Hot Milk: The Discovery of the Milk-Iodine Pathway

James P. Thomas[1]

Innocent. Unsuspecting.

A young girl sits in a high chair, sunlight projecting her shadow onto the refrigerator door in her mother's kitchen. The year is 1945 and she drinks milk from a quart bottle. She lives in the middle of the Palouse, one of the most productive farming regions in the world – consisting of rich soil astride undulating hills in southeast Washington State.

Her name is Shannon Rhodes, age 4. Although she won't find out until she is in her fifties, the milk she is drinking is poisoned. The poison, radioactive iodine-131, has no taste, no smell – nothing to cause anyone to detect its presence, unless you were a scientist with the right equipment. This poison was brand new and one of the most closely guarded secrets of the Manhattan Project, the highly classified effort to develop the atomic bomb during World War II.

Shannon, her family and the other people living throughout Eastern Washington were being exposed to radioactive contaminants belching into the air from the Hanford Engineering Works, an ultra-secret war munitions plant – the first production-scale nuclear operations in the world.

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Most people believe the myth that those first atomic scientists were just like Shannon in their innocence – that they did not suspect, that they did not know the dangers lurking in the fresh milk.

Shockingly the truth is very different. Over twenty years of research by this author explodes the predominant myth. This article will show not only that atomic scientists suspected the danger of radioactive contaminants in milk, but also how those scientists gained the knowledge before the first radiation was released into the air.

There are many parts to understanding the myth and the truth about the release of huge amounts of radiation from Hanford, how the radiation made its way into the milk, what harm the contaminated milk caused to many who drank it, as well as when the scientists knew of the danger and how they discovered it.

Iodine-131: Hanford's Primary Radioactive Contaminant

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Discovered in 1938, the radioactive isotope of iodine of most concern to the history of Hanford operations is iodine-131. The chief way people are exposed to iodine-131 released to the environment is from drinking milk from cows or goats that consumed pasture contaminated by iodine-131 fallout. Beginning on the day after Christmas 1944, Hanford operations released approximately 1 million curies of radioactive iodine-131 into the air of Eastern Washington, Northern Idaho, and parts of Oregon, Montana, and Canada, exposing tens of thousands of people. More than half of the total iodine-131 was released in 1945, the first year of operations. Most of that was released after Japan had surrendered because, instead of reducing the production rate after the war's end, Hanford actually increased plutonium processing in the months following Japan's surrender. By contrast, the 1979 accident at the Three Mile Island, Pennsylvania, released about 24 curies of iodine-131. Although the Chernobyl disaster in 1986 resulted in a release of around 60 million curies of iodine-131, most of it was blasted into the upper atmosphere by the explosion and resulted in radioactive fallout around the globe.

Released from Hanford's processing plants as a gas, the iodine-131 spread over the surrounding countryside, transported by the wind. Snow or rain washed greater amounts of the iodine out of the air. The iodine fell on vegetation, some of which was eaten by cows and goats. Inside those grazing animals, the iodine concentrated in their milk. So, when people drank the contaminated milk, they ingested radioactive iodine-131.

Iodine and the Human Body

The human thyroid needs a certain amount of natural iodine each day to function properly. The thyroid is one of the glands that regulate the body's metabolism. If it does not have enough iodine, the gland is unable to secrete enough hormone to keep our bodies healthy. In severe cases, people can suffer from cretinism, which results in physical deformities and mental deficiency.

When radioactive iodine-131 enters a person's body, the body treats it just like natural iodine – there is no chemical difference between natural and radioactive iodine. The thyroid is a veritable sink for iodine. While present in other parts of our bodies, iodine is primarily concentrated in the thyroid.

Radioactivity

Before describing what iodine-131 will do inside the thyroid, it is useful to understand how iodine-131 is radioactive. When a substance is radioactive, it is unstable, meaning that it has a difference in the number of protons and electrons in the atom. Stable iodine (I-127) has 53 protons and 53 electrons. Iodine-131 has four more electrons and gives up these electrons as it decays. Iodine-131 becomes stable when it gives up enough electrons to become xenon, which is stable.

How fast a radioactive material decays is also important. The rate of radioactive decay is expressed in terms of half-life, the length of time it takes for half of a certain amount of a radioactive element (or isotope) to decay. Iodine-131 decays at a rate of about eight days. So if there was a release to the air of 1,000 curies of iodine-131, eight days later there would only be about 500 curies left in the environment. The other half would have decayed, or been transformed, into other elements.

Because the processing stacks at Hanford did not have any filters for the first years of operations, Hanford managers used the rate of I-131 decay in determining the length of cooling time. The cooling time was the time between when the irradiated fuel was discharged from the plutonium production reactors and when the fuel was dissolved in vats of nitric acid in the processing facilities. The longer the cooling time, the more I-131 had a chance to decay, and the less radioactive iodine released into the environment. More about the cooling time and how Hanford managers considered it in their operational decisions will be discussed toward the end of this article.

How Radiation Causes Harm

When a radioactive element decays, it gives off radiation, a form of energy. When radioactive decay occurs within the body, the energy given off can damage surrounding tissue. While the body is able to repair some of the damage done, some tissue will die or suffer a mutation. Some mutations can grow to become abnormal. There are two basic types of abnormal growths: benign nodules and malignant cancers. Other radiation-caused damage in the thyroid can result in the improper functioning of the gland when it fails to produce enough hormone. This condition is called hypothyroidism and can result in weight gain, thinning hair, or feeling cold.

Infants and young children are at highest risk for injury when exposed to iodine-131 for two main reasons. First, they are usually consuming a higher ratio of milk to body weight. Second, their thyroids are developing faster than when they are older. The faster development means their cells are dividing more rapidly and this increases the chance for mutations to occur. In fact, in adults exposed to iodine-131, scientific studies show that there is very little risk to them for developing thyroid cancer.

Release of Secret Documents Led to Scientific Study

On February 27, 1986, in response to a Freedom of Information Act request, the U.S. Department of Energy released 19,000 pages of Hanford documents, many of which were previously classified. The six-foot high stack of paper comprised a 40-year history of Hanford environmental monitoring reports. The documents confirmed people’s worst fears: Hanford had been contaminating the environment for decades and the radiation had escaped far beyond the plutonium facility.

In response to the public's concern about past exposures, Hanford initiated an effort to determine if information in the released documents could provide any information on possible health effects. As scientists working on the Hanford Environmental Dose Reconstruction (HEDR) project began their investigation, the panel directing the work held regular meetings throughout the Pacific Northwest.[i]

Many people living in the farming communities downwind of Hanford were skeptical about Hanford scientists being involved in a project to study past radiation releases from Hanford. They believed the scientists had a conflict of interest. Concerned citizens asked the project scientists, panel members, and their consulting experts the critical question: when did Hanford scientists become aware of the existence of the milk-iodine pathway? Invariably, the answer was that the existence of the milk-iodine pathway was not discovered until the late 1950s. Most scientists specifically credited the 1957 reactor accident at Windscale, England, as leading to the discovery.

In October 1957, a plutonium production reactor at Windscale caught fire. Located in northwest England along the coast of the Irish Sea, the Windscale reactor was similar to those at Hanford. The fire burned for several days and involved some of the fuel in the reactor. During that time, an estimated 20,000 curies of I-131 were released into the air, depositing over the surrounding countryside. Thousands of gallons of milk were confiscated by health authorities and dumped due to the iodine-131 contamination.

A major history of radiation safety in the Atomic Energy Commission (AEC) reflected this consensus: "The significance of the forage-cow-milk-human chain was not fully recognized before 1957, when a fire at the English Windscale reactor released large amounts of radio-iodine; surveys revealed for the first time how great a risk that pathway might become."[ii] This assessment is also supported by an early report of the Hanford Environmental Dose Reconstruction project: "Not until the mid-1950s, however, did researchers discover the possibility of milk as an important pathway for radioactive iodine."[iii]

Concerned citizens remained skeptical. Using the Freedom of Information Act, researchers obtained thousands of Hanford historical documents and were unable to find any reference to the milk-iodine pathway until the 1960s. Why was there no mention in any of the Hanford reports about the Windscale accident leading to the "discovery" of the major pathway?

With President Clinton's appointment of the Advisory Committee on Human Radiation Experiments in 1994, residents around Hanford saw an opportunity. Part of the committee's charge was to probe Hanford's Green Run. The Green Run was a secret experiment that released an estimated 7,000 curies of iodine-131, the largest single release of iodine-131 from Hanford (see separate article for more details). Perhaps the investigators working for Clinton's committee could find a more satisfying answer to the question about the discovery of the milk-iodine pathway.

However, the committee's final report had this to say:

[I]n 1949, at the time the Green Run was conducted, the most important environmental pathways for human exposure to radioiodine were unknown. (Understanding developed shortly thereafter that environmental radioiodine enters the human body from eating meat and drinking milk from animals that grazed on contaminated pastures.)[iv]

The committee report added these details in an accompanying footnote:

The earliest reference from Hanford to the milk pathway is H. M. Parker, "Radiation Exposure from Environmental Hazards," presented at the United Nations Conference on the Peaceful Uses of Atomic Energy, August 1955 … A reference to concern over milk contamination in Utah from a 19 May 1953 atmospheric test appears in "Transcript of Meeting on Statistical Considerations on Field Studies on Thyroid Diseases in School Children in Utah-Arizona, December 3, 1965, Rockville, MD."[v]

So, at least one Hanford scientist, H. M. Parker, knew about the milk-iodine pathway before the Windscale accident. Herbert Parker was the head of the radiation protection section at Hanford. How had he become aware of the pathway and when? Could it have been before Hanford began its plutonium processing? Unfortunately, such questions were beyond the scope of the advisory committee. It would take additional years of research to uncover the answer.

<u>If Not at Windscale, Then When?</u>

Perhaps by re-examining reports about the Windscale accident, one could find clues as to what Herbert Parker knew about the milk pathway and when it had been discovered. A closer reading of the official British government's Windscale investigation report revealed that British scientists were already aware of the iodine-milk pathway prior to the reactor fire. They knew they had released iodine-131 (an estimated 20,000 curies) and that it would find its way into the area's milk.

What concerned British government officials during the accident was the absence of an internationally accepted concentration level for iodine-131 in milk. There were established concentration levels for iodine in air and water, but none for milk. They had to determine which milk was safe and which would be hazardous if consumed. They needed some kind of contamination limit to decide which herds had to be quarantined and the milk dumped until enough of the iodine-131 decayed. In the midst of the accident, after receiving results of milk sampling from the surrounding area, officials were very concerned about at the high levels of iodine-131 in local milk. Within the course of several hours, there was intense consultation with radiation protection experts who then developed an action level for iodine-131 in milk.[vi] This level was used as the basis to restrict distribution of contaminated milk throughout a wide area in the weeks following the Windscale accident.

A 1954 article by R. F. Glascock of the National Institute provides further evidence that British scientists were aware of the iodine-milk pathway prior to Windscale. Glascock conducted research on dairy cows at the University of Reading (England). Glascock wrote, "in the event of an accidental emission of abnormally large quantities of fission-product iodine from nuclear energy plants cows grazing in the neighborhood may ingest sufficient of the isotope to constitute a danger to the consumers of their milk."[vii]

So, if people in the nuclear field were already aware of the iodine-milk pathway before Windscale, then how and when was this important discovery made? From documents found later in federal government archives, it became clear that as early as 1949, the AEC had begun research into the transport of radionuclides through milk. One project conducted by the University of Tennessee (UT) at Oak Ridge was called "UT-AEC Project 7, Radioisotopes in the Physiology of Milk Secretion."[viii] Starting the next year, Leo Bustad, a veterinarian working at Hanford, began iodine-131 experiments on sheep that included the analysis of the amount of iodine in their milk: "The I-131 content of the milk varied considerably; in some ewes the total activity/day in the milk was nearly equal to one-third of the daily radioiodine intake."[ix]

As intriguing as these references were, they were not reporting the discovery of an important exposure pathway. The moment of discovery was definitely not during the Windscale accident. And apparently the discovery had been made before 1949. But when was the “eureka” moment? When did scientists first become aware that the consumption of milk was the major source of iodine? By tracing journal articles back through the medical and scientific literature, it was discovered that scientists had known about the presence of iodine in milk at least as early as 1919, 25 years before Hanford began belching iodine-131 into the air.[x]

Of course, all of the articles before 1938 did not mention the radioactive isotopes of iodine (sometimes called radioiodines) because these had yet to be discovered. The previous studies only considered the natural form of iodine. The radioiodines were first produced in 1938, using the linear accelerator at Berkeley. A medical doctor there was doing pioneering work on treating thyroid disease with iodine-131. His name was Joseph G. Hamilton and we will find out more about him shortly. But first, what was in the scientific and medical literature about iodine and milk?

Early Research Connects Iodine and Milk

During the 1910s and 1920s, public health doctors, veterinarians, and farmers were concerned about the problem of goiters among humans and livestock. Goiters are abnormal growths of the thyroids. Goiters are caused by a deficiency of iodine in the diet. When the thyroid lacks adequate iodine, the gland will compensate by adding more tissue so as to produce more thyroid hormone. Researchers tried to find ways to increase the iodine amount in food and investigated ways to supplement the diet with iodine. Some enterprising scientists even experimented with adding iodine to cigarettes, so that when people smoked they would also inhale supplemental iodine. While researchers concluded that iodized cigarettes were not an efficient supplement (most of the iodine was found in the ash), they developed iodized salt and started spiking bread with iodine. The Morton Salt Company began marketing iodized salt in 1924.

Other scientists found that cows grazing in coastal areas had more iodine in their milk than cows that grazed further inland. The oceans are an abundant source of iodine and pastures along the coast receive deposits of iodine from sea mists and fog. Scientists began to build an extensive knowledge base. In a 1930 journal article, University of Minnesota physiological chemistry professor Jesse McClendon and his colleagues wrote that "the feeding of iodine compounds increases the iodine content of the milk . . ."[xi] The next year, a New Zealand team led by Sir C. E. Hercus reported, "milk is an important item in supplying iodine . . ."[xii]

Making the Connection to Hanford

But how do these discoveries connect with scientists at Hanford years later? Just prior to the initiation of the Manhattan Project,[xiii] discussion of the relationship of iodine and milk appeared in two major texts concerning the thyroid, one published by Oxford University Press and the other by Harvard University Press. Each book included a section that summarized the state of scientific knowledge of iodine in milk. In 1938, A. W. Elmer, a Polish medical professor, included the following in his chapter on iodine metabolism: "It has long been known that iodine is normally present in milk."[xiv] Two years later, W. T. Salter, an assistant professor of medicine at Harvard, recounted the results of a study that fed iodide to lactating goats. "In 30 minutes after oral administration of 7.5 mg. [milligrams] of iodide the concentration in the milk had increased twentyfold." Salter also mentions that another study found "similar results . . . in lactating women."[xv] Among the references cited by Salter was the 1930 McClendon paper.

Not only did major universities publish both texts, but there is evidence that at least one key Manhattan Project scientist, Joseph G. Hamilton, MD, had read the books. In an article that appeared in the November 1942 issue of *Radiology*, Hamilton cited both texts among his references.[xvi] While not discussing the role of milk in the metabolism of iodine within this article, he does state "the radioactive isotope of a stable element differs only in its property of radioactivity; the chemical and physiological properties of the two forms of the element are identical . . ."[xvii]

Dr. Hamilton pioneered the use of radioactive iodine to diagnose and treat thyroid disease. Earning his medical degree in 1936, he conducted groundbreaking research on the metabolism of sodium, iodine, and other radioactive elements that were produced at the University of California's cyclotron. Along with two colleagues, Hamilton published the first paper on the diagnostic uses of iodine-131 in patients in 1939. Like many of his fellow scientists, Hamilton took a rather cavalier attitude toward radiation exposure and sometimes included himself as one of his test subjects. During talks about his research, he would show how iodine-131 concentrates in the thyroid gland by drinking some at the beginning of his remarks and then later demonstrate the uptake by holding a Geiger counter to his throat, the instrument's rapid clicking indicating the radiation's presence. While working in and around the cyclotron, he would routinely ignore the safety precautions. According to Eileen Welsome's *The Plutonium Files*, Hamilton's colleagues warned him of the dangers. He was only 49 years old when he died of leukemia in 1957.[xviii]

Given that Hamilton was arguably the world's foremost expert on iodine-131 in humans at the beginning of World War II, how was that information shared with those in charge of Hanford? And more specific to the milk-iodine pathway, is there any evidence that knew about it or exchanged his knowledge with scientists involved with Hanford? Whereas there is no documentation that Hamilton communicated his knowledge about iodine with Hanford's Parker, both men were elite members of a small group of people whose knowledge became indispensable to the U.S. crash program to develop the atomic bomb in World War II. Parker and Hamilton became connected through their respective prewar research partners. The extent to which these two sets of scientific research pairs collaborated on the dangers posed by exposure to radioactive iodine holds the key to understanding what Manhattan Project scientists knew and when they knew it.

The Manhattan Project's effort to produce plutonium and other materials for the atomic bomb generated unprecedented volumes of radioactive materials. Pioneering work was needed to measure the new radioactive materials, assess the risk of exposure to them and develop protection standards to guide managers in limiting exposures to workers and the public. The nexus of this work on radiation safety was the Health Division of Chicago's Metallurgical Laboratory (usually called the Met Lab). During the Manhattan Project, the Met Lab was a major nexus in the rush to build the atomic bomb. After being recruited for the top secret project, many of the scientists and other radiation safety personnel assigned to one of the production sites would first visit the Met Lab to receive classified briefings into the details of their new work.

On August 6, 1942, Robert S. Stone, MD, began directing the Met Lab's Health Division, serving as the Associate Project Director for Health. Stone was

Dr. Hamilton's research collaborator at the University of California. In fact, Hamilton and Stone made nuclear medicine history when they injected a radioisotope (sodium-24) into a leukemia patient in 1936. At the University of California since 1928, Stone was a professor of radiology and the chair of the radiology department. It was Stone that had brought Hamilton into the Manhattan Project: "Stone knew of no scientist better qualified for the job than his old partner, Joseph Hamilton. Two months after Stone was hired, Hamilton was put under contract by the Met Lab to do the biological studies on the fission products."[xix] The prewar partnership of Stone and Hamilton was not the only set of radiation researchers that would be brought into the secret bomb effort.

In the summer of 1942, Stone asked Simeon T. Cantril, director of the Tumor Institute at Seattle's Swedish Hospital, to come to the Met Lab as the director of clinical medicine. Cantril arrived in Chicago on the same day as Stone, August 6, exactly three years before the atomic bombing of Hiroshima. Within a very short time, Cantril recruited Herbert M. Parker, who had partnered with Cantril at the Tumor Institute since 1938. Parker had directed the Tumor Institute's radiological physics program. His research concerned the hazards of X-ray exposure to children. In scientific articles and by other communications, Parker advised radiologists to keep exposures as low as possible. At Chicago's Met Lab, Parker served as the Chief of Physical Measurements Section of Stone's Health Division.

While working under Stone and Cantril, Parker worked on the development of instruments to measure radiation in the environment, a set of standards to use in limiting human exposure to the radiation, and methods of assuring compliance with those standards.

	Stone	**Hamilton**	**Cantril**	**Parker**
1938-1941	UC	UC	Swedish	Swedish
1942	Met Lab	Met Lab & UC	Met Lab	Met Lab
1943	Met Lab	Met Lab & UC	Oak Ridge	Oak Ridge
1944	Met Lab	Met Lab & UC	Hanford	Hanford

Parker was transferred to Oak Ridge in September 1943. Oak Ridge served two primary missions for the Manhattan Project. The better known was the production of the highly enriched uranium that destroyed Hiroshima on August 6, 1945. Oak Ridge also served as the location for a pilot plant for the plutonium process that would reach an industrial scale at Hanford. One purpose of the pilot plant was to allow the radiation control personnel some experience with an actual operating facility. Stone placed Parker in charge of the Health Physics Section. Parker's responsibility was to further develop equipment to detect the new radioactive materials in the environment.

After Parker established the health protection program at the Oak Ridge facility, he was assigned to Hanford in July 1944, which, due to the much larger production scale, posed a much greater danger to the workers and public than did the Oak Ridge operations. Cantril also made the transition from Oak Ridge to Hanford and became the medical superintendent. While remaining at the Met Lab, Dr. Stone served as "the chief liaison with the other two sites [Hanford and Oak Ridge] on matters relating to health and protection."[xx]

Since Stone and Hamilton had years of close collaboration before the war and Stone was in desperate need of Hamilton's unique understanding of radioisotopes, it strains credulity that such frequent consultation did not continue during the war years. When one also considers the great concern of iodine-131 and Hamilton's extensive research on I-131, it is very likely that Hamilton would have told Stone what he knew regarding iodine's proclivity to be ingested via drinking milk. Certainly if Stone knew he would have communicated this to Cantril and Parker, given the potential for very large releases of iodine from Hanford. Thus, the "eureka moment" of the milk-iodine pathway happened during the development of the atomic bomb.

Weighing Conflicting Evidence

In all of his reporting during the first ten years of Hanford operations, Parker only refers to inhalation and the ingestion of vegetables and water as human pathways for exposure to iodine-131. Nowhere does he explicitly mention milk until 1955. He often cites the danger to livestock posed by grazing on contaminated vegetation, but it is only in the context of the danger to the thyroids of those animals. Perhaps the rigid compartmentalization imposed on the bomb project prevented Parker from learning of the milk-iodine pathway until 1955.

In January of that year, toward the end of a regular quarterly report, Parker makes the follow comment about people drinking milk from cows on iodine-contaminated pasture: "the vegetation limit is such that acceptance of the I-131 limit for human breathing as in Handbook 52 could lead to disastrous overexposure."[xxi] Handbook 52 was a set of guidelines decided by the National Committee on Radiation Protection (NCRP) and published by the National Bureau of Standards (NBS). Recall from the Windscale accident that there had been contamination limits for air (breathing) and water, but not for milk. What Parker is pointing out here is the inadequacy of the prevailing radiation control limit because the contribution via the milk-iodine pathway had not been incorporated into the exposure standard.

In April 1955, Parker provides a more detailed look at the iodine-milk pathway. Surprisingly, he states that it is something he has known about all along: "The official limit for permissible concentration of radioiodine in the atmosphere is that given in NBS Handbook 52. This relates to the breathing hazard. Since the first year of Hanford operation,[xxii] we have known that this limit is too high because the real hazard arises from deposition of the active material on vegetation."[xxiii] Parker continues: "The hazard is a combination of

(1) direct inhalation – usually negligible
(2) eating of fresh garden produce
(3) drinking of milk from cows on contaminated pasture
(4) drinking of contaminated water – usually negligible."[xxiv]

Later in 1955, Parker included mention of the iodine-milk pathway in two presentations. At the first Untied Nations conference on the peaceful uses of atomic energy in Geneva, Switzerland, Parker stated: "Two significant routes of entry [of iodine-131] are consumption of fresh garden produce, and drinking milk from cows on contaminated pasture."[xxv] Parker also noted the pathway during his 1955 Janeway lecture.[xxvi]

If Parker did know about the milk-iodine pathway from the first year of Hanford operations, then why did he not write about it in any of his reports until 1955? Even though Hanford continued to be a very secretive place after the end of World War II, it is very plausible that certain aspects of the further development of atomic weapons were so sensitive that they were not to be written down.

<u>The Costs of Secrecy</u>

Secrecy allowed Hanford and the other bomb factories to operate without any meaningful oversight or accountability. That Hanford and other AEC managers were concerned that any public scrutiny would jeopardize America's ability to expand its nuclear arsenal is well documented. According to the official AEC history, following the Harry test in Nevada on May 19, 1953, Edward S. Weiss, the U.S. Public Health Service officer in St. George, Utah, "considered collecting milk samples from local dairies to check for radioactivity, but because of the uneasiness in the community Weiss concluded that such a survey might create alarm. For that reason he limited his investigation to a few samples of milk purchased in local stores. . . . Scientists later estimated that children living near the test site received thyroid doses from iodine-131 ranging from inconsequential levels to those possibly causing some thyroid abnormalities."[xxvii]

So what was the human toll of keeping the milk-iodine pathway secret for so long? Was it limited to the relatively sparsely populated areas downwind from Hanford? One indication that Hanford's policy of secrecy reached far beyond the desert of Eastern Washington is a letter in a 1952 issue of *JAMA* reports the concern of two practicing physicians in using I-131 in the treatment of patients who are lactating women:

The quantity of radioactive iodine in the milk and the quantity taken up by the thyroid gland of [breast-fed] infants suggested an element of danger in the use of radioactive iodine in lactating mothers and warranted a preliminary report of our observations. A survey of the literature on distribution of radioactive iodine in tissues did not reveal any instance of radioactive iodine activity in the milk of lactating human beings or transmission to the thyroid gland of nursing infants. Such transmission might have been anticipated from the animal experiments of Rugh[xxviii] and Courrier and his co-workers, who demonstrated sizeable uptakes of radioactive iodine by suckling mice and rabbits following . . . injection of radioactive iodine in nursing mothers, and the writings in which other radioactive isotopes were reported to be transmitted in maternal milk....

Radioactive iodine therapy is contraindicated in lactating women who breast feed their babies, since the thyroid gland of the infant may take up enough radioactive iodine from the milk to depress seriously or ablate functional activity of the gland.[xxix]

One can only wonder how many mothers unsuspectingly breastfed their babies hot milk because of Hanford's failure to publish the iodine-131/milk pathway in the scientific literature.

Conclusion

Based upon the documentation found in the scientific literature and historical reports, Manhattan Project scientists were aware of the iodine-milk pathway's significance as the first reactors and chemical separations facilities were being constructed at Hanford. Given the large atmospheric releases of iodine-131 from Hanford, the early knowledge of the iodine-milk pathway raises important policy and ethical questions. Hanford officials and scientists knew they were exposing thousands of people to dangerous levels of iodine-131, yet they did essentially nothing because they were protected by a curtain of secrecy. In order to prevent future Hanfords, citizens must have adequate and timely knowledge of government actions, be involved in the decision-making process, and hold their government accountable.

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[i] During the HEDR project, I worked for the Hanford Education Action League (HEAL), a public interest organization that served as a watchdog on Hanford activities. I attended most of the HEDR public meetings. The staff, directors, and members of HEAL knew that we couldn't trust anything about Hanford and my role was to hold HEDR scientists accountable.

[ii] Barton C. Hacker, *Elements of Controversy: The Atomic Energy Commission and Radiation Safety Nuclear Weapons Testing 1947 to 1974*, Berkeley: University of California Press, 1994, p. 209.

[iii] Pacific Northwest Laboratory, Air Pathway Report: Phase I of the Hanford Environmental Dose Reconstruction Report, PNL-7412 HEDR Rev. 1, July 1991, p. 1.7.

[iv] Advisory Committee on Human Radiation Experiments, *Final Report*, October 1995, p. 512.

[v] ACHRE Final Report, p. 549.

[vi] Atomic Energy Office, "Accident at Windscale No. 1 Pile on 10th October, 1957," London: Her Majesty's Stationery Office, November 1957, p. 13-14.

[vii] R. F. Glascock, "The Secretion of a Single-Tracer Dose of Labeled Iodine in the Milk of the Lactating Cow," *J. Dairy Res.*; 21 (1954), p. 318.

[viii] "University of Tennessee-Atomic Energy Commission Agricultural Research Program, Quarterly Progress and Work Accomplishment Report for Quarter Ending June 30, 1949," p. 3. It is interesting to note that on the next page, H. A. Kornberg of GE-Hanford, director of the biology program and a colleague of Parker, was listed as a visitor.

[ix] Bustad, et al., "Toxicity of I-131 in Sheep: I. General (preliminary report on low-level chronic effects)," in HW-25021, *Biology Research - Annual Report, 1951*, April 15, 1952, p. 146.

[x] I am indebted to Vivian Falcon for her many trips to the Health Sciences Library at the University of Washington in helping me reconstruct this trail.

[xi] J. F. McClendon, et al., The Determination of Traces of Iodine. III. Iodine in Milk, Butter, Oil and Urine, *J. Amer. Chem. Soc.*, 52:541-549 (Feb. 1930), p. 544.

[xii] C. E. Hercus et al., Further Observations on the Occurrence of Iodine in Relation to Endemic Goitre in New Zealand and on Iodine Metabolism, *J. Hyg. Camb.*, 31:493-522 (1931), p. 502.

[xiii] The secret U.S. government project that developed the atomic bomb during World War II.

[xiv] A. W. Elmer, *Iodine Metabolism and Thyroid Function*, London: Oxford University Press, 1938, p. 110.

[xv] William Thomas Salter, *The Endocrine Function of Iodine*, Cambridge, MA: Harvard University Press, 1940, pp. 70, 188, and 201.

[xvi] J. G. Hamilton, "The Use of Radioactive Tracers in Biology and Medicine," *Radiology*, 39:541-572 (1942), p. 571.

[xvii] Hamilton, p. 542.

[xviii] Eileen Welsome, *The Plutonium Files: America's Secret Medical Experiments in the Cold War*, New York: Dell Publishing, 1999, p. 29.

[xix] Welsome, *The Plutonium Files*, p. 43.

[xx] S. T. Cantril, “Industrial Medical Program – Hanford Engineer Works,” in Industrial Medicine on the Plutonium Project, edited by Robert S. Stone, 1951, p. 305.

[xxi] Parker, Quarterly Progress Report – Research & Development Activities, October-December 1954, January 10, 1955, HW-34408, p. 29.

[xxii] Atmospheric releases of iodine-131 from Hanford began on December 26, 1944 with the start-up of T-Plant that extracted plutonium from irradiated fuel elements.

[xxiii] H. M. Parker, HW-36207, "Current Views on the I-131 Emission Limits," April 4, 1955, p. 1.

[xxiv] Parker, p. 2.

[xxv] Parker, "Radiation Exposure from Environmental Hazards," UN Conference Proceedings, Vol. XIII, p. 306-307.

[xxvi] Parker, "The Radiological Sciences," p. 20 of copy found among the Herbert M. Parker papers (Accession No. 3616), University of Washington Libraries, Manuscripts and University Archives Division. The Janeway Lecture is an annual series that began in 1933 and is sponsored by the American Radium Society.

[xxvii] Richard G. Hewlett and Jack M. Holl, *Atoms for Peace and War: 1953-1961; Eisenhower and the Atomic Energy Commission*, Berkeley: University of California Press, 1989, p. 154. While Hewlett and Holl make the connection to iodine-131, it is possible that the sampling of milk was concerned with strontium-90 levels (perhaps even a primary concern, as a part of Project Gabriel).

[xxviii] This research by Roberts Rugh of Columbia University was performed under contract to the AEC.

[xxix] C. E. Nurnberger, and Alys Lipscomb, Transmission of Radioiodine (I-131) to Infants Through Human Maternal Milk, *JAMA* 150:1398-1400 (December 6, 1952). p. 1398 and 1400.