic) the samples from the 11 HP series cases studied at Rochester. It was a joint effort and involved many people. Classification (prolonged) and the passage of many years before even classified publication of the findings led to his eventual responsibility for analysis and publication of the results. **He is, I believe, distressed by this and other aspects of the study itself -- particularly the fact that the injected people in the HP series were unaware that they were the subjects of an experiment**. . . Dr. Langham has been associated in the minds of many in the radiation protection field with only this one aspect of the subject, and the study itself has been associated with the Los Alamos Laboratory. I believe he grew very weary of attending meetings and conferences at which he was expected to discuss this material over and over again. **I also believe that in retrospect he wishes that there had been some other way to obtain the needed relationship between Pu excretion and body burden**. [emphasis added]
>
> "I had a long telephone conversation with Dr. Langham . . . and [he] wants to have some fraction of any excretion samples that can be obtained [from the surviving patients]. . . He said that if such material were available, the Los Alamos group would be interested in participating, but that **they did not want to be directly responsible nor in direct**

contact with whomever was actually obtaining samples. [emphasis added]

"Over the years since 1951 when the report of the original findings was issued as LA-1151, no one has suggested follow-up most likely because 'that was Wright Langham's study'. . . I wrote to him for help in clearing up some questionable details. . . He always encouraged me . . . and indicated that he felt someone should undertake the effort . . . **but he did not wish to be responsible for locating it.** I think this sums up the matter, although my prose can hardly do justice to what are obviously deeply held doubts about the study itself and to my strong impression that **he justifiably resents the pervasive influence on his whole professional life of Pu in general and the human study in particular.**" [emphasis added]

Less than six months after this discussion with Durbin, Wright Langham was killed in an airplane crash (May 19, 1972).

On October 3, 1995, President Clinton issued an apology on behalf of the Nation to the 18 U. S. citizens who were used in these experiments, and to those citizens used in other radiation experiments (Time, 1995).

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