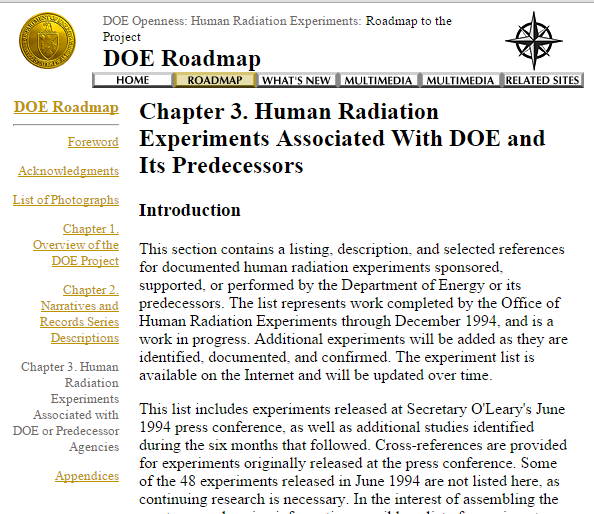
<https://ehss.energy.gov/ohre/roadmap/roadmap/part3.html>



**Chapter 3. Human Radiation Experiments Associated With DOE and Its Predecessors**

**Introduction**

This section contains a listing, description, and selected references for documented human radiation experiments sponsored, supported, or performed by the Department of Energy or its predecessors. The list represents work completed by the Office of Human Radiation Experiments through December 1994, and is a work in progress. Additional experiments will be added as they are identified, documented, and confirmed. The experiment list is available on the Internet and will be updated over time.

This list includes experiments released at Secretary O'Leary's June 1994 press conference, as well as additional studies identified during the six months that followed. Cross-references are provided for experiments originally released at the press conference. Some of the 48 experiments released in June 1994 are not listed here, as continuing research is necessary. In the interest of assembling the most comprehensive information possible, a list of experiments described in the 1986 congressional report entitled *American Nuclear Guinea Pigs: Three Decades of Radiation Experiments on U.S. Citizens* is provided as an appendix. It should be noted that information about some studies in *American Nuclear Guinea Pigs*has been updated and included in the current DOE list; further update efforts are ongoing.

***The experiment list is available on the Internet and will be updated over time.***

Basic guidance for identifying experiments is contained in Executive Order 12891 issued January 15, 1994, and in a January 19, 1994 White House memorandum entitled "Retrieval and Inventory of Records of Human Radiation Experiments." These authorities define human radiation experiments as:

Experiments on individuals involving intentional exposure to ionizing radiation. This category does not include common and routine clinical practices, such as established diagnosis and treatment methods, involving incidental exposures to ionizing radiation;

and

Experiments involving intentional environmental releases of radiation that (A) were designed to test human health effects of ionizing radiation; or (B) were designed to test the extent of human exposure to ionizing radiation.

**Criteria for Listing Experiments**

Several additional criteria were used in compiling the list. First, clear evidence that an experiment took place was required. Given the fragmented and highly disparate nature of the documentation, this was often a challenge. Many documents refer to proposed studies, and in other cases documents provide inconclusive leads that require further research. The experiments listed below have been confirmed through research in primary and secondary sources.

Second, the list is limited to experiments conducted or supported by DOE, its predecessor agencies, or agency contractors. Starting in the late 1940s, hundreds of hospitals and other institutions did work with scores of radionuclides and radioactively labeled compounds. Much of this work involved human radiation experiments. Yet apart from distributing licenses and isotopes, DOE and its predecessors had no active role in most of these experiments. Yet the agency did operate its own cancer hospitals and other research facilities where human subjects were used in radiation research. Moreover, the agency contracted with universities and other institutions for human radiation research. Such experiments are included.

The third consideration for inclusion on the list was evidence that an experiment involved exposure of human subjects to radiation. Studies involving only human tissue samples were not included. Research involving various drugs, hormones, minerals, or other substances also were not included unless radiation was involved.

In judging if a procedure was a "common and routine clinical practice," the following guidelines were used. A human radiation experiment included any of the following situations where radiation was administered

* without realistic expectation of a benefit to the subject;
* to test or determine the potential usefulness of a treatment for other individuals;
* to healthy human subjects;
* to an individual to calibrate radiation detection instruments.

Several types of procedures did not fall within the scope of human radiation experiments. These included procedures where:

* workers occupationally exposed to radiation were measured for potential internal or external radiation exposure by routine dosimetry, bioassay, or whole body counting methods;
* workers were assayed after accidental internal or external radiation exposures;
* individuals were treated with chelating agents for removal of accidental or occupational internal contamination;
* patients were measured for internal radioactivity as part of a legitimate medical, diagnostic or therapeutic process;
* preexisting internal deposition of radionuclides were assessed, measured, or studied in body fluids, excreta, blood, cells, or tissue samples.

**Basic Categories of Human Radiation Experiments**

There are several common and recurring categories of human radiation experiments.*Tracer studies* involved use of radioisotopes as tools to learn more about the properties of other biological compounds, transport pathways, and processes in the body. Tracer studies also involved using isotopes as labeling agents where a drug was labeled with a radioactive isotope, including studies conducted to gain knowledge of the effect of radiation upon humans.

***Many of the experimental treatment therapies moved from the experimental stage to the routine. The point at which they ceased to be experimental may be difficult to draw with precision.***

All *radionuclide metabolism studies* in human subjects were considered as human radiation experiments. These tests involved the study or analysis of radioisotope uptake, retention, and excretion, and were done to learn more about the specific behavior of elements in the body.

Biological effects of radiation were often determined during *dose response studies*.

Radionuclides were used in *diagnostic studies* to research human physiological conditions, or to calibrate radiation detectors or imaging systems.

Finally, *experimental treatments for disease,* cancer perhaps the most prominent, involved the use of various radiations and radioactive materials. Over time, many of these therapies moved from the experimental stage to the routine. The point at which they ceased to be experimental may be difficult to draw with precision. The reviewers have used their best judgment in listing those treatments that appear to have been experimental at the time they were administered.

**The Process of Identifying Experiments**

Several steps were involved in locating and reviewing documentary evidence related to human radiation experiments. To start, DOE Office of Human Radiation Experiments (OHRE) staff other personnel searched records with information of potential value. This selective search covered records in work spaces, offices, Federal Records Centers, the U.S. National Archives, and other archival repositories.

***References usually contain fragmentary information, and considerable research in primary and secondary sources is often necessary to verify and describe a specific experiment.***

When documents were found that might contain information related to human radiation experiments, the documents were copied and provenanced. Provenancing involves noting the location of the original document (site, series, box, and folder). The copies were sent to OHRE through a document processing facility, the Coordination and Information Center (CIC). The CIC numbered and indexed the documents, optically scanned them, and produced copies for distribution to DOE public reading rooms and other interested parties, including the Advisory Committee on Human Radiation Experiments. About 150,000 pages are included in this system. The basic document indexes are now available electronically, including through the Internet. Work is underway to provide enhanced searching capabilities and access to document images through the Internet World Wide Web.

Many varieties of documents reference experiments. These include reports from laboratories or contract correspondence between researchers and agency officials, researcher notes, medical files, experiment protocols and proposals, and research bibliographies. References usually contain fragmentary information, and considerable research in primary and secondary sources is often necessary to verify and describe a specific experiment. This research involved gathering all documents related to a particular experiment and comparing the information with published journal literature. Much of the information on human radiation experiments was published in the open scientific literature.

**Summarizing and Listing Experiments**

The experiment summaries provide a concise description of what occurred based on the information that could be found. The focus has been on learning when and where the experiment took place; type and dosage of radiation used; how radiation was administered; why the experiment was conducted; numbers and types of subjects involved; experimental results; and funding sources for the experiment. Each experiment summary is followed by a reference section which lists citations to information sources. In addition, case files have been prepared with information concerning each experiment listed.

**Challenges**

In preparing this list, and in continuing the work to find experiments, a variety of challenges have been encountered. One issue relates to subject populations. With some exceptions, little evidence exists about how researchers chose experimental subjects or what factors went into such decisions. More details are often available about the composition of subject populations, but information in this area is hardly complete.

Another obstacle is dating: references to experiment dates are often incomplete, as some studies were conducted over several years. Occasionally, the date given in the experiment summary is an estimated date based on available information.

The use of informed consent--or any degree of consent at all--is also very difficult to document for many experiments dating before the standard requirements issued by the National Institutes of Health in 1974. Contemporary professional literature typically did not provide much detail about consent issues, nor do contracts, progress reports, or other information sources.

In addition, it can be difficult to determine the role of the Federal government in some experiments. Studies occurring at AEC research hospitals or other agency facilities have an obvious connection to the Government. Yet experiments done in private hospitals often do not. The AEC provided grants, contracts, and other forms of direct support for human radiation experiments, and examples are included in the list. Funding status, however, is not always clear. Where available, funding information is provided.

Finally, this list does not constitute a comprehensive compilation of all human radiation research in which DOE and its predecessors were involved. As indicated above, the work of collecting, assessing, researching, and confirming continues. "

**List of Experiments**

**Plutonium Injection Experiments**

**PI-1. Plutonium Injection Studies**

During 1945 to 1947, 18 persons were injected with amounts of plutonium at the Manhattan Engineer District Hospital in Oak Ridge, TN (1 patient), at Strong Memorial Hospital in Rochester, NY (11 patients), at Billings Hospital of the University of Chicago (3 patients), and at the University Hospital of the University of California in San Francisco (3 patients). Excreta were obtained from patients and sent to Los Alamos for plutonium analysis. These data were used to establish mathematical equations describing plutonium excretion rates.

This research was funded by the Manhattan Engineer District; follow-up studies were supported by the U.S. Atomic Energy Commission and the Energy Research and Development Administration. (This experiment was referenced in the Markey report. See Chapter 2 of this *Roadmap* for further information about this experiment.)

**References**

Durbin, P.W.*Plutonium in Man: A Twenty-Five Year Review*. Berkeley: Lawrence Radiation Laboratory, UCRLB20850, 1971.

Durbin, P.W. "Plutonium in Man: A New Look at the Old Data." Chapter 7.2 in *Radiobiology of Plutonium*, edited by B.J. Stover and W.S. Jee. Salt Lake City: The J.W. Press, 1972. pp. 469B530.

Langham, W.H., H. Bassett, P. S. Harris, and R.E. Carter.*Distribution and Excretion of Plutonium Administered Intravenously to Man*. Los Alamos: Los Alamos Scientific Laboratory, LAB1151. Republished in *Health Physics*. Vol. 38, 1980, pp. 1,031B1,060.

Stannard. J.N. *Radioactivity and Health: A History.* Office of Scientific and Technical Information. 1988, p. 350B355. "

**Argonne National Laboratory**

**ANL-1. Radium as an Experimental Therapy for Treating Mental Disorders at Elgin State Hospital in Elgin, IL**

Patients in a state mental hospital were injected with radium as an experimental therapy for mental disorders. The experiment appears to have been conducted at the Elgin State Hospital, in Elgin, IL, between 1931 and 1933. Documents indicate that 70 to 450 micrograms of radium-226 (Ra226) were injected. This experiment occurred prior to the establishment of the Argonne National Laboratory and the U.S. Atomic Energy Commission. Argonne National Laboratory later collected records and attempted to locate the subjects. Researchers believed that if the patients could be located and body content measurements made in the 1950s, a valid retention curve for radium in humans over several decades could be constructed. Argonne National Laboratory made all later measurements. This information was useful for radiation protection guidelines for alpha particle emitters.

The records contain information regarding radium content of the located subjects, medical information relating to the subjects' admission to the hospital, periodic medical examination results, and causes of death and death certificates for deceased subjects. (Previously described in #31 on the original list of 48 experiments released by DOE in June 1994)

**References**

Rowland, R.E., A.F. Stehney, and H.F. Lucas. "Dose-Response Relationship for Radium-Induced Bone Sarcomas." *Health Physics*. Vol. 44 (Suppl. 1), 1983, pp.15B31.

Looney, W.B., R.J. Hasterlik, and A.M. Brues. "A Clinical Investigation of the Chronic Effects of Radium Salt Administered Therapeutically." *American Journal of Roentgenology, Radium Therapy, and Nuclear Medicine.* Vol. 73, 1955, pp. 1,006B1,037.

Norris, Speckman, and Gustafson. "Studies of the Metabolism of Radium in Man." *American Journal of Roentgenology, Radium Therapy, and Nuclear Medicine.* Vol. 73, 1955, p. 785.

Miller, C.E., R.J. Hasterlik, and A.J. Finkel. *The Argonne Radium Studies: Summary of Fundamental Data*. Chicago: Argonne National Laboratory and Argonne Cancer Research Hospital. ANLB7531 and ACRHB106. "

**ANL-2. Effect of Phosphorous-32 on Hemoglobin Metabolism in Polycythemia Rubra Vera**

This study was conducted by the Health Division of the Metallurgical Laboratory at the University of Chicago at the University Hospital's Hematology Clinic (six patients) and at the University of Minnesota (one patient). Five patients were administered 15 to 40 microcuries of phosphorus-32 (P32), and two patients were injected with undetermined amounts of P32 in a study of the metabolism of hemoglobin in man. These experiments took place between October 1944 and June 1945. (Previously described in #10 on the original list of 48 experiments released by DOE in June 1994)

**References**

Schwartz, S., E.J. Katz, L.M. Porter, L.O. Jacobson, and C.J. Watson. *Studies of the Hemolytic Effect of Radiation*. Chicago: Metallurgical Laboratory, CHB3760, July 10, 1946. National Archives and Records Administration, Record Group 326, U.S. Atomic Energy Commission, MED/AEC, Metallurgical Laboratory/Argonne National Laboratory, Classified Correspondence Files, Box 23X, 2 of 4, Folder 651. "

**ANL-3. Plutonium Ingestion Study**

In May 1946, six male employees of the Metallurgical Laboratory of the Manhattan Engineer District in Chicago drank a water solution containing about 0.18 nanocurie of plutonium-239 (Pu239). The purpose of this study was to investigate the gastrointestinal absorption and fecal excretion rate of ingested plutonium. Researchers also hoped to use the results to improve the interpretation of previously collected data on persons occupationally exposed to plutonium. Participation in this experiment was voluntary, and the amounts of plutonium ingested were sufficiently low to be barely detectable in urine and feces with instrumentation available in 1946. At least two of the subjects were still alive in 1994. (Previously described in #7 on the original list of 48 experiments released by DOE in June 1994)

**References**

Memorandum. E.R. Russell to J.J. Nickson. June 20, 1946. U.S. Department of Energy, Chicago Operations, Center for Human Radiobiology, Plutonium Documents. "

**ANL-4. Arsenic-76 Biodistribution and Excretion Studies**

This study was conducted by the Argonne National Laboratory in 1947 in Chicago. Twelve hospital patients were injected intravenously with arsenic-76 (As76), administered as potassium arsenite, to study the uptake, retention, distribution, and excretion of arsenic. The subjects included five males and seven females, all between the ages of 18 and 67 years and hospitalized with leukemia, Hodgkin's disease, polycythemia rubra vera, melanocarcinoma, and carcinoma of the parotid. Amounts of As76 administered were 0.5 to 15.4 millicuries. This study showed that As76 rapidly distributed throughout the body, failed to localize in tumors or lymphatic tissue, and was rapidly excreted in urine and via the intestinal tract. The study was supported by the U.S. Atomic Energy Commission. (Previously described in #11 on the original list of 48 experiments released by DOE in June 1994)

**References**

Neal, W.B., L.O. Jacobson, H. Ducoff, and T. Kelly. *Arsenic-76 Preliminary Studies Progress Report.* Chicago: Argonne National Laboratory, Biology Division, CH-3830, June 1, 1947, pp.1B16. National Archives and Records Administration, Record Group 326, U.S. Atomic Energy Commission, MED/AEC, Metallurgical Laboratory/Argonne National Laboratory, Classified Correspondence Files, Box 23, Box 3 of 5, Folder 699.

**ANL-5. Whole Body Counter Calibration With Sodium-24**

This study was conducted at Argonne National Laboratory, in the early 1950s, to test and calibrate a sodium iodide scintillation counter. Three individuals ingested a few microcuries of sodium-24 (Na24) and the sodium iodide scintillation counter apparatus was used to determine the gamma-ray activity of Na24 in the subjects. The three subjects were Argonne employees.

**References**

Marinelli, L.D., C.E. Miller, P.F. Gustafson, and R.E. Rowland. "The Quantitative Determination of Gamma-Ray Emitting Elements in Living Persons." *American Journal of Roentgenology, Radium Therapy, and Nuclear Medicine*. Vol. 73, No. 4, April 1955, p. 661B666. "

**ANL-6. Uptake of Thymidine by Human Tumor**

In 1962, a study was conducted on the uptake of thymidine labeled with tritium (H3) by human tumors. This study was a cooperative effort between the Departments of Pathology and Surgery, Northwestern University Medical Hospital, Chicago, and Argonne National Laboratory. Four male patients, between the ages of 54 and 69 years old, were included in the study. Three were in the terminal stages of various forms of cancer. All subjects were injected with 10 microcuries of H3-labeled thymidine prior to their previously scheduled surgery. Samples consisting of tumor and normal abdominal tissues were removed during surgery. Samples were also collected during the autopsies of the terminal subjects. The results showed similar growth in both cancerous and noncancerous cells, a finding that was in agreement with previous animal studies. This project was partly funded by the U.S. Atomic Energy Commission. (Previously described in #9 on the original list of 48 experiments released by DOE in June 1994)

**References**

Baserga, R., G.C. Henegar, W.E. Kisieleski, and H. Lisco. "Uptake of Tritiated Thymidine by Human Tumors *In Vivo*." *Laboratory Investigation.* Vol. 11, No. 5, May 1962, pp. 360B364. "

**Brookhaven National Laboratory**

**BNL-1. Effectiveness of Iodine-131 in Diagnosing and Treating Graves' Disease and Metastatic--arcinoma of the Thyroid**

In 1950, Brookhaven National Laboratory conducted a study on the use of iodine-131 (I131) to treat patients with metastatic carcinoma of the thyroid or with Graves' disease. Patients for the study were sent to Brookhaven from Memorial Hospital in New York City. In the study, a therapeutic dose of 4 to 360 millicuries of I131 was given to patients; the exact dose depended in part on the number of metastases and on previous radiation treatment. Graves' disease patients who were unsuitable for surgical therapy were treated with I131 in doses of 6 to 20 millicuries. The patients were monitored for hematological damage. Metabolic studies were also conducted, including study of the effects of radiation dose on renal tubular function. Twelve patients participated in the study, ranging in age from 15 to 63 years old. Of the 12 patients, 8 were females. The study was conducted in conjunction with the Memorial Hospital and was funded by the U.S. Atomic Energy Commission.

**References**

Memorandum. L.E. Farr to BNL Committee on Use of Radioactive Isotopes in Human Studies. January 20, 1950. Brookhaven National Laboratory Project HB1. Brookhaven National Laboratory, Clinical Research Center, Bldg. 490, Human Medical Research Protocols.

Memorandum. BNL Committee on Use of Radioactive Isotopes in Human Studies. January 20, 1950. Brookhaven National Laboratory Project HB1. Brookhaven National Laboratory, Clinical Research Center, Bldg. 490, Human Medical Research Protocols.

Farr, L.E. "Observations of Renal Function in Patients Receiving Internally Administered Radioactive Isotopes." from *Symposium on Radiobiology, A.A.A.S., Cleveland, Ohio*. December 30, 1950. "

**BNL-2. Boron Neutron Capture Therapy**

Brookhaven National Laboratory conducted boron neutron capture therapy (BNCT) on 45 patients from 1951 to 1961. The patients all were suffering from aggressive and otherwise untreatable types of brain tumors, such as glioblastoma multiforme or malignant glioma; all had received conventional radiation treatments. The purpose of BNCT was to attack more precisely the tumors with radiation, destroying the tumor cells. The patients were injected with a discrete amount of boron that was intended to deposit in the tumor. The tumors were then bombarded with a beam of neutrons that was directed to the boron and thus aimed at destroying the tumor. The results of this therapy were unsuccessful. Patients who were treated with BNCT generally lived only as long as those patients, with the same types of brain tumors, who were treated with conventional radiation therapies.

This work was funded by the U.S. Atomic Energy Commission. Currently, advances in technology allowing for greater precision in this technique have brought about the return of BNCT. As a result, Brookhaven is currently performing the therapy. (BNCT was referenced in the Markey report.)

**References**

Slatkin, D. N. "A History of Boron Neutron Capture Therapy of Brain Tumors." *Brain*. Vol. 114, 1991, pp. 1,609B1,629.

Lippincott, S.W., Y. L. Yamamoto, and L.E. Farr, "Radiation Effects of Neutron-Capture Therapy on a Malignant Vascular Neoplasm of the Cerebellum." *A.M.A. Archives of Pathology.* Vol. 69, January 1960, pp. 44B54.

Farr, L.E., S.W. Lippincott, W. Kahle, W.B. Haymaker, and P. Yakovlev. "The Neuropathological and Topographical Study of Whole Brains Following Neutron Capture Therapy for Glioblastoma Multiforme" in *Proc. III Congress Int'l de Neuropathologie, Acta Medica Belgica.,* 1958, pp. 227B228.

Farr, L.E., J.S. Robertson, and E. Stickley. "Use of the Nuclear Reactor for Neutron Capture Therapy of Cancer" from*International Conference on the Peaceful Uses of Atomic Energy.* June 23, 1955.

Godwin, J. T., L E. Farr, W.H. Sweet, and J.S. Robertson. "Pathological Study of Eight Patients with Glioblastoma Multiforme Treated by Boron Neutron Capture Therapy Using Boron 10." *Cancer*, Vol. 8. No. 3, May-June 1955, pp. 601B615.

Farr, L.E., W.H. Sweet, L.B. Locksley, and J.S. Robertson. "Neutron Capture Therapy of Gliomas Using Boron." *Transactions of the American Neurological Association*. 1954, pp. 110B113.

Memorandum. L.E. Farr. February 26, 1951. Brookhaven National Laboratory Project HB15. Brookhaven National Laboratory, Clinical Research Center, Bldg. 490, Human Medical Research Protocols.

Letter. D.L.Sutherland to L.E. Farr. May 23, 1953. Brookhaven National Laboratory Project HB15. Brookhaven National Laboratory, Clinical Research Center, Bldg. 490, Human Medical Research Protocols. "

**BNL-3. Iodine-131 Used to Measure Thyroid Function in Young Children with Nephrotic Syndrome**

Scientists at Brookhaven National Laboratory conducted a series of experiments using a group of young children suffering from nephrotic syndrome (kidney disease). In 1951, eight of these children, aged 2 to 6 years, with renal functions varying from 14 to 225 percent normal and with varying degrees of edema or lack thereof, were studied after administration of iodine-131 (I131).

A uniform ability by the thyroid gland to extract radioactive iodine from the blood was noted. The maximum uptake by the gland varied from 30 to 60 percent of the administered doses, which ranged from 3 to 5 microcuries. The data was evaluated against comparable data obtained in normal children. The scientists concluded that there is no impairment of the thyroid gland in its ability to take up iodine in young children with the nephrotic syndrome.

**References**

Farr, L.E., J.L. Gamble, C.G. Foster, and J.S. Robertson. "Thyroid Function in Young Children with Nephrotic Syndrome." *Quarterly Progress Report April 1BJune 30, 1951*. Upton: Brookhaven National Laboratory, p. 119. Brookhaven National Laboratory, BNL Medical Dept., Bldg. 490, Annual Periodic Reports. "

**BNL-4. Radioactive Chlorine, Bromine, and Sodium in Extracellular Fluids**

From 1952 to 1953, the total volume of extracellular fluids in 15 humans was studied at Brookhaven National Laboratory. Five chronically ill hospital patients were injected with chlorine-38 (Cl38) and sodium-24 (Na24). Ten other patients were injected with Cl38 and bromine-82 (Br82). Total radiation doses were planned so that the weekly dose limit of 0.3 rad would not be exceeded. Blood samples were drawn at various times after injection and the radioactivity measured. During the course of this experiment, urine, red blood cells, pleural fluid, gastrointestinal fluid, and spinal fluid were also measured for Cl38 and Br82. The subjects were considered to be "normal" for purposes of this study. The U.S. Atomic Energy Commission funded this study. (Previously described in #3 on the original list of 48 experiments released by DOE in June 1994)

**References**

Gamble, J.L., J.S. Robertson, C.A. Hannigan, C.G. Foster, and L.E. Farr. *Chloride, Bromide, Sodium, and Sucrose Spaces in Humans.*Upton: Brookhaven National Laboratory, BNLB1326, February 3, 1953. U.S. Department of Energy Archives, Record Group 326, U.S. Atomic Energy Commission, Division of Biology and Medicine, Box 3358, Folder 14. "

**BNL-5. Measurement of the Turnover Rate of Sodium in Nephrotic Children Using Sodium-24**

Brookhaven National Laboratory conducted an experiment in 1954 on nephrotic children to study the rates of exchange of sodium in edema fluid, in ascitic fluid, and in the blood plasma. Sodium-24 (Na24) as sodium chloride was injected intravenously and the plasma Na24 disappearance curve was analyzed and compared to the Na24 appearance curves in the two fluids. It was found that in both fluids the ratio of (a) the rate of change of the Na24 concentration to (b) the difference between the Na24 concentration in the plasma and that in the fluids increased with time during the first few hours after injection.

**References**

Robertson, J.S. "The Turnover Rate of Sodium in Edema Fluid and "scites." in *Federation Proceedings of the American Society for Experimental Pathology*. Vol. 13, March 1954, p. 442.

Robertson, J.S. "The Turnover Rate of Sodium in Edema Fluid and "scites." *Quarterly Progress Report April 1BJune 30, 1954*. Upton, NY: Brookhaven National Laboratory, p. 50. Brookhaven National Laboratory, BNL Medical Dept., Bldg. 490, Annual Periodic Reports. "

**BNL-6. Degradation Rate of Iodine-131- Labeled Normal Albumin Using the Whole Body Gamma Spectrometer**

In 1954, Brookhaven National Laboratory conducted metabolic studies in humans with I131- tagged serum albumin. In prior studies, plasma protein fractions labeled with I131 had been administered to both normal subjects and to patients. A gamma spectrometer was constructed to determine transfer rates of locally injected I131 serum albumin and other substances tagged with gamma-emitting isotopes.

In this study, the biological half-life of I131-labeled human albumin was determined by two methods. The first method was the calculation from serum and urine samples following injection of 59 microcuries of I131. The second method used the whole body gamma spectrometer to measure the amount of label present in the body at stated intervals following injection of 6.6 microcuries of I131. Plasma-specific activity and urinary excretion were followed up to 60 days following injection. The rate of disappearance of the labeled albumin was measured in two patients. The first was a 49-year-old woman with chronic cystic mastitis; the second was a 40-year-old woman who had previously had a mastectomy. This research was supported by the U.S. Atomic Energy Commission.

**References**

Lippincott, S.W., S.H. Cohn, J.S. Robertson, and L.E Farr, "*In Vivo*Measurement by the Whole Body Gamma Spectrometer of the Degradation Rate of I131 Labeled Normal Albumin." *Laboratory Investigation.* Vol. 10, Pt. 1, May-June 1961, pp. 481B491.

Lewallen, C.G. "Studies in Humans with I131 Serum Albumin."*Quarterly Progress Report July 1BSeptember 30, 1954*. Upton, NY: Brookhaven National Laboratory, p. 51. Brookhaven National Laboratory, BNL Medical Dept., Bldg. 490, Annual Periodic Reports.

Cohn, S.H. "Whole body Counting." *Quarterly Progress Report April 1BJune 30, 1959*. Upton, NY: Brookhaven National Laboratory, pp. 41B42. Brookhaven National Laboratory, BNL Medical Dept., Bldg. 490, Annual Periodic Reports. "

**BNL-7. Studies on the Metabolism of Plasma Proteins in the Nephrotic Syndrome**

This study was conducted at Brookhaven National Laboratory from 1955 to 1956. The subjects were six children in various phases of the nephrotic syndrome, including one child who had recovered from the illness, and nine normal subjects, consisting of 8 men and one woman, all between the ages of 21 and 29. These subjects were given intravenous tracer doses of radioiodinated human plasma albumin and radioiodinated human gammaglobulin. Three of the children were then given intravenous injections of radioiodinated human iron-binding globulin. The amount of activity administered was not to exceed 1.5 microcuries per kilogram of body weight.

The disappearance of specific radioiodinated plasma protein from circulation and its cumulative appearance in the urine were studied; the urinary excretion of nonprotein radioiodine was also investigated. This study was supported by grants from the National Institutes of Health, the United States Public Health Service, the Muscular Dystrophy Association of America, the Playtex Park Research Institute, and the U.S. Atomic Energy Commission.

**References**

Gitlin, D., D.G. Cornwell, D. Nakasato, J.L. Oncley, W.L. Hughes, and C.A. Janeway. "Studies on the Metabolism of Plasma Proteins in the Nephrotic Syndrome: The Lipoproteins." *Journal of Clinical Investigation*. Vol. 37, No. 2, February 1958, pp. 172B184.

Gitlin, D., C.A. Janeway, and L.E. Farr. "Studies on the Metabolism of Plasma Proteins in the Nephrotic Syndrome: Albumin, Gamma-Globulin and Iron-Binding Globulin." *Journal of Clinical Investigation.* Vol. 35, January-June 1956, pp. 44B56.

Gitlin, D., C.A. Janeway, and L.E. Farr. "Studies on the Metabolism of Plasma Proteins in the Nephrotic Syndrome. I. Albumin, Gammaglobulin, and Iron-Binding Globulin." *Quarterly Progress Report January 1BMarch 31, 1956*. Upton, NY: Brookhaven National Laboratory, p. 52. Brookhaven National Laboratory, BNL Medical Dept., Bldg. 490, Annual Periodic Reports. "

**BNL-8. Metabolism Studies with Acetate Labeled with Carbon-14**

In 1957, at Brookhaven National Laboratory, studies were carried out to investigate carbon acetate metabolism. Forty to 100 microcuries of 1-C14Blabeled acetate or 2-C14Blabeled acetate were intravenously injected into human subjects. Diabetics, who had fasted and were denied insulin on the day of the experiment, served as subjects. Both stable and unstable diabetics were used in this experiment, including a 12-year-old girl who had fasted for 15 hours and had received no insulin on the day of the experiment.

After medical staff administered the intravenous trace dose of C14-labeled acetate, metabolism products as triglycerides, cholesterol, ketone bodies, glucose, pyruvic and alpha-ketoglutaric acids, and carbon dioxide were isolated from the blood, urine, and breath, and analyzed by C14 content. The study was supported by the U.S. Atomic Energy Commission.

**References**

Hennes, A.R. and W.W. Shreeve. "Hormonal Effects on C14 Acetate Metabolism in the Human." in *Proceedings of the Society for Experimental Biology and Medicine*. Vol. 100, February 1959, pp. 246B250.

Shreeve, W.W. and A.R. Hennes. "Effect of Adrenal Steroid Hormones on the Metabolic Fate of C14-Labeled Acetate in Human Subjects." *Quarterly Progress Report July 1BSeptember 30, 1957*. Upton, NY: Brookhaven National Laboratory, p. 36. Brookhaven National Laboratory, BNL Medical Dept., Bldg. 490, Annual Periodic Reports.

Shreeve, W.W. and A.R. Hennes. "Effect of Adrenal Steroid Hormones on the Metabolism of 2-C14-Pyruvate in Diabetic Humans." *Quarterly Progress Report July 1BSeptember 30, 1957*. Upton: Brookhaven National Laboratory, pp. 36B37. Brookhaven National Laboratory, BNL Medical Dept., Bldg. 490, Annual Periodic Reports. "

**BNL-9. Metabolic Studies with Manganese-54**

In 1957, Brookhaven National Laboratory conducted human metabolic studies with the isotope manganese-54 (Mn54). This study was the first to use Mn54 in human subjects. Manganese had been assumed to participate indirectly in hematopoiesis (blood formation). Two or more patients were injected with Mn54 and followed to determine body surface, blood radioactivity, and excretion rates. Blood taken from one of the patients 66 days after injection contained almost the entire radioactivity in the red cell fraction. This research was supported by the U.S. Atomic Energy Commission.

**References**

Borg, D.C. and G.C. Cotzias. "Incorporation of Manganese into Erythrocytes as Evidence for a Manganese Porphyrin in Man."*Nature*. Vol. 182, December 13, 1958, pp. 1,677B1,678.

Borg, D.C., G.C. Cotzias, and M. Birnbaum. "Basic Physiology of Manganese." *Quarterly Progress Report July 1BSeptember 30, 1957*. Upton, NY: Brookhaven National Laboratory, p. 41. Brookhaven National Laboratory, BNL Medical Dept., Bldg. 490, Annual Periodic Reports. "

**BNL-10. Magnesium Metabolism Studies in Humans with Magnesium-28**

In 1959, Brookhaven National Laboratory used magnesium-28 (Mg28) to study the *in vivo* distribution and retention function of magnesium in man. Ten adultsC3 males and 7 females--were studied at the metabolic wards of the Brookhaven Medical Research Center Hospital. All but one of the male subjects suffered from hypertension. Nine of the subjects received intravenous injections of the isotope; two were studied after oral administration of Mg28. The intravenous dosages, which ranged from 20 to 104 microcuries, were slowly administered to prevent toxic symptoms. Excretion rates were analyzed by measuring Mg28 in urine and stool specimens. This study was conducted with support from the U.S. Atomic Energy Commission.

**References**

Silver, L.J. Robertson and L.K. Dahl. "Magnesium Turnover in the Human Studied with Mg28." *Journal of Clinical Investigation*. Vol. 39, February 1960, pp. 420B425. "

**BNL-11. Whole Body Counting Technique Used to Study Turnover of Globulins Labeled with Iodine-131**

In 1959, Brookhaven National Laboratory conducted studies on the turnover of beta- and gamma-globulins labeled with iodine-131 (I131). The investigators used both the conventional method of blood and urine sampling and a new technique that used the whole body gamma spectrometer. The new device allowed scientists to measure the retention of labeled globulins over long periods of time following administration of low levels of isotopes, particularly internally deposited gamma emitters.

One patient participated in these studies; he was placed in the whole body counter 34 times. The subject was a multiple myeloma patient who was injected with the I131-labeled globulins on three occasions. The amount of iodine activity in the labeled globulins ranged from 17 to 50.16 microcuries. The study was supported by the U.S. Atomic Energy Commission.

**References**

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Lippincott, S.W., W.L. Hughes, and S. Korman. "Turnover of Labeled Globulins as Correlated with Serum Electrophoretic Pattern in Multiple Myeloma." *Bulletin of the Medical Department July 1, 1959*. Upton, NY: Brookhaven National Laboratory, p. 16. Brookhaven National Laboratory, BNL Medical Dept., Bldg. 490, Annual Periodic Reports. "

**BNL-12. A Study of Metabolic Pathways of Carbohydrate Formation Using Carbon-14**

Studies were carried out at Brookhaven National Laboratory to study the metabolic pathways by which human subjects in various metabolic states form glucose. In this study, the subjects were three men with bronchogenic carcinoma, three male diabetics, and one 13-year-old female diabetic.

On the day of the experiment, the subjects were denied food and insulin and then were injected with C14-acetate. Carcinoma patients received 200 microcuries; diabetic patients received from 40 to 100 microcuries as a single 1- to 2-minute injection. Breath samples were collected and analyzed. Some of these patients participated in multiple studies.

In a related study, two moderately diabetic subjects fasted and were given by mouth 0.5B1.0 grams of C14-labeled ethanol per kilogram of body weight. The blood and urinary glucose were isolated. The results indicated that in one patient about 1 percent as much C14 was present in total body glucose as had been excreted as CO2 after 22 hours. In the other patient about 2 percent as much was present. Both patients had excreted about 25 percent of the total administered C14 by the end of 24 hours. This research was partly supported by the U.S. Atomic Energy Commission.

**References**

Shreeve, W.W., A.R. Hennes, and R. Schwartz. "Production of C14O2 from 1- and 2-C14-Acetate by Human Subjects in Various Metabolic States." *Metabolism*. Vol. 8, September 1959, pp. 741B756.

Shreeve, W.W. and M. Conovitz. AA Study of Metabolic Pathways of Carbohydrate Formation in Diabetes by Means of Carbon-14."*Quarterly Progress Report July 1BSeptember 30, 1955*. Upton, NY: Brookhaven National Laboratory, p. 45. Brookhaven National Laboratory, BNL Medical Dept., Bldg. 490, Annual Periodic Reports. "

**BNL-13. Analysis of Blood Glucose Following Intravenous Injection of Carbon-14**

In 1959, at Brookhaven National Laboratory, diabetic and nondiabetic patients were given intravenous injections of 40 to 150 microcuries of lactate or pyruvate labeled with carbon-14 (C14). The injections were followed by serial analysis of blood glucose for C14 content. Subsequently, glycogen was injected in an attempt to estimate relative glycogen labeling. Seven diabetic and three nondiabetic subjects were used in this study. The effects of insulin, tolbutamide, and glucose load were also studied in the same patients. This study was funded by the U.S. Atomic Energy Commission.

**References**

De Meutter, R.C. and W.W. Shreeve. "Conversion of DL-Lactate-2-C14 or -3-C14 or Pyruvate-2-C14 to Blood Glucose in Humans: Effects of Diabetes, Insulin, Tolbutamide, and Glucose Load."*Journal of Clinical Investigation*. Vol. 42, No. 4, 1963, pp. 525B533.

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**BNL-14. The Metabolism and Fate of Tritiated Thymidine in Man**

This study was conducted in 1959, at Brookhaven National Laboratory as part of an investigation of H3-thymidine as a label for DNA of proliferating cells *in vivo* and *in vitro* systems. In this study, H3-thymidine metabolism was studied in selected patients following intravenous injection. All patients were beyond reproductive age and were judged to have short life expectancies. In two control patients with normal hematopoiesis (blood-formation), H3-thymidine rapidly cleared the plasma and distributed in a volume as large as total body water within a few minutes after injection. Two of the subjects selected for this initial investigation were patients with brain tumors, judged to have short life expectancies and to be in hemopoietic equilibrium at the time of study. This research was supported by the U.S. Atomic Energy Commission.

**References**

Rubini J.R., E.P Cronkite, V.P. Bond, and T.M. Fliedner. "The Metabolism and Fate of Tritiated Thymidine in Man." *Journal of Clinical Investigation.* Vol. 39, June 1960, pp. 909B918.

Cronkite, E.P., J.R. Rubini, S.A. Killmann, V.P. Bond, J. Bateman, L. Feinendegen, E. Adamik, L. Wood, M. Canner, M. Pavelec, and C. Sipe. "Metabolism of H3-Thymidine and H3-Labeled DNA."*Quarterly Progress Report April 1BJune 30, 1959.* Upton, NY: Brookhaven National Laboratory, pp. 55B56. Brookhaven National Laboratory, BNL Medical Dept., Bldg. 490, Annual Periodic Reports. "

**BNL-15. Study of Carbon-14-Labeled Ascorbic Acid Metabolism**

A research collaboration in the early 1970s between Brookhaven National Laboratory and Verwoerd Hospital in Pretoria, South Africa, resulted in a study of ascorbic acid (Vitamin C) labeled with carbon-14 (C14) metabolism in Bantu tribesmen with a disease called hemosiderosis. This disease is similar to scurvy and is common among the South African Bantu. It involves excessive iron accumulation and failure to utilize ascorbic acid. This research was conducted to determine the metabolism of ascorbic acid. Four adult Bantu men who had been diagnosed with hemosiderosis and scurvy participated in this study. Ascorbic acid labeled with carbon-14 was given orally, after which blood samples, urine samples, and respiratory CO2 samples were collected and analyzed. The results indicated that most of the C14 was excreted primarily by respiration and secondarily in the urine. This work was jointly supported by the U.S. Atomic Energy Commission and the South African Atomic Energy Board.

**References**

Hankes, L.V., C.R. Jansen, and M. Schmaeler. "Ascorbic Acid Catabolism in Bantu with Hemosiderosis (Scurvy)." *Biochemical Medicine.* Vol. 9, 1974, pp. 244B255. "

**Hanford Sites**

**HS-1. Ingestion of Iodine-131 in Milk by Hanford Employees**

In 1963, milk from dairy cows fed iodine-131 (I131) was consumed by eight General Electric/Hanford workers either as a single dose or as several daily doses. During the study, the amount of iodine in the cows' diet was increased from 5 milligrams per day to 2 grams per day. The resulting uptake by the human thyroid was determined in Hanford's whole body counter facility. Participants were Hanford scientists who volunteered to drink the milk and be counted over a period of about one month. This work was supported by the U.S. Atomic Energy Commission. (Previously described in #41 on the original list of 48 experiments released by DOE in June 1994)

**References**

Watson, E.C., I.C. Nelson, D.H. Wood, R.O. McClellan, and L.K. Bustad. "Effect of Varying Stable Iodine in Diets of Cows Fed I131 on Uptake of I131 in Man Drinking the Milk--An Abstract." in*Biology of Radioiodine: Proceedings of the Hanford Symposium on the Biology of Radioiodine, Richland, Washington, July 17B19, 1964.* Oxford: Pergamon Press, 1964, p. 339.

Handwritten Monthly Report. J.K. Soldat to R.F. Foster. July 1963. Washington State University Tri-Cities Campus, PNL, DOE Richland Public Reading Room, I131, Open Shelving, PNLB9369BDEL. "

**HS-2. Intentional Release of Iodine-131 at Hanford in 1963**

In July 1963, Hanford Laboratory conducted a study that involved the release of 120 microcuries of iodine-131 (I131) into the environment. These releases were designed to characterize the dispersion of radiation to the environment. The purpose of the experiment was to enable scientists to study how the radioactive iodine spread in turn through the air, soil, and vegetation, and how it affected animals. Two volunteer human subjects (Hanford employees), were stationed in the expected path of the radiation cloud. These subjects intentionally inhaled I131 from the release and were subsequently measured for thyroidal uptake of I131. These experiments were performed under contract with the U.S. Atomic Energy Commission.

**References**

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Handwritten Monthly Report. J.K. Soldat to R.F. Foster. July 1963. Washington State University Tri-Cities Campus, PNL, DOE Richland Public Reading Room, I131, Open Shelving, PNLB9369BDEL.

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**Idaho Sites**

**IS-1. Administration of Radioactive Material to Volunteers to Test or Calibrate Analytical Equipment**

From 1965 to 1972, as many as 18 employees at the U.S. Atomic Energy Commission's Health Services Laboratory at the National Reactor Testing Station in Idaho voluntarily swallowed radioactive material, or inhaled radioactive noble gases, prior to being placed in whole body counters. The following radionuclides were used in the experiments: Ar41, K42, Mn54, Co60, Zn65, Kr85m, Zr95/Nb95, Ru106, Ag110m, I131, Cs132, Xe133, Cs137, and Ce144. In most of the ingestion cases, the radioactive material was encapsulated in plastic so that no radioactive material was absorbed into body tissues. These measurements were performed to develop and evaluate new whole body-counting equipment and to calibrate that equipment. The whole body-counting equipment was used to measure the amount of radioactivity inside the body of occupational radiation workers exposed to radioactive material. Policies for conducting these experiments limited radiation doses to volunteers to levels below the occupational radiation-protection guidelines in effect at the time. (This experiment was referenced in the Markey report.)

**References**

Anderson, J.I. and D.G. Olson. "A Rotational Technique for Assessing Quantity and Distribution of Body Radioactivity."*Health Physics*. Vol. 13, 1967, p. 719.

Olson, D.G. AA Direct Calibration Using Gamma Spectrometry for Measuring Radioactivity in Humans." *Health Physics*. Vol. 14, 1968, p. 438.

Howard, L.E., J.H. Spikard, and M. Wilhelmsen. "A Human Radioactivity Counter and Medical Van."*Health Physics*. Vol. 21, 1971, p. 417.

Anderson, J.I. and D.G. Olson. "Computerized Helical Scanning to Determine the Location of Specific Nuclides in the Human Body."*Health Physics*. Vol. 23, 1972, p. 325.

Sill, C.W. *Some Guidelines for Studies Involving Internal Administration of Radioactive Materials to Human Volunteers*. Idaho Falls: Idaho Operations Office, U.S. Atomic Energy Commission, IDOB12058, October 1966. "

**IS-2. Controlled Environmental Radioiodine Tests (CERT)**

Atomic Energy Commission scientists and other professionals at the National Reactor Testing Station in Idaho conducted the Controlled Environmental Radioiodine Tests (CERT) to study the transport of radioiodine through the air-vegetation-cow-milk-human food chain from 1963 through 1968. Five of the 24 CERT tests involved exposure of volunteers to iodine-131 to study the transport of radioiodine to and through the human body.

In the first test--CERT No. 1Cseven individuals consumed milk from a cow that had grazed in a pasture where the radioiodine was deposited, and their uptake of radioiodine was determined by thyroid gland monitoring. Average thyroid dose was 0.39 rad; the maximum thyroid dose was 0.63 rad. In CERT Nos. 2, 7, and 10, three individuals, seven individuals, and one individual, respectively, were reportedly exposed during radioiodine releases over the pasture to determine their uptake by inhalation. The number of individuals involved in a similar inhalation experiment during CERT No. 11 was not listed in published reports; however, whole body-counting logs indicate that 10 individuals were apparently involved. Thyroid doses from inhalation during CERT No. 2 were no greater than 0.015 rad, and the reported thyroid activity observed during CERT No. 7 was about the same as that in CERT No. 2. Thyroid doses to volunteers were not reported for CERT Nos. 10 and 11. The volunteers were employees of the U.S. Atomic Energy Commission. (This experiment was referenced in the Markey report.)

**References**

Hawley, C.A., C.W. Sill, G.L. Voelz, and N.F. Islitzer. *Controlled Environmental Radioiodine Tests at the National Reactor Testing Station.* Idaho Falls: Idaho Operations Office, U.S. Atomic Energy Commission, IDOB12035, June 1964.

Hawley, Jr., C.A., Editor. *Controlled Environmental Radioiodine Tests at the National Reactor Testing Station 1965 Progress Report*. Idaho Falls: Idaho Operations Office, U.S. Atomic Energy Commission, IDOB12047, February 1966.

Bunch, D.F., Editor. *Controlled Environmental Radioiodine Tests Progress Report Number Two.* Idaho Falls: Idaho Operations Office, U.S. Atomic Energy Commission, IDOB12053, August 1966.

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**Lawrence Berkeley Laboratory**

**LBL-1. Treatment of Leukemia With Phosphorous-32**

Between 1936 and 1947, patients with various types of leukemia were treated with phosphorous-32 (P32) with and without supplemental x-ray treatments. Approximately 129 patients with chronic myelogenous leukemia and 100 patients with chronic lymphatic leukemia were treated at the Radiation Laboratory and the Donner Laboratory of the University of California in Berkeley and San Francisco. Previously it had been demonstrated that radiophosphorous concentrated in the bone marrow and soft tissue of leukemic mice. Therefore, it was expected that P32 would provide a highly localized radiation source for human leukemic patients.

Both studies employed similar average doses of 1 to 2 microcuries per week for 4 to 8 weeks, although higher doses were also included. Approximately half of the patients studied previously received x-ray treatment. It was found that P32 treatment increased the quality of life for chronic myelogenous leukemic patients, but did not prolong the duration of life. In the case of chronic lymphatic leukemia patients, the quality of life was improved and the duration was prolonged. Based on these findings, an unspecified number of chronic lymphatic patients were treated with P32 through 1960. This research was partly supported by grants from the International Cancer Research Foundation.

**References**

Lawrence, J.H., R. L. Dobson, B.V.A. Low-Beer, and B.R. Brown. "Chronic Myelogenous Leukemia." *Journal of the American Medical Association*. Vol. 136, 1948, pp. 672B677.

Lawrence, J.H., B.V.A. Low-Beer, and J.W.J. Carpender. "Chronic Lymphatic Leukemia." *Journal of the American Medical Association.* Vol. 140, 1949, pp. 585B588. "

**LBL-2. Metabolic Studies of Bone Tumors Using Strontium-89**

An experiment was conducted in 1942 at the Radiation Laboratory of the University of California, Berkeley, on the uptake of radiostrontium by bone tumors. Strontium-89 (Sr89) was administered to six subjects prior to biopsy or amputation. Tissue samples were collected and analyzed to determine the Sr89 uptake. The subjects consisted of five males and one female, ranging in age from 9 to 54 years. Five of the subjects received intravenous injection solutions which ranged from 326 to 1,462 microcuries. The sixth subject was given 1,183 microcuries of Sr89 orally. This experiment showed that Sr89 had therapeutic value in treating certain types of bone cancers. Some of these cancer patients also received therapeutic amounts of Sr89 (a few millicuries), but details are not available. This research was supported by the Rockefeller Foundation and the Columbia Fund for Medical Physics.

**References**

Treadwell, A. de G., B.V.A. Low-Beer, H. L. Friedell, and J.H. Lawrence. "Metabolic Studies on Neoplasm of Bone with the Aid of Radioactive Strontium." *American Journal of the Medical Sciences.* Vol. 204, 1942, pp. 521B523. "

**LBL-3. Inhalation Studies Using Carbon**

From 1944 to 1945, the Aero Medical Laboratory, University of California, Berkeley and the Department of Physiology, Columbia University, conducted a collaborative study using carbon. The radioactive carbon was used as a tracer to determine whether in the human body carbon monoxide (CO) oxidizes to carbon dioxide (CO2). The subjects consisted of four men, including three of the researchers conducting the experiment. The four men inhaled a relatively large dose of CO labeled with carbon, subsequent to which they breathed oxygen. During this time, their expired CO2 was collected and measured for radioactivity, the presence of which would prove that the human body could convert CO to CO2. Geiger counters were placed over various parts of the body (thigh, chest, spleen, and liver) to measure the uptake and elimination of CO2. The CO oxidized to CO2 by the body amounted to less than 0.1 percent of the CO lost from the blood. This work was supported by the U.S. Atomic Energy Commission.

**References**

Tobias C.A., J.H. Lawrence, F.J.W. Roughton, W.S. Root, and M.I. Gregersen. "The Elimination of Carbon Monoxide from the Human Body with Reference to the Possible Conversion of CO to CO2."*American Journal of Physiology.* Vol. 145, No. 2, December 1945, pp. 253B263.

Lawrence, J.H. "Positron Emitting Isotopes: Investigative and Diagnostic Studies," pp. 247B262. Lawrence Berkeley Laboratory, John Hundale Lawrence Files, Accession 434B92B0066, File Code 19B14B6, Carton 15, Folder Positron Emitting Isotopes. "

**LBL-4. Inhalation of Zirconium-89 on Smoke Particles**

Inhalation studies were conducted at Lawrence Berkeley Laboratory in about 1945 using an active smoke containing zirconium-89 (Zr89). One member of the research team was the only human subject. The purpose of this experiment was to determine the degree of retention by the lungs of very finely divided active smoke suspended in air. The results showed that almost 100 percent of the inhaled activity (about 0.5 microcurie of Zr89) was retained within the lungs and upper respiratory tract. This work was supported by the U.S. Atomic Energy Commission. (Previously described in #30 on the original list of 48 experiments released by DOE in June 1994)

**References**

Scott, K.G., D. Axelrod, J. Crowley, and J.G. Hamilton. "Deposition and Fate of Plutonium, Uranium and Their Fission Products Inhaled as Aerosols by Rats and Man." *Archives of Pathology***.**Vol. 48, No. 1, July-December 1949, pp. 31B54. "

**LBL-5. Radioactive Phosphorous as a Possible Diagnostic Procedure for Breast Tumors**

In 1946, the University of California Hospital, San Francisco, employed phosphorous-32 (P32) in tracer studies to develop a new diagnostic procedure for distinguishing between malignant and benign breast tumors. Twenty-five female patients with breast tumors were included in the study. All patients had been scheduled for surgery. Each patient was intravenously administered 300 to 500 microcuries of P32 as sodium phosphate 24 or 48 hours prior to surgery. Surface measurements were made over the tumor and over a control area on the opposite normal breast, 2, 4, 6, and 20 hours after the injection of P32. An increase in counts was found over the surface of malignant tumors, whereas counts were not elevated over benign tumors. The malignancy of the tumor was determined by surgery. Results indicated that P32 might be used as a diagnostic procedure for breast cancer, except for very slow-growing or deep-seated cancers.

**References**

Low-Beer, B.V.A., H.G. Bell, H.J. McCorkle, R.S. Stone, H.L. Steinbach, and W.B. Hill. "Measurement of Radioactive Phosphorus in Breast Tumors in Situ: a Possible Diagnostic Procedure." *Radiology*. Vol. 47, pp. 429B496. "

**LBL-6. Comparison of the Uptake of Zirconium-95 in Tumor and Normal Tissue**

In 1946, at the University of California San Francisco and the Crocker Radiation Laboratory, University of California, Berkeley research was carried out to study the deposition of zirconium in a human subject. The subject, a 55-year-old female patient with a reticulo endothelial tumor that had arisen in the spleen and then metastasized to the liver and left leg, was given a test dose of Zr95. This was administered intravenously as an isotonic saline solution 24 hours prior to a midthigh amputation of the left leg. This subject was administered 1.76 millicuries of Zr95 in saline by intravenous injection 24 hours prior to a scheduled midthigh amputation of the left leg. Samples of the tumor, as well as normal tissue, were later obtained from the limb for Zr95 assay. The tumor was found to have greater uptake of Zr95 than the normal tissues of the body. External counting 2 hours after the Zr95 injection showed that the liver contained about 90 percent of the total measurable deposition and the tumor had about 10 percent of the total deposition. This study was supported by the U.S. Atomic Energy Commission.

**References**

Low-Beer B.V.A., K.G. Scott, J.G. Hamilton, and R.S. Stone. "Comparative Deposition of Zr95 in a Reticulo Endothelial Tumor to Normal Tissues in a Human Patient." Berkeley: University of California Radiation Laboratory, UCRLB68. "

**LBL-7. Autoradiographic Studies of the Distribution of Radiolabeled Lewisite and Mustard Gas on Skin**

This experiment was conducted in 1947 at the Crocker Radiation Laboratory, University of California, Berkeley and the University of California Medical School in San Francisco. The experiment sought to determine the distribution of mustard and lewisite in skin and eye tissues. These two chemical-warfare gases were labeled with radioactive sulfur (S35) and radioactive arsenic (As74). Small areas of the skin of four normal subjects were exposed to the two labeled gases. Two experiments were performed with mustard gas labeled with S35. The first involved a 10-minute exposure to 475 micrograms of labeled chemical; the second, a 15-minute exposure to 475 micrograms. In both cases, the exposed area was 0.43 square centimeter and biopsy specimens of these areas were taken 24 hours after exposure.

Two experiments were also performed on lewisite labeled with 10 micrograms of As74; the first involved a 10-minute exposure to 475 micrograms of lewisite; the second, a15-minute exposure to 475 micrograms. The new technique of autoradiography was used to determine the skin layer at which the fixation took place on the biopsied human skin samples. Lewisite was found to fix primarily in the epidermis and mustard gas fixed in both the epidermis and dermis.

**References**

Axelrod, D.J. and J.G. Hamilton. "Radio-Autograph Studies of the Distribution of Lewisite and Mustard Gas in Skin and Eye Tissues." *American Journal of Pathology.* Vol. XXIII, 1947, pp. 389B411. "

**LBL-8. Injection of Americium-241**

On June 10, 1947, at the University of California San Francisco, a 16-year-old Chinese male patient of Chinese Hospital in San Francisco, identified as Cal-A, with osteogenic sarcoma of the left femur, and general metastases, received an intramuscular injection of americium-241 (Am241). Estimated dose is around 0.2 microcurie. The same day, two rats were given intramuscular injections of 1 cc of solution made from the same specifications as the Cal-A injection. Readings of the human subject's urine and feces were collected through at least June 24, 1947. On June 12, 1947, the subject was amputated at the left midthigh. Samples of the amputation tissue were dissected the next day. The samples were read for isotope uptake, as the tumor was expected to have higher uptake than normal body tissues. Studies were made of the tumor; the bone tissue in which the tumor was found; the surrounding tissues, both bone and connective; and the muscles. Measurements from the amputated tissues were compared with the rat data; the patient was discharged on July 27, 1947. Rat data showed considerable uptake by the liver; human data appears to show 13 to 20 percent uptake by the bone. The patient died of preexisting ailments on June 15, 1948. The experiment appears to have been done as a comparison to previous human subjects studies involving plutonium, as data sheets for Cal-A show standards for measurements set against Cal-1 (a human injected with plutonium-238).

**References**

Lawrence Berkeley Laboratory, Joseph G. Hamilton Records, Archives and Records Office, Folder No: Am H (95H).

**LBL-9.Uptake of Iodine-131 in Thyroids of Psychiatric Patients**

From July 1949 to April 1950 a cooperative research project was conducted by the Departments of Psychiatry, Radiology and Medicine at the University of California Medical School and the Langley Porter Clinic in San Francisco. The objective of this project was to determine whether thyroid function was normal or abnormal in persons with mental illness. Sixty-five subjects were selected from the regular in-patient group at the Langley Porter Clinic. Among the subjects were patients with schizophrenia, manic-depression, mixed psychoneurosis, and anorexia nervosa. A control group was selected of volunteers from the clinics, clerical, and medical staff. Subjects were injected with 150 microcuries of iodine-131 (I131); subsequently, the concentration of I131 in the thyroid was then measured six times over a 72-hour period. The test and control groups underwent medical and psychiatric evaluations , including serum-bound iodine, basal metabolism, plasma cholesterol, and electroencephalogram. No abnormal thyroid function was found in the group with mental illness and no significant differences were detected between the patients and the controls in this study. This study was partly funded by the U.S. Atomic Energy Commission. (Previously described in #2 on the original list of 48 experiments released by DOE in June 1994)

**References**

Stone, R.S. *Biological Effects of Radiations from External and Internal Sources, Progress Report July 1, 1949 to April 15, 1950*. San Francisco: University of California Radiation Laboratory, April 1950. U.S. Department of Energy Archives, Record Group 326, U.S. Atomic Energy Commission, Box 3358, Folder 22.

Bowman, K.M., E.R. Miller, M.E. Dailey, A. Simon, B. Frankel, and G.W. Lowe. "Thyroid Function in Mental Disease Measured with Radioactive Iodine, I131." *The American Journal of Psychiatry.* Vol. 106, No. 7, February 1950. "

**LBL-10. Sodium-24 Uptake Studies on Patients with Rheumatoid Arthritis**

During the mid 1940s to the early 1950s, the University of California Lawrence Berkeley Laboratory conducted studies on the uptake of sodium-24 (Na24) to evaluate vascular abnormalities in persons with rheumatoid arthritis. Sodium-24 was administered by intravenous injection, usually in 50-microcurie amounts. Systemic transport of Na24 was followed using two gamma Geiger counters: one in the subject's hand, the other placed under a knee. The results showed an impeded blood flow in diseased areas of the body. Uptake of Na24 in the knee joint was also studied after three patients drank a solution of sodium chloride labeled with Na24 in water.

**References**

Tobias, C. "Sodium Uptake Studies." Lawrence Berkeley Laboratory,*Cornelius A. Tobias Papers,* Accession 434B89B100, File Code 10B08B063, Carton 25/38, Folder Sodium Uptake Studies. "

**LBL-11. Radiation-Related Studies Involving Inmates at San Quentin Prison**

From 1949 to the late 1950s, the University of California conducted studies involving radioactive isotopes using inmates at San Quentin Prison as volunteer subjects. Studies included the following: (a) 1949 to 1951: studies on red blood cell production--Blood was drawn from participants, labeled with iron-59 (Fe59), and reinjected into the respective subjects. Four samples were drawn at specific intervals over the next 2 hours. The procedure was repeated for 4 successive days, during which Fe59-labeled red blood cells were counted. (b) 1950: studies on blood volume--At least 13 participants had blood drawn, labeled with phosphorus-32 (P32), and reinjected. Blood volume in the subject was subsequently measured. (c) late 1950s: Studies on red cell volumeCchromium-51 (Cr51) was used as a label to measure red blood cell volume in 201 healthy participants.

**References**

Letter. J.H. Lawrence to Mr. J.H. Corley. August 17, 1949. Lawrence Berkeley Laboratory. Administrative Files of Administrative Assistants to the Directors of the Biology and Medicine Division and Donner Laboratory, Accession 434B90B0209, File Code 16B5B22, Carton 2, Folder "Historical Donner Laboratory."

Donner Laboratory Clinical Books, 1946B1977. Patient Sheets from February to March 1950, noted "San Quentin" after patient's name. Lawrence Berkeley Laboratory. Donner Laboratory Clinical Logs and Notebooks, Accession 439B89B0151, File Code 8B2B2, Carton 7/10, Binder No. 2.

Wennesland, R., E. Brown, J. Hopper, Jr., J.L. Hodges, Jr., O.E. Guttentag, K.G. Scott, I.N. Tucker, and B. Bradley. "Red Cell, Plasma, and Blood Volume in Healthy Men Measured by Radiochromium (Cr51) Cell Tagging and Hemocrit." *The Journal of Clinical Investigation*. Vol. 38, No. 7, July 1959, pp. 1,065B1,077. "

**LBL-12. Blood and Tissue Studies With Iron-59**

This research was conducted at the Donner Laboratory, University of California at Berkeley, in the early 1950s. The purpose of this study was to investigate the rates and pathways of iron transport in the human body, including the differences in iron turnover rates between normal individuals and patients with anemia. The subjects consisted of 22 individuals with anemia and other diseases and 16 normal individuals. From 5 to 30 microcuries of radioactive iron (Fe59) globulin was injected intravenously to label the circulating plasma iron globulin. External radiation measurements were made on the liver, spleen, and bone marrow using a gamma-fluorescence detector. In addition, plasma and whole blood samples were analyzed for Fe59 content. The results showed that iron turnover rates varied, the exact rate depending on the disease state of the patient. This research was partly funded by the U.S. Atomic Energy Commission.

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**LBL-14. Studies on the Rate of Uptake of Iodine-131 in the Thyroid**

In the early 1950s, studies were conducted at the University of California, San Francisco on various aspects of thyroid function in patients with normal and abnormal thyroid glands. At least 427 subjects were studied; of these, at least 25 healthy individuals served as controls, 122 patients had normal thyroid function, and 110 patients had various thyroid problems. After the subjects drank a solution containing approximately 100 microcuries of iodine-131 (I131), an external gamma counter was placed over the thyroid to measure the uptake of radioiodine. A good correlation was found between high rates of uptake and hyperthyroidism and between lower rates and absence of hyperthyroidism.

Further research was also conducted to study aspects of the physiology of the thyroid and other endocrine glands. Studies were conducted on obese patients, and on adult and child hyperthyroid patients requiring thyroid stimulating hormone. This research was funded by the U.S. Atomic Energy Commission.

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**LBL-15. Measures of Body Fat and Related Factors in Normal Adults Using Potassium-40 and Cesium-137**

From 1950 to 1960, the Donner Laboratory at the University of California, Berkeley, in collaboration with the California State Department of Public Health and the Bureau of Public Health Nutrition, conducted a series of experiments using potassium-40 (K40) and cesium-137 (Cs137) to measure body composition. The experiments were designed to accurately determine the human body's total water content, body fat, protein content, and bone mineral content. In all, 2,301 healthy volunteers were used for these experiments. These individuals each received a letter describing the purpose of the study and the parameters to be measured. The laboratory analyses included measurements of total body water after an oral tracer dose of tritium, analysis of specific gravity by the helium dilution technique, and whole body counting of K40. This study was partly supported by a grant from the National Institutes of Health.

**References**

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**LBL-16. Study of Ascitic Fluid Using Tritium-Labeled Water and Phosphorus-32**

During 1951 and 1952, the University of California Donner Laboratory and the Highland-Alameda County Hospital, Oakland, CA, conducted experiments to determine the total of ascitic fluids in humans. Tritium (H3) was used to trace the flow of water into, and out from, the peritoneal cavity. Six patients with ascites (a condition characterized by fluid buildup in the peritoneal cavity) were injected with 2 microcuries of tritium-labeled water, either intravenously or intraperitoneally. Samples of blood and ascitic fluid were taken over the following 7 to 24 hours. Blood samples were labeled

with phosphorus-32 (P32) and one cc of the labeled blood was injected into the peritoneal cavity. This study showed that the water content of ascitic fluid entered and left the peritoneal cavity at a very rapid rate. It also showed that the peritoneal surfaces of both normal and diseased subjects reabsorbed large volumes of fluid. This work was supported by the U.S. Atomic Energy Commission and the Life Insurance Medical Research Fund.

**References**

Prentice, T.C., W. Siri, and E.E. Jones. "Quantitative Studies of Ascitic Fluid Circulation with Tritium-Labeled Water." *American Journal of Medicine*. Vol. 13, No. 6, December 1952, pp. 668B673. "

**LBL-17. A Physiological Study in the Peruvian Andes Using Iron-59**

The Donner Laboratory of Medical Physics, University of California, Berkeley, used iron-59 (Fe59) in high-altitude studies similar to the previously conducted studies using tritium (H3). The purpose of these experiments was to investigate the physiology of reduced barometric pressure, particularly as seen in high-altitude flights, and the physiology and treatment of various hematopoietic (blood-forming) disorders, especially polycythemia rubra vera, leukemia, and aplastic anemia. In these studies, reported in 1952, healthy subjects (medical students from the University of San Marcos, Lima, Peru) and native Peruvians in the Andes mountains were studied. Four Andean natives suffering from pulmonary silicosis (as well as high-altitude polycythemia rubra vera) were also studied. A few micrograms of Fe59 were incubated for 20 minutes with 10 to 20 milliliters of the subject's plasma and then injected into the subjects. After injection, Fe59 analysis was made on plasma samples taken at hourly intervals for 4 to 5 hours. Acclimatization to high altitude was found to be related to changes in blood volume, plasma volume, and red blood-cell mass. Post-plasma-iron turnover rates and red cell renewal rates increased to roughly twice their normal values in less than 12 hours at high altitude. This study was supported by the U.S. Atomic Energy Commission, United States Navy and the United States Air Force.

**References**

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**LBL-18. Studies on the Metabolism of Glycine Labeled With Carbon-14**

In experiments reported in 1952 and 1953, nine terminally ill patients received intravenous injections of 100 microcuries of glycine labeled with carbon-14 (C14) in an attempt to determine the urinary excretion of C14, the elimination of C14 in the breath, the tissue distribution levels of C14, and the life span of red blood cells in leukemia and polycythemia rubra vera. For four patients, autopsies were carried out within 12 hours after death. Of these patients, the first was autopsied 57 days after administration of the isotope, the second after 105 days, the third after 152 days, and the fourth after 526 days. The study was conducted by the Section on Experimental Medicine, Donner Laboratory of Medical Physics and the Radiation Laboratory, University of California, Berkeley. It was supported by the U.S. Atomic Energy Commission.

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**LBL-19. Astatine--211 and the Thyroid**

The objective of this experiment was to test the uptake of astatine-211 (At211) and to evaluate its potential benefits in the treatment of thyroid diseases. Eight human subjects were injected with 50 microcuries of the 7-hour half-life alpha emitter At211). These experiments were conducted at the University of California Hospital during early 1954. (Previously described in #37 on the original list of 48 experiments released by DOE in June 1994)

**References**

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**LBL-20. Body Water at Sea Level and at High Altitudes by Tritium Analysis**

In 1954, scientists from the Donner Laboratory, University of California, Berkeley, and the Instituto de Biologia Andina, Lima, Peru, used tritium (H3) to determine changes in weight and total body water for subjects living in Lima at high altitudes and at sea level. Two groups of subjects were studied. The first group consisted of 15 young male medical students; the second group consisted of 13 normal male Peruvian Indian mine workers. The tritium was administered both orally and intravenously. The mean values of body water for the two groups was normal for their age range and occupations. This research was supported by the Public Health Service, the U.S. Atomic Energy Commission, and the U.S. Air Force.

**References**

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**LBL-21. High-Energy Beam Irradiation of Breast Cancer Patients**

About 1955, the University of California Radiation Laboratory conducted studies on high-energy proton beam irradiation of the human pituitary gland, using breast cancer patients as subjects. The purpose of the studies was to determine whether irradiation of the pituitary gland would cause regression of tumor growth. Twenty-six patients with metastatic breast carcinoma and ranging in age from 27 to 70 participated in the study. Patients came from all parts of the United States, traveling to the Donner Laboratory in Berkeley for treatment. Cumulative doses ranged from 9,000 to 32,000 rads. During the course of the study, patients were irradiated in small doses three times per week. As the study progressed and the effects were observed, individual and cumulative dose levels were increased, and the time required for the entire course or irradiation was decreased. The first patient received 14,000 rads over a 63-day period. Later patients received as much as 30,000 rads in six sessions within 2 weeks. Pituitary function was assessed by measuring thyroid uptake of radioiodine (iodine-131) and by measuring 24-hour pituitary hormone excretion in the urine. The studies demonstrated decreased pituitary function and both gross and microscopic damage to the pituitary gland. A few of the patients studied showed clinical evidence of improvement. At about the same time, four additional cancer patients were similarly irradiated in a separate study, but results were not reported with those of the breast cancer patients. This work was supported by the U.S. Atomic Energy Commission.

**References**

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**LBL-22. Iron-59 Metabolism in Patients with Cancer and Anemic Conditions**

Studies were conducted in 1959 at the University of California Lawrence Radiation Laboratory, on the metabolism of iron in humans using iron-59 (Fe59) as a tracer. The aim of these studies was to determine the effects of age, gender, and health status on iron metabolism in humans. Approximately 80 cancer patients and subjects with various anemias, hemochromatosis (a disease characterized by an excessive absorption of iron), and iron deficiencies were used in these studies. The rate of hemoglobin synthesis, mean red-blood-cell life span, and mean time required for hemoglobin formation within the total red-cell volume were measured. Gastrointestinal bleeding was correlated with iron and red cell movement in seven human subjects. This work was supported by the U.S. Atomic Energy Commission.

**References**

Polycove, M. and J.H. Lawrence. "Iron Metabolism." *University of California Lawrence Radiation Laboratory Project Description.*June 30, 1959. Lawrence Berkeley Laboratory, Cornelius A. Tobias Papers, Accession 434B92B0154, File Code 19B14B43, Carton 21, Folder Program Book. "

**LBL-23. Radionuclide Studies to Determine Bone Marrow Distribution in Man**

In the early 1960s, at the Donner Laboratory and the Lawrence Radiation Laboratory, University of California, Berkeley, iron-52 (Fe52), iron-59 (Fe59) and technetium-99m (Tc99m)-sulfur colloids were administered to study marrow distribution. The marrow, liver, and spleen were then imaged, using conventional scanners or scintillation cameras. Administered activities ranged from 3 to 100 microcuries. Samples of bone marrow, plasma, red cells, and liver were analyzed to determine tissue activity over time. Subjects included hospital patients and normal volunteers, including children. This work was supported in part by the U.S. Atomic Energy Commission and in part by a grant from the National Cancer Institute of the National Institutes of Health.

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**LBL-24. Iron Kinetics and Hemoglobin Synthesis in Human Subjects With Iron-59-Bound Plasma**

This study was conducted in about 1959 at the University of California, Berkeley, in collaboration with the Veterans Administration in Boston. Its purpose was to develop a suitable mathematical model of hemoglobin synthesis, using sequential measurements of iron-59 present in human blood plasma, red cells, and peripheral blood. Data were obtained from 13 normal, healthy subjects (1 female and 12 male volunteers) between the ages of 24 and 72 years, plus 6 male hospital patients with endogenous hemochromatosis. Five to 20 milliliters of plasma labeled with 10 to 40 microcuries of iron-59 (Fe59) were intravenously injected into the subjects. Plasma and erythrocyte radioactivity were measured with a scintillation counter. This study was supported by the U.S. Atomic Energy Commission with partial support by a grant from the U.S. Public Heath Service.

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Pollycove, M. and R. Mortimer. "The Quantitative Determination of Iron Kinetics and Hemoglobin Synthesis in Human Subjects."*Journal of Clinical Investigation*. Vol. 40, 1961, pp. 753B772. "

**LBL-25. Intestinal Iron Absorption Studies Using Iron-52, Iron-55, and Iron-59**

In a study conducted at the Donner Laboratory, University of California, Berkeley, in 1966, radioactive isotopes of iron were used to measure the rate of iron absorption into the plasma and its distribution in the gastrointestinal tract. Forty microcuries of iron-52 (Fe52) were administered orally to 6 fasting normal subjects. Just prior to the oral dose, iron turnover studies were performed using 2 microcuries of transferrin-bound iron-59 (Fe59) injected intravenously; the subjects were then whole body counted. For the iron turnover studies, 20 to 30 microcuries of iron-55 (Fe55) were injected into the same subjects. Photoscans of the abdomen using the Anger Positron Camera were taken throughout the study. The maximum rate of intestinal iron absorption was found to occur at the time when iron was in the upper gastrointestinal tract. This work was supported by the U.S. Atomic Energy Commission.

**References**

Fawwaz, R.A., H.S. Winchell, M. Pollycove, T. Sargent, H. Anger, and J.H. Lawrence. "Intestinal Iron Absorption Studies Using Iron-52 and Anger Positron Camera." *Journal of Nuclear Medicine.* Vol. 7, 1966, pp. 569B576. "

**LBL-26. Chromium-51 Metabolism Studies in Patients with Hemochromatosis**

Chromium-51 metabolism studies were conducted at Lawrence Berkeley Laboratory on healthy males and on patients with hemochromatosis (a disease characterized by an excessive absorption of iron). Five normal, male subjects were injected with 100 microcuries of chromium-51 to study the retention of chromium. This study was conducted to show that homochromatic diabetes was due to the exclusion of chromium from either the carrying agent or from the liver because of saturation by iron. Eleven subjects were injected with Cr51-chloride. Among the subjects were patients with varying degrees of hemochromatosis, including two hemochromatotic patients depleted of excess iron and two subjects with excess iron but no clinical disease. All of the subjects were followed by whole body counting for up to 6 months. The results showed that the exclusion of chromium occurs principally at binding sites in the liver. Two further studies were conducted on chromium metabolism using plasma analysis, Cr51 clearance rates, the whole body scanner, and the whole body counter. This work was supported by the U.S. Department of Energy.

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Lim, T.H., T. Sargent, and N. Kusubov. "Kinetics of Trace Element Chromium (III) in the Human Body." *American Journal of Physiology.* Vol. 244, Vol. 4, April 1983, pp. R445B454. "

**LBL-27. Calcium-47 Retention Studies in Juvenile Diabetics**

This research was conducted at the Berkeley Donner Laboratory in the early 1970s. This study was undertaken to determine the rate of uptake and retention of calcium-47 (Ca47) in juvenile diabetics. The subjects consisted of eight healthy individuals, of various ages and diets, and three juvenile diabetics (ages 23, 26, and 26). One to 25 microcuries of Ca47 was intravenously administered and the retention of Ca47 in the whole body was determined by direct *in vivo* counting. The whole body retention of Ca47 did not significantly vary over the wide range of calcium and protein intakes and ages of healthy subjects. Diabetics excreted Ca47 at a higher rate. This work showed a decreased rate of bone mineralization in diabetics. The research was supported by the Energy Research and Development Administration.

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**LBL-28. Whole Body Counting Studies on the Retention of Copper-67 and Phosphorus-32**

In the mid- to late 1970s, the University of California Lawrence Berkeley Laboratory conducted studies on the retention of radionuclides in humans. The subjects were healthy individuals and patients with a variety of diseases. The protocol for each study with each isotope was separately approved by the Lawrence Berkeley Laboratory for Safeguards in Human Research on Human Subjects. Four subjects were injected with 100 microcuries of copper-67 (Cu67) to determine copper uptake, retention, and excretion rates. Of the four subjects, three were healthy, and one had a copper storage disease. The results showed that there is no abnormality of total body turnover of copper when iron stores are normal. Results also showed that for the subject with the copper storage disease, the excretion of copper was slower than for normal subjects by a factor of two. Six subjects with diseases related to bone marrow production were injected with 1 to 5 millicuries of phosphorus-32 (P32) to determine excretion rates. This was one of the first published studies on human whole body phosphorus turnover. This work was supported by the U.S. Department of Energy.

**References**

Sargent, T. W. and H. Stauffer. "Whole body Counting of Retention of Cu67, P32, and Cr51 in Man." *International Journal of Nuclear Medicine and Biology.* Vol. 6, 1979, pp. 17B21. "

**LBL-29. Metabolism of Carbon-14-Labeled Methionine in Schizophrenics**

This research was conducted in the 1980s at the Lawrence Berkeley Laboratory. Researchers suspected that a defect in the methyl-carbon metabolic pathway was a causative factor in schizophrenia. Methionine labeled with carbon-11 (C11) or carbon-14 (C14) was administered to both schizophrenics and healthy subjects to test this hypothesis. The oxidation of methionine was studied in seven unmedicated schizophrenics, and the effect of high and low methionine in the diet was studied in control subjects. This research was supported by the National Institute of Mental Health, the Donner Laboratory, and the U.S. Department of Energy.

**References**

Sargent, T.W., N. Kusubov, S. Taylor, and T.F. Budinger. "Tracer Kinetic Evidence for Abnormal Methyl Metabolism in Schizophrenia." *Biological Psychiatry*. Vol. 32, 1992, pp. 1,078B1,090.

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**Lawrence Livermore National Laboratory**

**LLNL-1. *In Vivo* Calibration Studies Using Humans Administered Niobium-92m, Barium-133, Palladium-103, Chromium-51, and Strontium-85**

The purpose of these studies was to develop accurate calibration factors for *in vivo* counting equipment and to cross-calibrate the various U.S. and European counting centers. Volunteer subjects were administered radionuclides at Harwell Laboratory (United Kingdom) and were whole-body or chest counted at the Lawrence Livermore National Laboratory and at other Department of Energy contractor *in vivo* counting facilities in the U.S. Two subjects were from Lawrence Livermore Laboratory and the remainder were from the United Kingdom.

This study was broad in scope and spanned several years. From 1972 to 1976, three males inhaled palladium-103 (Pd103) and chromium-51 (Cr51)-labeled microspheres and were counted in 14 labs in Europe and the United States. From 1979 to 1982, 18 men inhaled niobium-92m (Nb92m)-labeled microspheres and were counted at several labs. During the 1988 to 1990 period, five males, who earlier had inhaled Nb92m, were again exposed to Nb92m and counted. Two of these five were injected with barium-133 (Ba133) in March 1986 and one of those two was injected with strontium-85 (Sr85) in June 1987. This research was jointly sponsored by the Atomic Energy Research Establishment--Harwell, British Nuclear Fuels, the General Electricity Generating Board, the International Atomic Energy Agency, and the U.S. Department of Energy (and its predecessor agencies). (Previously described in #15 on the original list of 48 experiments released by DOE in June 1994)

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**LLNL-2. Ozone Effects on Overall and Regional Lung Function**

In this collaboration between the University of Washington (Seattle) and Lawrence Livermore Laboratory, the impact of ozone on the human lungs was studied. The objective was to determine the functional changes that might result from low ozone levels in smog. Four healthy, male subjects were exposed to low (0.4 part per million by volume) concentrations of nonradioactive ozone for a total of 2.5 hours. Periods of exercise and rest were alternated during the exposure. The subjects then inhaled small quantities of radioisotope-labeled gas mixtures for the purpose of measuring lung function. The first mixture was a blend of 20 percent oxygen and 80 percent nitrogen-15 (N15), intended to simulate air. The second mix contained 10 percent carbon-15 labeled carbon dioxide (CO2) in air. The results of this test suggested that ozone caused nonuniform mechanical alteration to the central and peripheral airways. The study was performed under a contract from the U.S. Department of Energy from 1977 to 1978 and in part by a grant from the National Heart, Lung, and Blood Institute. (Previously described in #16 on the original list of 48 experiments released by DOE in June 1994)

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**LLNL-3. Decompression Sickness Studies Using Nitrogen-15 and Argon-41**

A joint study between the Lawrence Livermore National Laboratory and the U.S. Navy was conducted during the 1980s, using the radionuclide tracers nitrogen-15 (N15) and argon-41 (Ar41) to determine information on the uptake and clearance of nitrogen gas in man. This research was necessary to better understand decompression sickness of deep-sea divers, which results from excessive accumulation of inert gases (stable nitrogen and argon) in divers' bodies. More than one experiment was conducted during this collaboration. In one such study, nine normal, healthy human subjects (Navy volunteers) breathed air containing N15 and Ar41 and then waited 40 to 100 minutes to allow redistribution and washout. The subjects were then monitored using positron detectors to determine the concentration of N15 and Ar41 remaining in the body.

The amounts of N15 and Ar41 inhaled depended on the amounts breathed by the subjects. This air contained about one microcurie of N13 and 24 microcuries of Ar41 per liter of breathing air. Absorbed doses to subjects were estimated to be about 0.3 to 0.5 rad to the lungs and trachea and 0.01 rad to the whole body. The experiment met the requirements of both the Navy's and Lawrence Livermore National Laboratory's human subjects committees. This work was supported by the Naval Medical Research Institute and the U.S. Department of Energy. (Previously described in #14 on the original list of 48 experiments released by DOE in June 1994)

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**Los Alamos National Laboratory**

**LANL-1. Tritium Studies at Los Alamos Scientific Laboratory**

During the early 1950s, Los Alamos Scientific Laboratory conducted studies on the human uptake, distribution, and retention of tritium (H3). Three volunteers, all researchers working on the studies, participated as subjects. In one experiment, a male subject immersed his arm up to the elbow in water containing 0.1 millicurie of tritium per cubic centimeter.

This study showed that the rate of absorption through the skin was too slow to pose a hazard. The whole body would have to be immersed for more than an hour before an Atomic Energy Commission recommended exposure limit was reached. In another study, all three subjects inhaled for 4 to 5 minutes oxygen that was saturated with tritium water vapor (HTO) which, when condensed, contained 1.16 millicuries of tritium per milliliter of water. Results showed that 98B99 percent of the tritium was retained in the body after inhalation.

In a third study, the three subjects drank water containing tritium. Water volumes ranged from 100 to 1,000 milliliters (a to 4 cups) and level of activity ranged from 1,640 to 2,920 microcuries. These studies showed that water absorption from the gastrointestinal tract begins 2 to 9 minutes after ingestion, that absorption is a linear function of time, and that it is proportional to the amount ingested. All these studies were used to establish standards for occupational exposure to tritium. This work was supported by the U.S. Atomic Energy Commission. (These experiments were referenced in the Markey report.)

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**LANL-2. Metabolism of EDTA in Humans**

In 1953, Los Alamos Scientific Laboratory conducted studies on the human metabolism of the chelating agent ethylenediaminetetraacetic acid (EDTA) labeled with carbon-14. The purpose was to gain information that would help establish optimum dosage schedules and identify any harmful effects. Twelve young adult healthy males served as subjects in four groups of three. One group was administered an intravenous injection of 2.2 milligrams of C14-labeled EDTA; the second received an intramuscular injection of 2.2 milligrams; the third received oral administration of 1.5 milligrams; and the fourth group had 2.0 milligrams applied directly to the skin.

The studies showed that EDTA passed through the body essentially unchanged and that it was excreted primarily by the kidney within 1 hour of intravenous injection and 1.5 hours of intramuscular injection. It is poorly absorbed in the gastrointestinal tract and practically not at all through the skin. This work was supported by the U.S. Atomic Energy Commission. (Previously described in #43 on the original list of 48 experiments released by DOE in June 1994)

**References**

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*Biomedical Research Group of the Health Division Annual Report 1953*. Los Alamos: Los Alamos Scientific Laboratory, LAB1690, 1954, p. 17. "

**LANL-3. Radiation Exposure of Aircrews in Mushroom Clouds**

During the 1955 TEAPOT and the 1956 REDWING nuclear test series, manned aircraft were used to map the amount and distribution of radiation within some of the resulting "Mushroom" clouds. The objective was to obtain information needed to plan for the safe and effective use of military aircraft in cloud areas during combat operations. Studies conducted in 1953 using animal subjects in drone aircraft had previously shown that it would be safe for manned aircraft to enter atomic clouds relatively soon after detonation. Penetrations of clouds from low-yield detonations were made during Operation TEAPOT in 1955. Penetrations of the larger clouds from high-yield detonations were made during Operation REDWING in 1956. Special radiation exposure limits, in excess of the usual 3.9 roentgens Maximum Permissible Exposure, were established for some of these flight crews. During Operation TEAPOT, 4 Air Force officers were permitted to receive up to 15 roentgens, and 2 received this amount. Exposures of up to 25 roentgens were permitted during Operation REDWING, but no one received this amount; the largest doses were approximately 15 roentgens for three officers. Pre- and postmission urine tests and evaluation in whole body counters showed no significant internal deposition of fission products or unfissioned plutonium. This work was supported by the U.S. Atomic Energy Commission. (This experiment was referenced in the Markey report.)

**References**

Headquarters Field Command. "The Radiation Hazards to Personnel Within an Atomic Cloud." *Report of Operation UPSHOT/KNOTHOLE Project 4.1*. Armed Forces Special Weapons Center, WTB743. Reynolds Electrical and Engineering Co., Inc., Coordination and Information Center, Las Vegas, NV, CIC Document 40992.

Headquarters Field Command. "Manned Penetration of Atomic Clouds." *Report of Operation TEAPOT Project 2.8a*. Armed Forces Special Weapons Center, WTB1156. Reynolds Electrical and Engineering Co., Inc., Coordination and Information Center, Las Vegas, NV, CIC Document 12800.

Headquarters Field Command. "Early Cloud Penetrations." *Report of Operation REDWING Project 2.66a*. Armed Forces Special Weapons Center, WTB1320. Reynolds Electrical and Engineering Co., Inc., Coordination and Information Center, Las Vegas, NV, CIC Document 68117. "

**LANL-4. Determination of the Survival Time of Red Blood Cells by Chromium-51 Labeling**

A study was conducted by Los Alamos Scientific Laboratory in 1957 to determine the survival times of circulating blood red blood cells in healthy and diseased subjects. Thirty-two human subjects (7 healthy and 25 diseased) received intravenous injection of samples of their own red blood cells that had been previously removed and tagged with radioactive chromium-51 (Cr51). After tagging, the red cells were injected back into the donor, and the person's uptake and radioactivity was assessed in the whole body counter. Half-times for the survival of the chromium tag were determined. Large volumes of urine were also obtained from the subjects and counted to determine excretion rates. This research was supported by the U.S. Atomic Energy Commission. (Previously described in #26 on the original list of 48 experiments released by DOE in June 1994)

**References**

"Application of Low Level *In Vivo* Counting Techniques to Clinical Investigations." *H-Division Progress Report August 20, 1948BSeptember 20, 1948*. Los Alamos: Los Alamos Scientific Laboratory, LAMSB790, pp. 62B63. "

**LANL-5. Studies of the Metabolism and Excretion of Alkali Metal Radionuclides in Man**

Scientists at the Los Alamos Scientific Laboratory conducted a series of studies to determine the metabolism and excretion of alkali metals as part of a general research program on the retention, excretion, and absorption of radioactive materials in humans. Sodium-22 (Na22), potassium-42 (K42), and rubidium-86 (Rb86) were administered orally to 10 normal, healthy human subjects and were measured at various times thereafter in the whole body counter. The distribution and retention patterns for these materials were determined periodically for about 1 year. Radiocesium (Cs134 or Cs137) was also administered and measured. These experiments are described separately, under LANLB8. This research was supported by the U.S. Atomic Energy Commission. (Previously described in #25 on the original list of 48 experiments released by DOE in June 1994)

**References**

Richmond, C.R. "Retention and Excretion of Radionuclides of the Alkali Metals by Five Mammalian Species." *Biological and Medical Research Group of the Health Division Semiannual Report July-December 1959*. Los Alamos: Los Alamos Scientific Laboratory, LAMSB2445, 1960, pp. 71B79. "

**LANL-6. Absorption and Retention of Orally Administered Iron-59 in Humans**

This study was conducted at Los Alamos Scientific Laboratory in 1959. The purpose was to determine the absorption and retention of orally administered iron in human subjects. A second objective was to evaluate the whole body counting technique and equipment as a tool for measuring iron in the human body. Sixty-six subjects were part of this test, including 1 pregnant woman and 4 children. Also included in the study were hospital patients with anemia, leukemia, or polycythemia rubra vera. Each of the study participants ingested 0.5 to 0.7 microcuries of iron-59 (Fe59) as ferrous citrate in water. The oral dose was followed with an additional 100 to 200 milliliters of tap water to wash the radioactive iron into the stomach. Body counting and fecal bioassay were used to determine the relationship between ingested, retained, and excreted iron.

The study showed that there was an apparent lack of iron absorption with leukemia and infection. Also, the pregnant woman absorbed larger amounts of iron. This study was supported by the U.S. Atomic Energy Commission. (Previously described in #40 on the original list of 48 experiments released by DOE in June 1994)

**References**

Lushbaugh, C.C. and D.B. Hale. "Clinical Applications of Whole body Counting: A Clinical Comparison of the Absorbability of Ferrous versus Ferric Salts in Normal Human Subjects." *Biological and Medical Research Group of the Health Division Semiannual Report July 1961BJune 1962.* Los Alamos: Los Alamos Scientific Laboratory, LAMSB2780, 1962, pp. 337B347. "

**LANL-7. Determining Thyroid Uptake and Retention of Iodine-131**

In 1959, Los Alamos Scientific Laboratory conducted studies on whole body measurement techniques for determining thyroid uptake of iodine-131 (I131). Seventeen normal or ill male or female patients ranging in age from 10 to 57 drank water solutions containing 1.5 to 3.0 microcuries of I131 as sodium iodide. Study results showed that the whole body liquid scintillometer measurement technique provided a simple, valid means of determining thyroid uptake and thyroid function. Additional studies were conducted to address how thyroid retention changed with disease, chemotherapy, and metabolic status. These studies involved some of the same patients, but added others, as well. Six children whose thyroid gland had been removed were added, as was one patient with an overactive thyroid and one patient with an underactive thyroid. A total of 63 patients were administered I131 either orally or intravenously in these studies. These studies showed that retention rates in diseased patients varied widely from normal rates, and that retention was influenced by therapy. This work was supported by the U.S. Atomic Energy Commission. (Previously described in #45 on the original list of 48 experiments released by DOE in June 1994)

**References**

Lushbaugh, C.C. and P.S. New. "Clinical Applications of Whole Body Scintillometry. II. A Comparison of Three Different Methods of Determining Retention and Thyroid Uptake of Orally Administered I131*." Biological and Medical Research Group of the Health Division Semiannual Report July-December 1959*. Los Alamos: Los Alamos Scientific Laboratory, LAMSB2445, 1960, pp. 348B360.

Lushbaugh, C.C. and D.B. Hale. "Clinical Applications of Whole Body Scintillometry. III. Whole Body Retention of Iodine-131 as a Method of Studying Thyroid Function in Man." *Biological and Medical Research Group of the Health Division Semiannual Report July-December 1959*. Los Alamos: Los Alamos Scientific Laboratory, LAMSB2445, 1960, pp. 361B373. "

**LANL-8. Long-Term Retention of Cesium-134 and Cesium-137 in Humans**

From about 1959 to 1961, a study was conducted at the Los Alamos Scientific Laboratory on the long-term retention of radioactive cesium (Cs) in humans. Four healthy, adult males participated in this study. Two of subjects received oral doses of 1 and 1.4 microcuries cesium-134 (Cs134) as cesium chloride. The subjects were followed by whole body counting for 106 and 910 days, respectively, to determine the gastrointestinal tract uptake and whole body retention with time. The other two subjects were administered about 1 microcurie Cs137 and were followed by whole body counting for about 500 days. This study showed that the biological retention half-time of cesium in man was about 137 days. This work was supported by the U.S. Atomic Energy Commission. (Previously described in #25 on the original list of 48 experiments released by DOE in June 1994)

**References**

Richmond, C.R., J.E. Furchner, and W.H. Langham. "Long-Term Retention of Radiocesium by Man." *Biological and Medical Research Group of the Health Division Semiannual Report January-June 1961.* Los Alamos: Los Alamos Scientific Laboratory, LAMSB2627, 1961, pp. 163B174. "

**LANL-9. Study of the Retention and Excretion of Iodine-131**

A study was performed at Los Alamos Scientific Laboratory, in 1960 to determine the retention and excretion of iodine-131 (I131) by humans. Twenty-six normal subjects, including 17 women, 3 men, 3 girls, and 3 boys, participated in the study. Each volunteer was given an oral dose of liquid containing 8 microcuries of I131 as sodium iodide, then measured for whole body and thyroid content of I131 within 1 hour. Additional measurements were made on the 1st, 2nd, 3rd, 4th, 7th, 10th, 14th, and 18th days following the ingestion. This study showed that approximately 20 percent of the ingested I131 was taken up by the thyroid gland, and the remaining 80 percent excreted by the kidneys by the urine. This research was supported by the U.S. Atomic Energy Commission. (Previously described in #19 on the original list of 48 experiments released by DOE in June 1994)

**References**

Lushbaugh, C.C., D.B. Hale, and C.R. Richmond. "Clinical Applications of Whole Body Scintillometry. IV. Turnover Rate of Protein-Bound Iodide." *Biological and Medical Research Group of the Health Division Semiannual Report January-June 1960*. Los Alamos: Los Alamos Scientific Laboratory, LAMSB2455, 1960, pp. 364B371. "

**LANL-10. Absorption and Uptake of Iodine-131 and Sodium-24 in Humans**

In 1960, an experiment was conducted at Los Alamos Scientific Laboratory to determine the feasibility of *in vivo* measurements to study the absorption of radionuclides through the skin. Liquid solutions of sodium-24 (10 microcuries) or iodine-131 (51 microcuries) were placed on the palms of two volunteer subjects employed at the Laboratory. After allowing absorption to occur, the palms were washed and the subjects were counted periodically in the Laboratory's whole body counter to determine the fraction of either radionuclide absorbed through the skin.

In a second experiment, two volunteer subjects ingested 0.18 microcurie of sodium-24 or 0.14 microcurie of iodine-131 to determine the gastrointestinal absorption and whole body retention of these radionuclides. This research was supported by the U.S. Atomic Energy Commission. (Previously described in #27 on the original list of 48 experiments released by DOE in June 1994)

**References**

Van Dilla, M.A. , C.R. Richmond, and J.E. Furchner. "Cutaneous Absorption by Human Subjects, I. Studies with Sodium-24 and Iodine-131." *Biological and Medical Research Group of the Health Division Semiannual Report July-December 1960*. Los Alamos: Los Alamos Scientific Laboratory, LAMSB2526, 1961, pp. 164B171. "

**LANL-11. Retention of Iodine-131 in Subjects with Inflammatory Liver Disease**

In 1960, a study was conducted at Los Alamos Scientific National Laboratory on the use of an iodine-131 (I131) labeled blood dye in determining liver function. Ten normal subjects and 18 persons suffering from inflammatory hepatic disease were injected intravenously with 10 microcuries of I131-labeled dye (rose bengal). The time-activity curves for retention of I131 in the blood stream were determined using the Los Alamos arm counter. The blood retention curve was found to be a better measurement of function than the clearance rate of labeled rose bengal dye measured in urine. This research was supported by the U.S. Atomic Energy Commission. (Previously described in #28 on the original list of 48 experiments released by DOE in June 1994)

**References**

Lushbaugh, C.C., D.B. Hale, and R. McGill. "The Use of the Arm Counter to Determine the Degree of Hepatic Function.*"Biological and Medical Research Group of the Health Division, Semiannual Report January-June 1960*. Los Alamos: Los Alamos Scientific Laboratory, LAMSB2455, 1960, pp. 223B229. "

**LANL-12. Gastrointestinal Passage of Radioactive Particles**

In the early 1960s, Los Alamos Scientific Laboratory conducted studies on the passage of radioactive particles through the human gastrointestinal tract. These studies addressed the issue of reentry and destruction of nuclear-powered space vehicles in the earth's atmosphere and subsequent ingestion of the resulting particles by humans. Fifty-seven normal adults participated. Each swallowed a gelatin capsule containing three radioactive particles. One particle was ceramic, about 150 microns in diameter, and contained approximately 150 picocuries of manganese-54. The other two particles were uranium carbide, about 175 microns in diameter, and contained an unspecified amount of uranium-235 activity.

The total calculated radiation dose delivered to the gastrointestinal tract in these studies was extremely low-- well below the maximum permissible level for these materials. Several subjects repeated the ingestion at different times of day to estimate the time-of-day variable in the study. One subject repeated the test 10 different times to estimate the variation within a single individual. The studies showed that particle density did not influence passage rate and that there was no significant holdup of particles in the digestive system. Transit times corresponded more to bowel movement habits than a normal distribution. This work was supported by the U.S. Atomic Energy Commission. (This experiment was referenced in the Markey report.)

**References**

*Some Biological Aspects of Radioactive Microspheres.* Los Alamos: Biological and Medical Research Group, Los Alamos Scientific Laboratory, LAB3365BMS, June 20, 1965. "

**LANL-13. Metabolism of Zinc-65 in Human Leukemia**

A study was conducted at Los Alamos Scientific Laboratory in early 1961 on the metabolism of zinc-65 (Zn65) in human cancer patients with chronic leukemia. This experiment involved a single subject. A 15-year-old female patient with chronic myelogenous leukemia was given a oral dose of 0.6 microcurie of zinc-65 (Zn65) as zinc chloride 137 days prior to death. One hour after administration and on days 1, 2, 3 ,20, and 137 the subject was studied for whole body Zn65 in the Los Alamos human counter. Also, tissue samples were removed at autopsy and sampled for zinc-65. The findings of this study showed that Zn65 was retained less tenaciously by the leukemia patient than by normal subjects. This work was supported by the U.S. Atomic Energy Commission. (Previously described in #32 on the original list of 48 experiments released by DOE in June 1994)

**References**

Richmond, C.R., J.E. Furchner, and G.A. Trafton. "Long Term Retention of Zinc-65 by Man." *Biological and Medical Research Group of the Health Division Semiannual Report July-December 1960*. Los Alamos: Los Alamos Scientific Laboratory, LAMSB2526, 1961, pp. 15B20.

Furchner, J.E., C.R. Richmond, and G.A. Trafton. "Metabolism of Zinc-65 in Humans." *Biological and Medical Research Group of the Health Division Annual Report July 1961BJuly 1962.* Los Alamos: Los Alamos Scientific Laboratory, LAMSB2780, 1962, pp. 66B77.

Furchner, J.E. and C.R. Richmond. "Effect of Dietary Zinc on the Absorption of Orally Administered Zn65." *Health Physics*. Vol. 8, 1962, pp. 35B40.

Richmond, C.R., J.E. Furchner, G.A. Trafton, and W.H. Langham. "Comparative Metabolism of Radionuclides in Mammals-I: Uptake and Retention of Orally Administered Zn65 by Four Mammalian Species." *Health Physics*. Vol. 8, 1962, pp. 481B489.

Richmond, C.R., C.C. Lushbaugh, M.W. Rowe, and M.A. Van Dilla. "Metabolism of Zinc-65 in a Terminal Leukemia Case."*Biological and Medical Research Group of the Health Division Semiannual Report January-June 1961.* Los Alamos: Los Alamos Scientific Laboratory, LAMSB2627, 1960, pp. 263B269. "

**LANL-14. Iodine-131 Used to Determine Thyroid Uptake Measurement Techniques**

In 1961, Los Alamos Scientific Laboratory conducted studies intended to improve the accuracy of whole body counting techniques for determining thyroid uptakes. Previous experience had shown that body mass influenced overall absorption and affected the accuracy of thyroid uptake measurements. An unspecified number of subjects received oral administration of 8 microcuries of iodine-131. A "mock iodine" mixture of barium-133 and cesium-134 equal to 2.48 microcuries was also administered to establish a control standard. The results of these studies were used to develop standards in establishing normal human absorption values for men, women, and children of various ages. (Previously described in #45 on the original list of 48 experiments released by DOE in June 1994)

**References**

Lushbaugh, C.C. "Progress in Refinement of the Whole Body Counting Technique for Determining Thyroid Uptake." *Biological and Medical Research Group of the Health Division Semiannual Report January-June 1961*. Los Alamos: Los Alamos Scientific Laboratory, LAMSB2627, 1961, pp. 291B297. "

**LANL-15. Uptake and Retention of Zinc-65**

During 1961 and 1962, a study was conducted at Los Alamos Scientific Laboratory, NM on the uptake and retention of radioactive materials by mammals. Three males and one female between the ages of 31 and 48 received a single oral dose of 0.6 to 1.0 microcurie as zinc chloride in water. The subjects were evaluated for whole body distribution and retention of Zn65 with time. These measurements were made in the Los Alamos whole body center. Urine and feces were also obtained and analyzed for Zn65. Measurements continued out to 416 to 664 days after administering Zn65. These data were used to determine the retention and excretion of Zn65 in men and women for comparison with other animal species. This study was supported by the U.S. Atomic Energy Commission. (Previously described in #32 on the original list of 48 experiments released by DOE in June 1994)

**References**

Richmond, C.R., J.E. Furchner, G.A. Trafton, and W.H. Langham. "Comparative Metabolism of Radionuclides in Mammals--I: Uptake and Retention of Orally Administered Zn65 by Four Mammalian Species." *Health Physics*. Vol. 8, 1962, pp. 481B489. "

**LANL-16. Iron-59 Absorption in Normal Human Subjects**

From mid-1961 to mid-1962, a study was conducted at the Los Alamos Scientific Laboratory on the absorption of iron by normal human subjects. The objective of the study was to determine whether the ferrous or ferric form was more readily absorbed. A group of volunteers composed of 20 normal men and 30 normal women was included in the study. The subjects were divided randomly into two subgroups. Each subject received 0.27 microcurie of iron orally. Some received the iron in the form of ferrous citrate labeled with iron-59 (Fe59). The others received the iron in the form of ferric chloride labeled with Fe59. A whole body count was performed immediately after ingestion and again 7 days later. At the time of the second body count, blood samples were withdrawn and characterized. No difference was found in human uptake between the ferrous and ferric forms of iron. This study was supported by the U.S. Atomic Energy Commission. (Previously described in #40 on the original list of 48 experiments released by DOE in June 1994)

Lushbaugh, C.C. and D.B. Hale. "Clinical Applications of Whole body Scintillometry I. Retention of Orally Administered Iron."*Biological and Medical Research Group of the Health Division Semiannual Report July-December 1959.* Los Alamos: Los Alamos Scientific Laboratory, LAMSB2445, 1960, pp. 337B347. "

**LANL-17. Cutaneous Absorption of Strontium-85**

From 1961 to 1962, Los Alamos Scientific Laboratory conducted studies on the absorption of strontium-85 (Sr85) through human skin. Radioactive strontium chloride was applied in a gauze patch to the forearm of two subjects and held in place with adhesive tape. The amount of Sr85 administered was about 70 microcuries. After 2 days, one subject had absorbed 0.2 percent and the other had absorbed 0.6 percent. The study showed that absorption through the skin occurred, but at very low levels. This work was supported by the U.S. Atomic Energy Commission. (Previously described in #44 on the original list of 48 experiments released by DOE in June 1994)

**References**

Van Dilla, M.A., C.R. Richmond, J.E. Furchner, and M.W. Rowe. "Cutaneous Absorption of Radionuclides by Human Subjects. II. Strontium-85." *Biological and Medical Research Group of the Health Division Annual Report July 1961BJune 1962*. Los Alamos: Los Alamos Scientific Laboratory, LAMSB2780, 1962, pp. 154B157. "

**LANL-18. Retention of Strontium-85**

From 1961 to 1962, Los Alamos Scientific Laboratory conducted studies on the whole body retention of strontium-85 (Sr85) in humans. Three male laboratory employees ingested 1.07 microcuries of Sr85 in 100 milliliters of tap water. The studies showed that Sr85, with its 65-day half-life, is suitable for studying short-term retention of fallout but not appropriate for long-term retention studies. This work was supported by the U.S. Atomic Energy Commission. (Previously described in #44 on the original list of 48 experiments released by DOE in June 1994)

**References**

Furchner, J.E., M.A. Van Dilla, M.W. Rowe, and C.R. Richmond. "Retention of Strontium-85 by Man." *Biological and Medical Research Group of the Health Division Annual Report July 1961BJune 1962*. Los Alamos: Los Alamos Scientific Laboratory, LAMSB2780, 1962, pp. 43B49. "

**LANL-19. Studies On the Retention of Iodine-131 in Humans**

In 1961 to 1962, the Los Alamos Scientific Laboratory conducted studies on the retention of radioiodinated paratoluidine polyvinylpyrrolidone, also known as PVP-I131. The purpose of the study was to determine whether PVP-I131 could be used to detect the presence of vascular leaks into the gastrointestinal or renal excretory tracts. Eight adults were injected intravenously with 0.7 microcurie of PVP-I131. Four of the subjects had medical conditions that included known internal bleeding. The study showed that the bleeding subjects lost the iodine more rapidly than the nonbleeding subjects--in one case, almost twice as fast--indicating that PVP-I131 was an effective detector of internal bleeding.

In a related study, one of these subjects drank a water solution containing 0.06 microcurie of PVP-I131 to determine retention in the thyroid gland. The study showed little retention, indicating that PVP-I131 is not readily absorbable. This work was supported by the U.S. Atomic Energy Commission. (Previously described in #45 on the original list of 48 experiments released by DOE in June 1994)

**References**

Lushbaugh, C.C. and D.B. Hale. "Clinical Applications of Whole body Counting: Retention of Raovin Iodine-131 as a Measure of Serum or Blood Loss." *Biological and Medical Research Group of the Health Division Annual Report July 1961BJune 1962.* Los Alamos: Los Alamos Scientific Laboratory, LAMSB2780, 1962, pp. 188B193. "

**LANL-20. Thyroid Function Studies Using Sodium Iodide-131**

From 1961 to 1962, Los Alamos Scientific Laboratory conducted studies on human thyroid function using iodine-131 (I131) administered as sodium iodide. At least two adult females received 0.5 microcurie by oral administration. Tests were repeated several times in combination with various drugs and uptakes were measured and compared. These studies showed which drug therapies were most effective in treating thyroid disorders. This work was supported by the U.S. Atomic Energy Commission. (Previously described in #45 on the original list of 48 experiments released by DOE in June 1994)

**References**

Lushbaugh, C.C. and D.B. Hale. "Clinical Applications of Whole body Counting: Determination of Thyroidal Activity from Sodium Iodine-131 Retention Measurements with Humco II." *Biological and Medical Research Group of the Health Division Annual Report July 1961BJune 1962.* Los Alamos: Los Alamos National Laboratory, LAMSB2780, 1962, pp. 181B187. "

**LANL-21. Metabolism of Zinc-65 in Humans**

A study of the metabolism of zinc-65 was conducted at Los Alamos Scientific Laboratory in 1962 to evaluate the gastrointestinal absorption, distribution in the body, retention time, and excretion rates. The study involved four laboratory employees--three male and one female--between 29 and 48 years of age. The subjects were given an oral dose of 0.6 to 1.0 microcurie of Zn65 in the form zinc chloride, in water and were studied by whole body counting. Urinary and fecal samples were also obtained and counted to measure the excretion rates of Zn65 from the subjects. Their study was supported by the U.S. Atomic Energy Commission. (Previously described in #18 on the original list of 48 experiments released by DOE in June 1994)

**References**

Richmond, C.R., J.E. Furchner, G.A. Trafton, and W.H. Langham. "Comparative Metabolism of Radionuclides in Mammals: Uptake and Retention of Orally Administered Zn65 by Four Mammalian Species." *Health Physics.* Vol. 8, 1962, pp. 481B489. "

**LANL-22. Cesium-132 Metabolism in Humans**

From 1962 to 1963, a study was conducted at Los Alamos Scientific Laboratory to determine the retention and excretion of cesium-132 (Cs132) in humans. The subjects were three male and one female normal, young adults in good health. These subjects were injected intravenously with 0.65 microcurie of Cs132 as cesium chloride. Three of the subjects were counted approximately 30 times over a 45-day period. Whole body retention of Cs132 was determined by measurements of the subjects in the Laboratory's whole body counters. This research was supported by the U.S. Atomic Energy Commission. (Previously described in #25 on the original list of 48 experiments released by DOE in June 1994)

**References**

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**LANL-23. Thyroid Studies Using Small Amounts of Radioactive Iodine**

In about 1963, the Los Alamos Scientific Laboratory conducted studies on thyroid metabolism, using very small amounts of iodine-125 (I125) and iodine-131 (I131). The purpose was to determine the retention of iodine in the thyroid as a function of time, with a particular interest in radioiodine metabolism in children. Nineteen normal male and female subjects ranging in age from 4 to 46 drank approximately 10 nanocuries each of I125 and I131 mixed together in water. Subsequent measurements showed that there was no difference in radioiodine metabolism between children and adults. This work was supported by the U.S. Atomic Energy Commission. (Previously described in #45 on the original list of 48 experiments released by DOE in June 1994)

**References**

Van Dilla, M.A. and M.J. Fulwyler. "Thyroid Metabolism in Children and Adults Using Very Small (Nanocurie) Doses of Iodine-125 and Iodine-131." *Health Physics.* Vol. 9, 1963, pp. 1,325B1,331.

Van Dilla, M.A. and M.J. Fulwyler. "Radioiodine Metabolism in Children and Adults After the Ingestion of Very Small Doses."*Science*. Vol. 144, No. 3614, April 1964, pp.178B179. "

**Oak Ridge Sites**

**OR-1.Gallium-72 for Diagnosis and Therapy at Oak Ridge**

From 1949 to 1951, the Oak Ridge Institute of Nuclear Studies conducted studies on the therapeutic use of gallium-72 (Ga72). More than 50 patients with various kinds of bone cancer participated. The patients were divided into two groups: one in which a therapeutic effect was attempted, and another in which only gallium uptake and localization were studied with no therapeutic effect attempted. All patients, except one, had fatal cancers that were not amenable to surgery or radiotherapy. The radiogallium was administered intravenously in doses ranging from 10 to 100 millicuries. Most patients tolerated two to four injections of less than 70 millicuries. Further doses or higher level doses caused anorexia, nausea, vomiting, and severe mental depression, with later appearance of skin reactions, diarrhea, and serious bone marrow depression. These studies showed that Ga72 was not suitable as a therapy or tracer because of its toxicity in humans. As a result, subsequent studies focused on other isotopes, such as Ga67 or gallium-68 (Ga68). This work was supported by the U.S. Atomic Energy Commission.

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Nelson, B., R.L. Hayes, C.L. Edwards, R.M. Kniseley, and G.A. Andrews. "Distribution of Gallium in Human Tissues After Intravenous Administration." *Journal of Nuclear Medicine*. Vol. 13, 1972, pp. 92B100. "

**OR-2.Colloidal Gold-198 Studies at Oak Ridge**

Colloidal gold-198 was studied in the 1950s at Oak Ridge Institute of Nuclear Studies for potential diagnostic and therapeutic applications in nuclear medicine. Gold-198 (Au198) was used intravenously in an experiment involving terminal cancer patients. Four males and three females with different types of cancer were included in this study between 1949 and 1953. Au198 was administered in various amounts over the course of the patient's disease in the hope of demonstrating a therapeutic effect. In addition, activities of 2.3 to 33 millicuries were administered just prior to death to enhance the isotope concentrations in tissues and to study the biodistribution at time of autopsy. Colloidal Au198 was also employed in intracavitary infusions to study and treat patients with tumors of the chest or abdomen. These studies were supported by the U.S. Atomic Energy Commission. (Previously described in #12 on the original list of 48 experiments released by DOE in June 1994)

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Root, S.W., G.A. Andrews, R.M. Kniseley, and M.P. Tyor. "The Distribution and Radiation Effects of Intravenously Administered Colloidal Au198 in Man." *Cancer*. Vol. 7, No. 5, September 1954, pp. 856B866.

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**OR-3.Use of Serum Albumin Labeled With Iodine-131**

In the early 1950s, the Oak Ridge Institute for Nuclear Studies conducted experiments on the transfer of labeled serum albumin between the peritoneal cavity (within the abdominal cavity) and the blood vessels. Eleven women hospitalized for ascites (accumulation of fluid in the peritoneal cavity) were the subjects of this study; 9 had abdominal carcinomatosis and 2 had cirrhosis of the liver. These patients were injected either intraperitoneally or intravenously with human serum albumin labeled with 200 to 300 microcuries of iodine-131 (I131). Samples of ascitic fluid and blood were analyzed for I131-labeled human serum albumin content. The results showed complete equilibrium of the injected tagged albumin between compartments, and that a similar mechanism was involved in the accumulation of ascitic fluid in the two diseases studied. This work was supported by the U.S. Atomic Energy Commission.

**References**

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**OR-4.Iodine-131 in the Treatment of Malignant Melanoma**

An experiment conducted at the Oak Ridge Institute of Nuclear Studies in 1951 investigated the use of iodine-131 (I131) in the treatment of malignant melanoma. A secondary objective was to determine the distribution of I131 in patients with this type of tumor both in the presence and in the absence of functioning thyroid tissue. Two experimental subjects were studied. The first subject was a 37-year-old man in the terminal stages of metastatic malignant melanoma of the liver. He received 100 microcuries of I131 orally. Three days later, the subject was given 57.6 millicuries of I131 orally. Tissue samples were obtained during the autopsy, 6 days after ingestion of the I131. The second subject was a 43-year-old woman with malignant melanoma of the arms and legs. This patient received three oral doses of I131 (305 millicuries, 69.7 millicuries, and 69.7 millicuries). Tissues samples were obtained by biopsy after each dose. I131 failed to localize the tumor and was judged ineffective for therapy. This work was supported by the U.S. Atomic Energy Commission.

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**OR-5.Use of Radioiodine in Surgical Removal of Thyroid Cancers**

Between 1950 and 1974, 117 patients admitted to the Oak Ridge Institute of Nuclear Studies, Oak Ridge Associated Universities, with cancer of the thyroid received at least one dose of therapeutic iodine-131(I131) as part of their therapy in addition to surgery. The project was started before the formation of the ORAU/ORNL Committee on Human Studies in 1967. However, prior to 1967, experimental protocols were reviewed by all members of the clinical staff, with consensus required for approval. The project was terminated in October 1974 and ORAU personnel began compiling data and evaluating the clinical course of the patients. Eighty-seven of these patients were still alive at that time. This work was supported by the U.S. Atomic Energy Commission.

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**OR-6.Comparison of the Metabolism of Rubidium-86 and Potassium-42**

In 1953, four patients at Oak Ridge Institute for Nuclear Studies with leukemia and carcinoma participated in tracer experiments to determine whether rubidium-86 (Rb86) could be used as an analog for potassium-42 (K42) in studying biological systems. Simultaneous intravenous injections of K42 and Rb86 were administered to the experimental subjects. Multiple samples of plasma, red cells, and urine were obtained and analyzed from each patient. The researchers concluded that Rb86 was a satisfactory substitute for K42 in biological studies. This work was funded by the U.S. Atomic Energy Commission.

**References**

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Tyor, M. P. and J.S. Eldridge. "A Comparison of the Metabolism of Rb86 and K42 Following Simultaneous Injection into Man.*"*Abstract of paper presented to American Society for Clinical Investigation, Atlantic City, April 1954. "

**OR-7.Metabolism Studies Using Calcium-47**

The metabolism of calcium in humans was studied at the Oak Ridge Institute of Nuclear Studies in 1959. Eleven patients with various diseases, including bone lesions and breast cancer, were given calcium-47 (Ca47). Analyses for Ca47 were then conducted on blood, urine, feces, and saliva. Whole body retention of Ca47 was also determined. Two patients were administered 70 microcuries intravenously and two patients received oral dosages of 138 and 104 microcuries, respectively. One patient received both an intravenous and an oral dose. Comparisons were made between intravenous and oral routes of administration. This research was funded by the U.S. Atomic Energy Commission.

**References**

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**OR-8.Whole Body Gamma Radiation Therapy of Patients With Hematologic Disorders**

From 1956 to 1973, the Oak Ridge Institute for Nuclear Studies/Oak Ridge Associated Universities Medical Division conducted studies on the efficacy of total body irradiation (TBI) for the treatment of hematologic disorders, particularly leukemia, polycythemia rubra vera, and lymphoma. The purposes were to develop better irradiation methods for therapy, improve methods for assessing and treating accidental gamma and neutron radiation, compile and evaluate related data, and devise new and more precise endpoints that define human radiation dose-response.

The 194 male and female patients, all diagnosed with some kind of hematologic malignancy, ranged in age from 12 to 86 years. They were exposed to totals of 50 to 250 roentgens (R) per treatment series. However, in 1970, one patient was exposed to 500 R in conjunction with an attempted bone marrow graft. The external gamma radiation sources were either cobalt-60 (Co60) or cesium-137 (Cs137) used in three types of facilities: a medium-exposure-rate total body irradiator (METBI) providing 1.5 R/min and two low-exposure-rate total body irradiators (LETBIs) providing 1.5 R/hr and 0.8 R/hr.

The therapeutic total body irradiation project was discontinued after 194 patients received exposures to 250 R in METBI or LETBI. However, there was a higher frequency of remissions at 150 R compared to 250 R, which occurred because of excessive marrow suppression at the higher exposure rates. Survival data indicated that TBI patients survived about as long as, but not significantly longer than, patients treated by other methods. The program, which was discontinued in 1974, was funded by the U.S. Atomic Energy Commission. (TBI was referenced in the Markey report.)

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**OR-9.Studies Using Radioactive Vitamin B12**

This research, conducted in the early 1960s, was a collaborative effort between the Oak Ridge Institute of Nuclear Studies, the Long Island Jewish Hospital (Jamaica, NY), South Nassau Communities Hospital (Oceanside, NY), and Brookhaven National Laboratory. A series of experiments was conducted to study the plasma clearance of vitamin B12 labeled with cobalt-57 (Co57). The studies sought to determine why the serum and plasma levels of vitamin B12 were elevated in patients with chronic myelocytic leukemia. In one study, three patients in remission were intravenously administered 0.13 microcurie of vitamin B12 labeled with cobalt-57. The procedure was repeated twice in the same patients, after administration of loading doses of stable vitamin B12.

In another study, 10 patients with various degrees of chronic myelocytic leukemia and 5 healthy individuals each received 3 or more intravenous injections of Co57 labeled B12. This research was supported by the U.S. Atomic Energy Commission and by a grant from the National Cancer Institute.

**References**

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**OR-10. Iodine-131-Labeled L-Thyroxine Turnover by Whole Body Counting**

During 1966 and 1967, a study was conducted by the Oak Ridge Institute of Nuclear Studies/Oak Ridge Associated Universities to compare the turnover of L-thyroxine (thyroxine is the active iodine compound existing normally in the thyroid gland) in subjects with hyperthyroidism, hypothyroidism, and normal thyroid functions. Ten patients with abnormal L-thyroxine metabolism were compared against a control group of five normal subjects. All subjects received 20 to 40 microcuries of iodine-131 (I131)-labeled L-thyroxine intravenously. Body counting was conducted twice on the first day after the I131-labeled L-thyroxine was administered and daily thereafter. Daily thyroid counts were made on the subjects by standard methods. In addition, blood samples were obtained from five patients to compare blood turnover rates to whole body counts. This study showed that whole body counting provided quantitative information on the turnover of L-thyroxine. This work was funded by the U.S. Atomic Energy Commission.

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**OR-11. Tumor Scanning with Gallium-67**

From 1969 through 1977, Oak Ridge Associated Universities conducted studies on the use of gallium-67 (Ga67) as a tumor-scanning agent in humans. Participating were 357 male and female patients ranging in age from 6 to 83 years. All had known, viable bone or soft tissue tumors associated with a wide variety of cancers. All patients received at least one intravenous injection of 70 microcuries of Ga67 per kilogram of body weight up to a total dose of 6 millicuries. Thirty-four of these patients received more than one injection. Several received a series of injections to study the therapeutic effect and to look for recurrence of disease.

In a related study, four patients were administered Ga67 by injection into the lymphatic structure of the feet. These studies showed that gallium does not collect equally in all types of tumors. Rather, it collects in tumors of specific cellular types. The lymphatic injections showed no advantage to this approach, even in identifying tumors along the lymphatic vessels. In May 1976, the U.S. Food and Drug Administration approved Ga67 citrate for general diagnostic use. This work was supported by the U.S. Atomic Energy Commission.

**References**

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**OR-12. Therapeutic Allogenic Transplantation of Human Bone Marrow**

From 1970 to 1973, Oak Ridge Associated Universities conducted a study to evaluate the effectiveness of combining high-dose total body irradiation (TBI) with antilymphocyte-globulin as an immunosuppressive regimen to induce tolerance to a foreign bone marrow graft in humans. Three patients were involved initially. Each was exposed to 500 roentgens (R), which corresponded to an average total body absorbed dose of approximately 370 rads. Subsequent bone marrow grafts were successful in two patients. Failure of the graft in the third patient was determined to have resulted from an insufficient radiation dose. Accordingly, researchers requested and received approval to increase the exposure level to deliver an absorbed dose of 800 rads at the rate of 40 R/min.

The original protocol limited patients to those with acute leukemia. Researchers also requested and received approval to extend the procedure to patients with aplastic anemia. A fourth patient, with acute leukemia, was treated in 1973. This patient was exposed to a 694 R to the total body irradiation, but developed an unexplained severe graft-versus-host reaction that prevented a successful marrow transplant.

The Oak Ridge Institute of Nuclear Studies conducted a related study beginning in 1971 that was designed to identify objective signs and distinguish early graft-versus-host reactions from drug reactions, infections, and other complications related to or incidental to the marrow transplant/TBI procedure. In this study, skin biopsies were obtained from four patients or volunteers, without further exposing them to radiation of any kind. This work was supported by the U.S. Atomic Energy Commission. (TBI was referenced in the Markey report.)

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**OR-13. Scandium-Augmented Gallium Localization in Tumors--Phase I and Phase II Studies**

From 1972 to 1973, Oak Ridge Associated Universities conducted a study to determine whether intravenous administration of stable (nonradioactive) scandium citrate along with radioactive gallium increases the relative concentration of the gallium in tumors. The study protocol proposed administration of scandium in doses ranging from 0.005 to 1.0 milligram per kilogram of body weight, followed by 100 microcuries of gallium-67 (Ga67) to 21 patients with known malignancies. The first patient to be treated experienced an adverse reaction to the scandium citrate but made a satisfactory recovery. Testing was suspended pending further investigation. There is no indication of further activity. This work was supported by the U.S. Atomic Energy Commission.

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**OR-14. Clinical Testing of Strontium-85m as a Bone Scanning Agent**

From 1972 to 1975, Oak Ridge Associated Universities conducted a study of strontium-85m (Sr85m) as a bone scanning agent. Patients with known malignant tumors or suspected metastatic disease of the bone were administered up to 30 microcuries of Sr85m per kilogram of body weight (approximately 2 microcuries per patient) by intravenous infusion. Results of the Sr85m scans were compared with subsequent scans using strontium-85, fluorine-18 (F18) or technetium-99m (Te99m). Four patients were involved in the study. This work was supported by the U.S. Atomic Energy Commission.

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**OR-15. Comparison of Indium-111 and Bismuth-206 with Gallium-67 as Tumor Scanning Agents**

From 1972 to 1978, Oak Ridge Associated Universities conducted a study to determine the relative merits of indium-111 (In111) and bismuth-206 (Bi206) when compared to gallium-67 (Ga67) as tumor imaging agents. In actual application, the study was limited to evaluating In111 and Ga67. In 1973, six cancer patients received simultaneous injections of In111 (0.011 microcurie per kilogram of body weight) and Ga67 (0.045 microcurie/kg). Three additional patients were studied during 1974. The study showed that Ga67 was a better tumor scanning agent than In111. After July 1974, no patients were scanned with In111 at Oak Ridge. This work was supported by the U.S. Atomic Energy Commission.

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**OR-16. Use of an External Gadolinium-153 Source for Timing the Cardiac Cycle**

From 1972 to 1975, Oak Ridge Associated Universities conducted a study to determine the effectiveness of gadolinium-153 (Gd153) as a noninvasive technique for evaluating specific stages of the cardiac cycle, notably the left ventricular ejection time. A fine beam of gamma radiation from a Gd153 source, which was placed on the subject's back, was directed through the heart to a detector on the subject's chest. At least six patients were subjected to a radiation exposure of approximately 0.2 roentgen over a 1-inch-diameter area on their backs. The passage of blood through the left ventricle was determined by measuring the blockage of gamma rays emitted by the Gd153. This work was supported by the U.S. Atomic Energy Commission.

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**OR-17. Dysprosium-157 as a Clinical Imaging Agent for Solid Tumors**

From 1973 to 1977, Oak Ridge Associated Universities conducted a study to determine whether dysprosium-157 (Dy157) could be used effectively as a tumor localizing agent in humans. Both tumors and soft-tissue tumors were considered. Thirty-four patients with known cancer were included. This study was discontinued in 1977 after the investigators found that Dy157 did not provide better images of solid tumors than the technetium-99m (Te99m) phosphate compounds did for bone scans, nor was it better than gallium-67 (Ga67) citrate for soft tissue tumors. This work was supported by the U.S. Atomic Energy Commission.

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**OR-18. Effect of Splenectomy and Total Body Irradiation on Chronic Granulocytic Leukemia**

In 1974, Oak Ridge Associated Universities conducted a study to determine the effect of splenectomy (surgical removal of the spleen), with or without total body irradiation (TBI), on the onset of blast crisis and overall survival in leukemia patients. The blast crisis occurs when a patient, previously in remission, begins to produce large quantities of immature white blood cells (called "blast cells"). The blast crisis is usually a terminal condition. The spleen becomes enlarged during the blast crisis and causes the patient considerable discomfort. The researchers were studying whether removal of the spleen, with or without TBI, might postpone the onset of blast crisis. The study protocol called for radiation exposure of 100 to 250 R, depending on the white cell count of the patient. Only one patient was treated in the study. The patient was not kept in remission after the splenectomy and required subsequent suppressive therapy. The study was canceled in January 1975 and the patient was no longer followed by ORAU. This work was supported by the U.S. Atomic Energy Commission. (TBI was referenced in the Markey report.)

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**OR-19. Clinical Testing of a Line-Scanning Proportional Counter Camera Using Injected Iodine-125 and Technetium-99m**

Diagnostic doses of iodine-125 and technetium-99m (Tc99m) were administered to selected patients referred to Oak Ridge Associated Universities from the Oak Ridge Methodist Hospital for thyroid evaluation. The quality of images obtained with the two radioisotopes with the camera was evaluated and compared. Although these subjects were evaluated for preexisting disease, certain aspects of this study were experimental, and the objective was development of instrumentation and techniques for evaluating human thyroids. An estimated 100 subjects were studied. This study was conducted between August 27, 1975, and September 29, 1977. The protocol was approved by the Oak Ridge Associated Universities/Oak Ridge National Laboratory Institutional Review Board. (Previously described in #33 on the original list of 48 experiments released by DOE in June 1994)

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**OR-20. Uranium Injections Into Terminally Ill Cancer Patients**

From 1953 to 1957, Oak Ridge National Laboratory and Massachusetts General Hospital conducted a cooperative study on the distribution and excretion of uranium in humans using terminally ill brain cancer patients as subjects. Participants included male and female patients ranging in age from 26 to 63 years. All were near death (in a coma or semicoma) prior to injection and were receiving usual hospital care for comatose patients. Subjects were intravenously administered uranium-233 (U233) or uranium-235 (U235) as either uranyl nitrate hexahydrate (9 patients) or uranium tetrachloride (2 patients) in amounts ranging from 4 to 50 milligrams. The subjects expired from their brain cancer within several months of injection. Study results indicated that 99 percent of the injected uranium cleared the blood within 20 hours, either depositing in the skeleton and kidneys or exiting through urine. This work was supported by the U.S. Atomic Energy Commission. (This experiment was referenced in the Markey report.)

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**University of Chicago--Argonne Cancer Research Hospital**

**UC-1. Chromium-51 and Iron-59 Used to Study Red Blood Cell Production**

Studies were carried out in the early 1950s at the Argonne Cancer Research Hospital to determine the rate of red cell production and destruction in healthy and anemic subjects. Two to four microcuries of iron-59 (Fe59) was added to 20 milliliters of plasma and injected into the arms of the subjects. Several days after the administration of the Fe59, the procedure was repeated using chromium-51 (Cr51)-labeled plasma. The subjects were six healthy individuals and two anemic individuals. The combined use of Cr51 and Fe59 provided an indicator of red cell survival and total blood volume in humans. This work was carried out under a contract between the Office of the Surgeon General, the United States Army, and the Department of Medicine of the University of Chicago. The U.S. Atomic Energy Commission provided funding to the Argonne Cancer Research Hospital through the University of Chicago, its operating contractor.

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**UC-2. Studies on the Clinical Application of Yttrium-90**

In 1953, at the Argonne Cancer Research Hospital, preliminary studies were carried out with yttrium-90 (Y90) to determine whether Y90 might be used for intracavitary therapy. A patient in the terminal stage of carcinomatosis was injected intrapleurally with a solution containing about 1,350 microcuries of Y90. Samples of fluid were withdrawn from the pleural cavity at 3, 24, and 48 hours and at autopsy, which was 7 days after the administration of Y90. The study found that Y90 had a half-time of 30 to 36 hours. The U.S. Atomic Energy Commission provided funding to the Argonne Cancer Research Hospital through the University of Chicago, its operating contractor.

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**UC-3. Radioactive Sodium-2 Chromate Used to Study Primaquine Sensitivity**

In 1953, the University of Chicago and the Argonne Cancer Research Hospital conducted studies to determine the hemolytic defect that develops during primaquine administration. Primaquine is an anti-malarial drug that induces an acute hemolytic anemia in some people, mainly members of heavily pigmented races. The subjects for this study were healthy, male inmates from the Illinois State Penitentiary at Statesville. None of the inmates had ever had malaria. All of the primaquine-sensitive subjects were African-Americans and the primaquine-nonsensitive subjects included both African-American and Caucasian subjects. There was also one subject who was a student at the University of Chicago, who was included in the study because he had been splenectomized two years prior to the initiation of this research. Blood labeled with 200 to 300 microcuries of sodium chromate (Na2Cr51O4) was injected into both the normal subjects and the group of primaquine-sensitive subjects. Subsequently, primaquine was administered to subjects in both groups. Blood samples showed that the primaquine-sensitive subjects developed a severe anemia, which was attributed to a unique susceptibility of their red blood cells. This study was carried out under a contract between the Department of Medicine at the University of Chicago and the Office of the Surgeon General for the United States Army. The radiochromium was obtained under an authorization from the Isotopes Division of the U.S. Atomic Energy Commission at Oak Ridge, TN. The Argonne Cancer Research Hospital was operated by the University of Chicago, which was funded by the U.S. Atomic Energy Commission.

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**UC-4. Sodium-24 Chromate Used to Measure Red Cell Survival Times in Subjects with Liver Diseases**

In 1953, at the Argonne Cancer Research Hospital, sodium chromate labeled with sodium-24 (Na24) was used to measure the red cell survival time of patients with liver disease. The subjects in this study were 19 patients with various types of liver disease. Liver biopsies were taken from all cases, except from 4 patients with bleeding tendencies. The results indicated an abnormal red cell survival time in these patients. This study was supported in part by the Office of the Surgeon General, United States Army. The Argonne Cancer Research Hospital was operated by the University of Chicago, which was funded by the U.S. Atomic Energy Commission.

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**UC-5. Radioactive Carbon in Studies of Cholesterol Metabolism in Man**

In 1955, a study on the metabolism of cholesterol was reported by the Department of Medicine and the Argonne Cancer Research Hospital of the University of Chicago and the Los Alamos Scientific Laboratory. The objective of the study was to determine the rate at which cholesterol labeled with carbon-14 (C14) appeared in the plasma and to determine now much of the C14 was incorporated. This study was conducted on patients admitted to the research wards of the Argonne Cancer Research Hospital. Thirty-four subjects with various forms of cancer were studied. Both male and female subjects were included; their ages ranged from 23 to 71 years.

Patients received 100 or 200 microcuries of C14-labeled sodium acetate. The C14 labeled acetate was administered either orally or intravenously, and in some cases by both routes. Larger amounts were given to patients having the shortest life expectancies. Blood was withdrawn at a time point ranging from 30 minutes to several weeks after administering the C14 acetate. Some patients were subjected to additional tests to determine the amount of C14 lost from the body by respiration or excretion. This study was funded by the U.S. Atomic Energy Commission, the Damon Runyon Memorial Fund, and the American Cancer Society. (Previously described in #23 on the original list of 48 experiments released by DOE in June 1994)

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**UC-6. Study of the Origin of Steroid Hormones Using Tritium and Carbon-14-Labeled Compounds**

In 1955, a study was conducted at the Argonne Cancer Research Hospital, in collaboration with scientists at the Los Alamos Scientific Laboratory, to determine the relationship between dietary cholesterol and the synthesis of hormones in the body. Seven patients who were to have their adrenal glands surgically removed or who were scheduled to have a therapeutic abortion were fed 50 microcuries of tritium-labeled (H3) cholesterol seven days prior to surgery. An additional amount of 10 microcuries H3-labeled cholesterol was administered orally each succeeding day before surgery. During the surgery the patient was given 100 microcuries of acetate labeled with carbon-14 (C14) by intravenous injection. The aborted fetuses, the removed adrenal gland, and other biopsy tissue samples were analyzed for C14- and H3-labeled cholesterol and steroid-based hormones. This study showed that dietary cholesterol was rapidly converted to steroid hormones and that C14 from the acetate source was also incorporated into hormones. The research was supported by the U.S. Atomic Energy Commission. (Previously described in #23 on the original list of 48 experiments released by DOE in June 1994)

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**UC-7. Sodium Chromate Used to Study Red Blood Cells**

This research was carried out at the Argonne Cancer Research Hospital in the mid 1950s. This study was the first to use the chromium-51 (Cr51) labeling technique to study red cell survival in patients with abnormal hemoglobin syndrome. The subjects were 11 black patients with various blood disorders, including 4 with sickle cell anemia, and 2 healthy black subjects. One hundred milliliters of blood were withdrawn from each patient, labeled with 200 microcuries of Cr51, and reinjected. Samples of blood and feces were collected and analyzed to determine red cell survival times. The study showed that there was a decreased survival of erythrocytes (red blood cells) in patients with sickle cell anemia. The U.S. Atomic Energy Commission provided funding to the Argonne Cancer Research Hospital through the University of Chicago, its operating contractor.

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**UC-8. Blood Level Studies with Carbon-14 Digitoxin**

In the mid-1950s, studies were conducted at the Argonne Cancer Research Hospital on the uptake and retention of digitoxin labeled with carbon-14 (C14). Digitoxin is a drug used in the treatment of cardiac failure. This study sought to determine the rate of disappearance of unchanged digitoxin and to determine the conversion products arising from the parent drug. Eight subjects with congestive heart failure were given an intravenous injection of 0.5 to 1.5 milligrams of 0.36 to 0.65 microcurie per milligram of radioactive C14-digitoxin. Digitalis medication had been withheld from 14 to 34 days prior to the injection and none was given after the injection. Subsequent to the injection, several 10- to 20-milliliter blood samples were withdrawn in a 96-hour period.

The same researchers conducted another study, using three terminal patients. The purpose of the second study was to determine the distribution of digitoxin in various tissues of the body and to determine the pathway by which the drug is removed from the body. The radioactive digitoxin was isolated from digitalis plants that had been grown in an atmosphere of C14. The specific activity of the drug ranged from 0.48 to 0.65 microcurie per milligram. For three terminal patients, multiple doses were intravenously administered to maintain an adequate concentration in the tissues. Tissue samples were taken after the patients died. These tissues were analyzed for digitoxin content. Further research was conducted where radioactive metabolites of digitoxin were studied following the administration of single intravenous doses of digitoxin labeled with C14 or with H3. This research determined the reactions that digitoxin undergoes in humans. The Argonne Cancer Research Hospital was operated by the University of Chicago, which was funded by the U.S. Atomic Energy Commission.

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**UC-9. Carbon-14-Labeled Proteins in Multiple Myeloma**

This research was carried out at the Argonne Cancer Research Hospital in the early to mid 1950s. A total of 5.41 grams of carbon-14 (C14) labeled glycine were given orally in divided doses over an 11-hour period to a patient suffering from multiple myeloma, a malignant neoplasm that originates in the bone marrow and is characterized by abnormalities in formation of plasma protein. The myeloma cells produce abnormal proteins in the serum and urine. Blood samples were withdrawn and 24-hour urine collections were analyzed to determine the rate of synthesis and the possible precursor relationships of myeloma globulins and Bence-Jones proteins.

The same researchers conducted further experiments with another patient who had different pathological proteins and graver clinical conditions. The subject of this experiment was a 70-year-old male with multiple myeloma. The patient was given 20.94 grams of stable nitrogen-15-labeled glycine. The results of this later experiment showed the direct interaction of the Bence-Jones proteins with the metabolic pool of nitrogen.

In a third experiment, a 64-year-old female patient was injected with C14-labeled lysine to determine the rate of synthesis and excretion of the Bence-Jones protein. On the day of the experiment, a catheter was inserted and the patient was injected with 300 microcuries of L-lysine labeled with C14. Urine and respiration were analyzed and two dialysis experiments were performed on the patient. The patient died of uremia 2 months after admission to the hospital. Another patient, a 67-year-old male who was admitted to the Argonne Cancer Research Hospital for treatment and terminal care was injected with 450 microcuries of carbon-14 glutamic acid. One reason for conducting this last experiment was to learn whether glutamic acid might be a better compound to use to study protein synthesis than lysine or glycine. This research was supported by grants from the National Cancer Institute, National Institute of Health and the American Cancer Society. The Argonne Cancer Research Hospital was operated by the University of Chicago, which was funded by the U.S. Atomic Energy Commission.

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**UC-10. Carbon-14-Labeled Digitoxin Administered to Pregnant Women to Determine Fetal Distribution**

This study was conducted at the Argonne Cancer Research Hospital in the mid-1950s. The purpose of the study was to investigate the transfer of digitoxin across the placental barrier of pregnant women and to determine the relative concentration of the unchanged drug and its metabolic products in various fetal organs. The subjects were four pregnant women who were hospitalized at the Chicago Lying-in Hospital. Three of the women had abortions; the fourth delivered an anencephalic baby. Three to 5 hours before hysterotomy, three of the women were intravenously given from 0.25 to 0.5 milligram of digitoxin labeled with carbon-14 (C14) at a concentration of 0.25 to 0.5 microcurie per milligram. The fourth woman was given 0.5 milligram of the radioactive drug 2 to 3 hours before the expected time of delivery. The Argonne Cancer Research Hospital was operated by the University of Chicago, which was funded by the U.S. Atomic Energy Commission.

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**UC-11. Human Tracer Studies Using Tritium and Carbon-14-Labeled Cholesterol**

In 1957, an experiment was conducted at the Argonne Cancer Research Hospital, using radioactively labeled cholesterol. A 60-year-old man with chronic arthritis was the subject of this study. He received an intravenous injection containing 33.8 microcuries of tritium-labeled (H3) cholesterol and 4.3 microcuries of cholesterol labeled with carbon-14 (C14). Blood samples were withdrawn at various times starting about 4 hours after injection and continuing periodically for 10 days. Urine samples were also collected and analyzed for C14- and H3-labeled cholesterol and steroid hormones. This experiment showed the advantages of using H3 and C14 in humans. It also showed the distribution of C14 and H3 in hormones synthesized from cholesterol. This study was funded by the Damon Runyon Memorial Fund and the U.S. Atomic Energy Commission. (Previously described in #23 on the original list of 48 experiments released by DOE in June 1994)

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**UC-12. Hormone Conversion During Human Pregnancy**

This study was conducted by the Argonne Cancer Research Hospital in the mid- to late 1950s. The purpose of the study was to determine whether acetate and cholesterol are precursors of estrone in pregnant women. The subject was a 36-year-old white woman who underwent a thyroidectomy prior to pregnancy. An intramuscular injection of 35.09 microcuries of testosterone-4-C14 was administered during the 7th week of pregnancy and an abortion was performed 4 days after the injection. About 55 percent of the radioactivity derived from the labeled testosterone was eliminated from the body by way of the kidney. The results of this experiment demonstrated the conversion of testosterone to estrone during the course of human pregnancy. The U.S. Atomic Energy Commission provided funding to the Argonne Cancer Research Hospital through the University of Chicago, its operating contractor.

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**UC-13. Studies on Uric Acid Labeled With Carbon-14**

In the late 1950s, studies were carried out at the Argonne Cancer Research Hospital to investigate the metabolism of uric acid in humans. Uric acid labeled with carbon-14 (C14) was intravenously injected into five individuals, consisting of two healthy subjects, two gouty subjects, and one patient with arteriosclerotic heart disease. Urine samples were analyzed for C14 content. For three individuals, after the administration of the carbon-14-labeled uric acid, samples of expired air were collected and radioassayed. The expired air from all three patients showed that some of the injected uric acid had been degraded to carbon dioxide and ammonia. Saliva, gastric juice, and bile were also radioassayed to determine the amount of uric acid excreted into the intestine.

To verify the role of the intestinal flora on uricolysis, the degradation of intravenously administered uric acid C14 was studied before and after a high degree of intestinal bacteriostasis had developed. The subject was a healthy 57-year-old male, who was kept on a diet during the study and for 10 days prior to the study. After intravenous administration of 33.23 milligrams of uric acid containing 35 microcuries of C14, urine and expired-air samples were collected for 10 days. On the 11th day, three types of antibiotics were orally administered and after establishing the desired bacteria level in the intestinal tract, 35 microcuries of C14-labeled uric acid was intravenously injected. This research found that intestinal flora play a prominent role in the degradation of uric acid in humans. The Argonne Cancer Research Hospital was operated by the University of Chicago and supported by the U.S. Atomic Energy Commission.

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**UC-14. Carbon-14 Study of the Carbon Dioxide Pool in Man**

This research was conducted in the late 1950s at the Argonne Cancer Research Hospital. Since many materials labeled with carbon-14 (C14) are oxidized to carbon-dioxide-labeled C14, this research sought to determine the metabolic pool of carbon dioxide in humans. A solution of NaHC14O3 was given intravenously at a constant rate for a period of two to four hours, while the one subject breathed continuously through a beta-particle chamber. The Argonne Cancer Research Hospital was operated by the University of Chicago which was funded by the U.S. Atomic Energy Commission.

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**UC-15. Metabolism, Retention, and Excretion of Molybdenum-99**

In the late 1950s, the Argonne Cancer Research Hospital conducted studies on the absorption and excretion patterns by means of molybdenum-99 (Mo99). The studies were carried out on healthy subjects to determine the role of molybdenum in the oxidation of hypoxanthine and xanthine (precursors of uric acid). The urinary excretion rate of molybdenum in normal subjects was determined. Molybdenum was readily absorbed from the gastrointestinal tract. Seventy-five percent of ingested Mo99 was recovered in the first 24-hour urine sample. The Argonne Cancer Research Hospital was operated by the University of Chicago, which was funded by the U.S. Atomic Energy Commission.

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**UC-16. Metabolism of Strontium-85 and Calcium-47**

In 1960, at the Argonne Cancer Research Hospital, tracer amounts of strontium-85 (Sr85) as strontium chloride, in doses from 26 to 40 microcuries, were administered intravenously to seven adult subjects (six male and one female). Measurements were made of blood specimens, urine specimens, and total body gamma activity. The subjects included a woman with moderate osteoporosis, a 66-year-old male with multiple myeloma, and 2 males in the 60-year age group.

The research found that strontium is retained with greater avidity where there is deossification of the skeleton (skeletal disease). One other patient with metastatic parathyroid carcinoma was intravenously administered 50 microcuries of Sr85, and total body counting was performed over a 238-day period. Studies on the metabolism of calcium were carried out using calcium-47 (Ca47). Sixteen hospitalized patients were counted in the whole body counting facility following a single 20-microcurie dose of Ca47. The Argonne Cancer Research Hospital was operated by the University of Chicago, which was funded by the U.S. Atomic Energy Commission.

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**UC-17. Development of Iodine-131-Labeled Fluorescein as a Brain Tumor Imaging Agent**

This study was conducted in 1960 at the Argonne Cancer Research Hospital. Fluorescein labeled with radioiodine (I131) was developed to diagnose tumors of the central nervous system. Information obtained included the rate of disappearance from the blood, the rate of excretion, distribution in tissues, and comparison of concentrations in brain tumors and in normal brain tissue. Patients suspected of having brain tumors were selected for studies on the localization and retention of I131-fluorescein. Urine and stool samples were also collected from six patients over a 48-hour period for I131 analysis. Two normal volunteers were also injected with 5.7 microcuries of I131-fluorescein. A total of 102 patients were injected. This research was supported in part by a grant from the American Cancer Society. The Argonne Cancer Research Hospital was operated by the University of Chicago, which was funded by the U.S. Atomic Energy Commission.

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**UC-18. Studies Using Carbon-14-Labeled Compounds in Patients With Gout**

Studies were conducted by the Argonne Cancer Research Hospital in the early 1960s on patients with gout to determine the metabolism of uric acid in humans. This research was conducted to determine whether patients with various degrees and types of gout had an increased incorporation of glycine into uric acid. Gout is an inherited metabolic disorder characterized by chronic arthritis and usually by an elevated uric-acid blood level. Twelve patients with gout were intravenously administered glycine labeled with carbon-14 (C14) over a period of 60 minutes. The results of these experiments demonstrated that excessive incorporation of glycine into uric acid is usually confined to gouty subjects with abnormally high urinary outputs of uric acid. Three of the subjects who were overproducers of uric acid were studied in detail to determine the pathway whereby glycine is incorporated into uric acid more promptly than in normal humans.

Two of the healthy subjects and one other patient with gout, who did not overproduce uric acid, were also part of this study. These individuals were administered azathioprine, a cytotoxic and immunosuppressive agent, for 7 to 10 days prior to the intravenous administration of 100 microcuries glycine labeled with C14. This research found that when azathioprine was given to subjects who overproduce uric acid, their urinary uric acid fell to normal values. The Argonne Cancer Research Hospital was operated by the University of Chicago, which was funded by the U.S. Atomic Energy Commission.

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**UC-19. Use of Molybdenum-99 for Liver Scanning Studies**

Molybdenum-99 was used as a tracer agent in the early 1960s, at the Argonne Cancer Research Hospital, to image the liver and to determine the disappearance from the blood of intravenously injected molybdenum-99 (Mo99). Both normal subjects and patients with liver disease were administered between 40 and 100 microcuries of Mo99 by intravenous injection. Liver scans were performed at the Argonne Cancer Research Hospital's whole body counting facility. Subjects included normal volunteers and one patient with viral hepatitis. Approximately 100 liver scans were performed using Mo99 as a tracer. The Argonne Cancer Research Hospital was operated under contract by the University of Chicago which was funded by the U.S. Atomic Energy Commission.

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**UC-20. Metabolism of Lithocholic Acid Labeled with Carbon-14**

These studies were carried out by the Argonne Cancer Research Hospital in the early 1960s to determine the metabolism of lithocholic acid. Lithocholic acid, a steroid produced by the human body, is found in human bile and feces. A dose of eleven microcuries of lithocholic acid labeled with carbon-14 (C14) was orally administered to four patients, 20 to 72 hours before elective gallbladder surgery for gallstones. Two other patients with functioning gallbladders were studied after oral administration of 50 microcuries of lithocholic acid labeled with C14. Bile was obtained during their gallbladder operations and analyzed for C14. The Argonne Cancer Research Hospital was operated under contract by the University of Chicago which was funded by the U.S. Atomic Energy Commission.

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**UC-21. Preliminary Tracer Studies Using Technetium-99m**

Studies were conducted in 1961 at the Argonne Cancer Research Hospital on the use of technetium-99m (Tc99m) as a tracer and imaging agent for nuclear medicine. Scans of human subjects were made with a Picker Magnascanner 30 minutes after intravenous injection of Tc99m. One white female received an intravenous injection of 1 millicurie of Tc99m. Thyroid scans were conducted on a clinically normal white male 30 minutes after intravenous injection of Tc99m and the results were compared with scans conducted after iodine-131 (I131) administration. The urinary and fecal excretion of Tc99m pertechnate was studied in four patients. At least two normal subjects, including a healthy African-American male, were administered 440 microcuries of Tc99m in order to analyze radiocardiograms. Another male subject was administered 1 millicurie of Tc99m and dose calculations were made for the total body, stomach, and thyroid. The purpose of this research was to determine the biological retention half-time, and suitability as an imaging agent, of Tc99m. With a biological retention half-time of 48 hours, Tc99m was found to be a suitable imaging agent . The Argonne Cancer Research Hospital was operated under contract by the University of Chicago, which was funded by the U.S. Atomic Energy Commission.

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Harper P.V. and K. Lathrop. ATechnetium-99m as a Scanning Agent." *Semiannual Reports to the U.S. Atomic Energy Commission, Vol. 5, Parts 21B25, Part 102B104, 1964 to 1966.*Chicago: Argonne Cancer Research Hospital, pp. 96B98. The University of Chicago, Office of Legal Counsel, Semiannual Reports of the Argonne Cancer Research Hospital.

Harper P.V. and K. Lathrop. "The Pharmacodynamics of Technetium Pertechnetate (99m-TcO4)." *Semiannual Reports to the U.S. Atomic Energy Commission, Vol. 5, Parts 21B25, Part 102B104, 1964 to 1966.* Chicago: Argonne Cancer Research Hospital, pp. 97B98. The University of Chicago, Office of Legal Counsel, Semiannual Reports of the Argonne Cancer Research Hospital. "

**UC-22. Metabolism and Absorption of Skin Medications Labeled with Carbon-14**

This research was conducted by the Argonne Cancer Research Hospital in the mid-1960s. Eleven normal and nine psoriatic Caucasian volunteers served as experimental subjects. Palmitic acid containing 1 microcurie of carboxyl carbon (C14) label dissolved in petroleum ether was dripped onto each of two demarcated areas of lesion-free skin on the back of each subject. After 2.5 hours, the skin was wiped with petroleum ether-soaked cotton. The entire study was repeated in four additional normal volunteers following the application of an ointment comparable to the standard treatment for psoriasis. The study was also repeated in one other normal volunteer and in two patients with minor eczema. The Argonne Cancer Research Hospital was operated under contract by the University of Chicago, which was funded by the U.S. Atomic Energy Commission.

**References**

Gara, A., E. Estrada, S. Rothman, and A.L. Lorincz. "Deficient Cholesterol Esterifying Ability of Lesion-Free Skin Surfaces in Psoriatic Individuals." *Semiannual Reports to the U.S. Atomic Energy Commission, Vol. 5, Parts 21B25, Part 102B104, 1964 to 1966.* Chicago: Argonne Cancer Research Hospital, pp. 62B69. The University of Chicago, Office of Legal Counsel, Semiannual Reports of the Argonne Cancer Research Hospital.

Lorincz, A.L. "Specific Metabolic Processes in Skin." *Semiannual Reports to the U.S. Atomic Energy Commission, Vol. 5, Parts 21B25, Part 102B104, 1964 to 1966.* Chicago: Argonne Cancer Research Hospital, p. 75. The University of Chicago, Office of Legal Counsel, Semiannual Reports of the Argonne Cancer Research Hospital. "

**UC-23. Studies on the Use of Iodine-131 Antifibrinogen**

This was a collaborative study between the Argonne Cancer Research Hospital and the University of Rochester conducted in the mid-1960s. Its purpose was to determine the diagnostic and therapeutic potential of antifibrinogen labeled with iodine-131 (I131), which was thought to combine with circulating fibrinogen and to localize in tumors. In half of the tumors studied, localization allowed for clear visualization on scanning.

An antibody was intravenously administered. This procedure was carried out in two patients. Although some tumors imaged, this study was not successful in treating cancer because of poor localization of the antifibrinogen label with I131. The Argonne Cancer Research Hospital was operated under contract by the University of Chicago, which was funded by the U.S. Atomic Energy Commission.

**References**

Harper, P.V. and I. Spar. AI131-Antifibrinogen." *Semiannual Reports to the U.S. Atomic Energy Commission, Vol. 5, Parts 21B25, Part 102B104, 1964 to 1966.* Chicago: Argonne Cancer Research Hospital, pp. 98B100. The University of Chicago, Office of Legal Counsel, Semiannual Reports of the Argonne Cancer Research Hospital. "

**UC-24. Bone-tissue Radiography Using and External Source of Iodine-125**

A method was developed at the Argonne Cancer Research Hospital in Chicago to measure bone mineral content in animals or humans, using an external iodine-125 (I125) source. Bone mineral was determined by transmitting a small beam of photon radiation from an I125 source through a single human finger bone, capturing an image of the finger on radiographic film. Mineral content was determined by analyzing the image density. This technique was tested on a group of postmenopausal women (with ovaries removed) who were estrogen deficient to determine the beneficial effects of estrogen therapy on bone mineralization. Another group of postmenopausal women with ovaries and no hormone therapy was also studied, again using finger bone radiography. A group of premenopausal women served as controls. One hundred patients participated in this study. The study showed that hormone therapy had a beneficial effect on bone mineral content in women. The Argonne Cancer Research Hospital was operated by the University of Chicago and supported by the U.S. Atomic Energy Commission.

**References**

Lanzl, L.H. and N.M. Strandjord. "Measurement of Bone Mineral Content Using a Radioactive Device." *Semiannual Reports to the U.S. Atomic Energy Commission, Vol. 5, Parts 21B25, Part 102B104, 1964 to 1966.* Chicago: Argonne Cancer Research Hospital, pp. 141B142. The University of Chicago, Office of Legal Counsel, Semiannual Reports of the Argonne Cancer Research Hospital. "

**UC-25. Retention of Iron-59 in the Lungs**

This study was conducted at the Argonne Cancer Research Hospital in 1967. This study compared the amount of blood lost from the body to that retained from the lungs in a menopausal woman with pulmonary hemosiderosis, a disease characterized by expectoration of blood from the lungs or bronchial tubes. This was the first study in which linear profile scanning of iron-59 (Fe59) was used for this purpose. When the patient was in remission from the disease, 10 microcuries of Fe59 were injected intravenously. Analysis was done on plasma iron clearance, serial body surface counting rates, erythrocyte incorporation, and linear profile scanning of Fe59. The Argonne Cancer Research Hospital was operated under contract by the University of Chicago which was funded by the U.S. Atomic Energy Commission.

**References**

DeGowin, R.L., L.B. Sorensen, D.B. Charleston, A. Gottschalk, and J.H. Greenwald. "Retention of Radioiron in the Lungs of a Woman with Idiopathic Pulmonary Hemosiderosis." *Semiannual Reports to the U.S. Atomic Energy Commission, Vol. 6, Parts 26B33, 1966 to 1970.* Chicago: Argonne Cancer Research Hospital, pp. 28B37. The University of Chicago, Office of Legal Counsel, Semiannual Reports of the Argonne Cancer Research Hospital. "

**UC-26. Studies on the Interactive Effects of a Drug Which Induces Hyperthyroidism on X-ray Irradiation**

This research was conducted by the Argonne Cancer Research Hospital in the late 1960s to determine whether induced hyperthyroidism increased the sensitivity of tumors to therapeutic x rays. The subjects of this experiment were patients with advanced cancer who could tolerate an elevated metabolic rate caused by oral doses of triiodothyronine. X rays were also administered in daily fractionated doses. In two patients with bronchogenic carcinomas, after induction of the hyperthyroid condition, the metastases on one side was treated and the other side was treated only after the BMR had been allowed to return to normal. At autopsy, 3 months after the treatment, the side treated with the drug and the x rays showed only fibrosis while the tumor was still present in the side treated by x rays alone. Another patient with lung metastasis due to melanoma was subjected to the combined treatment with no response. In two patients with adenocarcinoma brain metastases and unknown primary lesions, the combined therapy was effective on the brain lesions but not on the primary lesions. The U.S. Atomic Energy Commission provided funding to the Argonne Cancer Research Hospital through the University of Chicago, its operating contractor.

**References**

Griem M.L. and J.A. Stein. "The Effect of L-triiodothyronine on Radiation Sensitivity." *Semiannual Reports to the U.S. Atomic Energy Commission, Vol. 3, Part 101, 1961 and Parts 11B15, 1959 to 1961*. Chicago: Argonne Cancer Research Hospital, pp. 52B54. The University of Chicago, Office of Legal Counsel, Semiannual Reports of the Argonne Cancer Research Hospital. "

**UC-27. Metabolism and Retention Studies Using Selenium-75**

These studies were carried out in the late 1960s at the Argonne Cancer Research Hospital to determine the organ uptake of selenium-75 (Se75). Four subjects were intravenously injected with Se75. The first was a male with a varicose ulcer who was administered 100 microcuries. The second was a male with mild diabetes who was administered 200 microcuries on one occasion and was subsequently administered 220 microcuries. Subjects were followed by whole body counting for up to 30 months. The biological half-time was found to be about 80 days. The results of this study found that after a single injection of Se75, one-half of the Se75 was eliminated from the body after 80 days. The Argonne Cancer Research Hospital was operated under contract by the University of Chicago, which was funded by the U.S. Atomic Energy Commission.

**References**

Lathrop, K.A., P.V. Harper, and F.D. Malkinson. "Human Total-Body Retention and Excretory Routes of Se75 from Selenomethionine." *Semiannual Reports to the U.S. Atomic Energy Commission, Vol. 6, Parts 26B33, 1966 to 1970*. Chicago: Argonne Cancer Research Hospital, pp. 49B57. The University of Chicago, Office of Legal Counsel, Semiannual Reports of the Argonne Cancer Research Hospital. "

**UC-28. Comparison of Gallium-68, Technetium-99m, and Indium-113m for Diagnosis of Tumors**

In the late 1960s, the Argonne Cancer Research Hospital conducted studies to determine the combination of radionuclide preparation and imaging system with the best lesion-detection capabilities per unit radiation dose. Preparations of gallium-68 (Ga68), technetium-99m (Tc99m), and indium-113m (In113m) were used to detect lesions in the brain, kidney, liver, and lung. Biological half-times in humans were compared with those in mice by measuring radioactivity in the excreta. The Argonne Cancer Research Hospital was operated under contract by the University of Chicago, which was funded by the U.S. Atomic Energy Commission.

**References**

Lathrop, K.A., T.D. Cohen, R.N. Beck, and P.V. Harper. "Comparison of Gallium-68, Technetium-99m, and Indium-113m Used with the Gamma Camera and the 3-Inch and 5-Inch Scanners for Visualization of Lesions in the Brain, Kidney, Liver, and Lung." *Semiannual Reports to the U.S. Atomic Energy Commission, Vol. 6, Parts 26B33, 1966 to 1970.*Chicago: Argonne Cancer Research Hospital, pp. 1B13. The University of Chicago, Office of Legal Counsel, Semiannual Reports of the Argonne Cancer Research Hospital. "

**University of Rochester**

**UR-1. Polonium-210 Metabolism and Excretion Study**

During the early 1940s, the University of Rochester in New York conducted studies on the retention, excretion, and gastrointestinal tract absorption of polonium-210 (Po210) in humans, using patients at Strong Memorial Hospital in Rochester, NY as subjects. The purpose of the study was to determine occupational exposure limits for use in radiation protection programs. Five patients with advanced lymphoma or leukemia participated. Four were administered an intravenous injection of 8 to 23 microcuries of Po210 and one patient was orally administered 18.5 microcuries of Po210 in tap water. Urine samples were subsequently collected and analyzed for Po210. All subjects died of preexisting ailments shortly after the administrations. Tissues were obtained at autopsy and examined for Po210 concentration. This research was supported by the Manhattan Engineer District. (This experiment was referenced in the Markey report.)

**References**

Fink, R.M. "Biological Studies with Polonium, Radium, and Plutonium." *National Nuclear Energy Series*. Div. VI, Vol. 3. New York: McGraw-Hill, 1950.

Stannard. J.N. *Radioactivity and Health: A History.* Office of Scientific and Technical Information. 1988, p. 213B214. "

**UR-2. Uranium Injections**

From August 1946 to January 1947, the University of Rochester conducted toxicity studies on uranium, using hospital patients as subjects. The purpose of the studies was to determine the dose level at which renal injury is first detectable, measure the rate at which uranium is eliminated from the body once it enters the bloodstream, and observe the effect of measures intended to alter the excretion rate. Human subjects included four males and two females, all with good kidney function, ranging in age from 24 to 61 years. All had medical conditions, such as undernutrition, alcoholism, or heart disease. Highly enriched uranium (uranium-234 and uranium-235) was administered intravenously as uranyl nitrate in amounts ranging from 6.4 to 70.9 micrograms per kilogram of body weight. At levels approaching 50 micrograms per kilogram, the preparation was diluted with natural uranyl acetate (U238) to limit the potential radiotoxicity associated with systemic enriched uranium. Five subjects received a single injection and experienced no kidney damage. The sixth subject experienced slight kidney tissue toxicity at the 70.9 microgram/kg level, suggesting that the human tolerance level had been reached. This patient was administered ammonium chloride to induce an acidosis condition (a decrease in alkali relative to acid in bodily fluids), then received a second injection of uranyl nitrate at a dose of 56.6 microgram per kilogram.

These studies showed that the tolerance level for uranium in the human circulation was about 70 micrograms per kilogram of body weight, that uranium excretion occurred mainly through urine, that 70 to 85 percent was eliminated in the first 24 hours, and that acidosis decreased the rate of uranium excretion. This research was supported by the Manhattan Engineer District. (This experiment was referenced in the Markey report.)

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Bassett, S.H., A. Frankel, N. Cedars, H. Van Alstine, C. Waterhouse, and K. Cusson. *The Excretion of Hexavalent Uranium Following Intravenous Administration. II. Studies on Human Subjects*. Rochester: The University of Rochester, URB37, June 1948. "

**UR-3. Ingestion of Milk Containing Iodine-131**

This study was conducted in 1963 by a graduate student at the University of Rochester to investigate the human body's metabolism of radioiodine found in dairy products. The research sought to determine if iodine found in milk was transferred to the thyroid in the same quantities as the inorganic iodide commonly used in medical studies. As much as 40 percent of the iodine found in milk was found to be protein bound. The study focused on the range of uptake percentages in children of various ages. Subjects for the experiment were chosen with an emphasis on the younger age groups, since the majority of known research had been conducted on adults. The subjects ranged in age from 6 years to 50 years; seven were less than 21 years old. The milk used for this study was obtained from Cornell University's Department of Veterinary Medicine, where a cow had been fed iodine-131 (I131) so as to produce 5,000 to 10,000 picocuries per liter in its milk. All subjects were put on an iodine restricted diet prior to the study and then were fed the I131 milk for a minimum of 14 days. One of the children in this study subsequently developed thyroid carcinoma. The research was performed under a contract with the U.S. Atomic Energy Commission.

**References**

Cuddihy, R.G. "Hazard to Man from I131 in the Environment."*Health Physics*. Vol. 12, 1966, pp. 1,021B1,025. "

**UR-4. The Fate of Radon Ingested by Man**

In 1964, the Department of Radiation Biology at the University of Rochester conducted a study on the fate of radon ingested by humans. Two male subjects, one 56 and the other 36, participated. On two occasions, each subject drank approximately 1 microcurie of radon-222 (Rn222) in equilibrium with its decay products in 100 milliliters of water. On three separate days, the ingestions of radon were followed by a normal breakfast; the fourth followed a larger breakfast high in fat. The subject's respired air, blood, and urine were obtained and sampled for Rn222 activity. This study provided rates at which the body loses radon and the impact of stomach contents on the rate of loss. The research was supported by the U.S. Atomic Energy Commission. (Previously described in #29 on the original list of 48 experiments released by DOE in June 1994)

**References**

Hursh, J.B., D. A. Morken, T.P. Davis, and A. Lovaas. "The Fate of Radon Ingested by Man." *Health Physics*. Vol. 11, 1965, pp. 465B476. "

**Other**

**OT-1. Study of Blood Volumes With Iodine-131-Tagged Plasma Protein**

Case Western Reserve University conducted this study in 1950. Blood volume determinations were made on 76 ambulatory hospital patients who exhibited normal fluid and protein balance. The subjects were injected with plasma protein tagged with iodine-131 (I131) while they were fasting. They were confined to bed until the experiment was completed. Approximately 40 to 60 microcuries of I131 were intravenously injected. Twelve patients who were to receive spinal anesthesia were also given radioactive iodinated protein at various intervals, preceding the administration of the anesthesia. No radioactivity was detected in the spinal fluid of these patients. The studies on the patients confined to bed showed that an average of 8 to 12 percent of the injected radioactive iodine was found in the urine within 24 hours of the injection. This research was partly supported by an Atomic Energy Commission contract.

**References**

Storaasli, J.P., H. Krieger, H.L. Friedell, and W.D. Holden. "The Use of Radioactive Iodinated Plasma Protein in the Study of Blood Volume." *American Journal of Obstetrics & Gynecology*. Vol. 91, October 1950, pp. 458B464.

Storaasli, J.P., H. Krieger, H.L. Friedell, and W.D. Holder. *The Use of Plasma Protein Tagged Iodine-131 in the Study of Blood Volumes*. Cleveland: Western Reserve University, NYOB1608, July 6, 1950. "

**OT-2. The Use of Iodine-131-Labeled Human Serum Albumin to Evaluate the Peripheral Circulation**

This research was carried out in 1952 at Case Western Reserve University. Human serum albumin labeled with iodine-131 (I131) was injected into 77 subjects and a scintillation counter was used to determine cardiac output and to observe peripheral vascular flow. Approximately 150 microcuries of radioiodinated albumin were injected into the subjects. A series of these experiments were performed on young subjects with normal circulation. Four of the young subjects had one foot immersed in hot water for 20 minutes before the labeled albumin was injected into them. In two other subjects, the foot was immersed in ice water for 10 minutes before the test was performed. The study was carried out under contract with the U.S. Atomic Energy Commission.

**References**

Krieger, H., J.P. Storaasli, W.J. MacIntyre, W.D. Holden, and H. Friedell. "The Use of Radioactive Iodinated Human Serum Albumin in Evaluating the Peripheral Circulation." *Annals of Surgery*, Vol. 136, No. 3, September 1952, pp. 357B365.

MacIntyre, W.J., J.P. Storaasli, H. Krieger, W.H. Pritchard, and H.L. Friedell. *I131 Labelled Serum Albumin--Its Use in the Study of Cardiac Output and Peripheral Vascular Flow*. Cleveland: Western Reserve University, NYOB1642, March 11, 1952. "

**OT-3. Use of I131-Labeled Protein in the Study of Protein Digestion and Absorption in Children with and Without Cystic Fibrosis of the Pancreas**

This study was performed in 1952 at Case Western Reserve University. During the two decades prior to the study, several studies of protein digestion and absorption were carried out both in normal individuals and in patients with various diseases. This study describes a simple and accurate method to determine the efficiency of protein digestion and absorption, by measuring the isotope content of the feces after oral ingestion of protein labeled with iodine-131 (I131). The subjects were 10 children with diseases that did not specifically involve the gastrointestinal tract and 5 children with cystic fibrosis of the pancreas. These patients fasted for 12 hours before the experiment; then, a test meal containing I131 was orally administered in place of breakfast. The test meal contained approximately 1 microcurie of labeled protein per kilogram of body weight. In the five children with cystic fibrosis of the pancreas, pancreatin was withheld for 3 days prior to and during the initial test. The subjects ranged in age from 1.6 years to 9 years. The research demonstrated a diminished retention of dietary protein in cystic fibrosis of the pancreas. This research was supported by a U.S. Atomic Energy Commission contract.

**References**

Lavik P.S., L.W. Matthews, G.W. Buckaloo, F.J. Lemm, S. Spector, and H.L. Friedell. "Use of I131 Labeled Protein in the Study of Protein Digestion and Absorption in Children with and without Cystic Fibrosis of the Pancreas." *Pediatrics*. Vol. 10, 1952, p. 667B675.

Lavik, P.S., L.W. Matthews, G.W. Buckaloo, S. Spector, and H.L. Friedell. *Use of I131 Labeled Protein in the Study of Protein Digestion and Absorption in Children with and without Cystic Fibrosis of the Pancreas.* Cleveland: Western Reserve University, NYOB4025, August 15, 1952. "

**OT-4. Thyroidal Deposition of Iodine-131 in Man, Rat, and Dog, From Milk and Nonmilk Sources**

In 1963, Cornell University conducted studies on the comparative uptake of iodine from ingested water and milk, using human and animal subjects. Eleven healthy male volunteers ranging in age from 26 to 52 years participated and ingested 0.1 liter of milk containing iodine-131 (I131). The study used milk obtained from cows that had been fed I131 two days prior to milk collection. The milk contained approximately 2.5 microcuries of I131 per liter. Inorganic I131 was administered with 100 milliliters of water containing about 0.26 microcurie of I131. Results of the study indicated that there was no significant difference in the uptake of iodine in humans when obtained through milk or water. This work was supported by the U.S. Atomic Energy Commission. (Previously described in #47 on the original list of 48 experiments released by DOE in June 1994)

**References**

Comar, C.L., R.A. Wentworth, and J.R. Georgi. "Thyroidal Deposition in Man, Rat and Dog of Radioiodine from Milk and Non-Milk Sources." *Health Physics*. Vol. 9, 1963, pp. 1,249B1,252. "

**OT-5. Plasma Volume Studies Using Chromium-51-Chloride**

This research was conducted at the Biophysical Laboratory and the Department of Medicine at Harvard Medical School and the Medical Clinic at Peter Bent Brigham Hospital in Boston. Approximately 100 microcuries of chromium-51 (Cr51) as chromium chloride were intravenously injected into 26 normal adults (5 women and 21 men). After allowing 5 minutes for mixing within the circulation, researchers drew four samples of blood and analyzed them in a gamma counter to determine plasma volumes. The plasma volumes were determined by this method. In some subjects, a second study was also performed. This method was further tested by measuring the plasma volume before and after transfusion or hemorrhage of between 250 and 500 milliliters of plasma in hospital patients and volunteer subjects. This research was supported in part by the U.S. Atomic Energy Commission and in part by the United States Public Health Service.

**References**

Frank, H. and S.J. Grey. "The Determination of Plasma Volume in Man with Radioactive Chromic Chloride."*Journal of Clinical Investigation*, Vol. 32, No.10, 1953, pp. 991B999. "

**OT-6. Iodine-131 Uptake by the Human Embryo**

In 1953, studies were conducted at the University of Iowa, Iowa City, on the uptake of iodine-131 (I131) in thyroids of human embryos in utero. Pregnant women scheduled for therapeutic abortions were given dosages of 100 to 200 microcuries of I131. Some time later, the abortions were performed. The aborted embryos were sectioned and autoradiographed. The human embryos showed thyroid uptake at 4 weeks, nearly one month earlier than was previously known. This finding was useful in understanding the transfer of radioiodine across the placental barrier. This study showed that it would not be prudent to administer I131 to pregnant women for diagnostic or therapeutic purposes. The number of subjects is not known. This work was funded by the U.S. Atomic Energy Commission. (Previously described in #5 on the original list of 48 experiments released by DOE in June 1994)

**References**

U.S. Atomic Energy Commission. *Monthly Status and Progress Report Division of Biology and Medicine.* June 1953. U.S. Department of Energy Archives, Record Group 326, Division of Biology and Medicine, Box 3363, Folder 23. "

**OT-7. Uptake of Iodine-131 in Normal Newborn Infants in Iowa City**

The uptake of iodine-131 was studied in newborn infants at the University of Iowa, Iowa City, in 1963. Twelve male and 13 female infants were included in this study. All were less than 36 hours old, weighted between 5.5 and 8.5 pounds, and were considered to be healthy and normal. Less than 1 microcurie of I131 was administered to each newborn. Eight received the radioiodine orally and 17 by intramuscular injection. The concentration of I131 in the thyroid was measured using a thyroid gamma probe. Measurements were continued at intervals of 2 to 8 hours for 3 to 4 days. This study showed that I131 was taken up by the thyroid at a higher level and more rapidly when administered by injection rather then ingestion. This study was supported by the U.S. Atomic Energy Commission and the American Cancer Society. (Previously described in #4 on original 48 experiments released by DOE in June 1994)

**References**

Morrison, R.T., J.A. Birkbeck, T.C. Evans, and J.I. Routh. "Radioiodine Uptake Studies Newborn Infants." *Journal of Nuclear Medicine*. Vol. 4, 1963, pp.162B166. "

**OT-8. Uptake of Iodine-131 in Normal Newborn Infants in Nebraska**

The thyroid function of infants was studied jointly by the Veterans Administration Hospital, Omaha, NB, and the Department of Radiology, University of Nebraska, College of Medicine, in 1960. Twenty-eight normal, healthy infants from the nursery at the College of Medicine, including 16 males and 12 females ranging in age from 72 to 180 hours, were involved in the experiment. The newborn infants were given 5 microcuries of iodine-131 (I131) through a gastric tube. The concentration of I131 in the thyroid was measured 24 hours later. This study showed the thyroid of a newborn functioned similarly to those of adult thyroids. The subject's sex and weight were not related to thyroid function. (Previously described in #4 on original 48 experiments released by DOE in June 1994)

**References**

Ogborn, R.E., R.E. Waggener, and E. VanHove. "Radioactive-Iodine Concentration in Thyroid Glands of Newborn Infants."*Pediatrics*. Vol. 26, November 1960, pp. 771B776. "

**OT-9. Uptake of Iodine-131 in Normal Newborn Infants in Memphis**

Iodine-131 was used to study the uptake of iodine in normal, newborn infants at the University of Tennessee, Memphis, in 1954. Seven male infants (one white and six black) between 2 and 3 days old were injected intravenously with 1 to 1.5 microcuries of I131. The concentration of I131 in the thyroid was measured 24 hours after injection. Absorbed doses to the infant thyroids were estimated to be about 60 rads. The I131 uptake of the thyroid of the subjects was found to lie within the range of values that would be found in hyperthyroid adults. This study was supported by a grant from the U.S. Atomic Energy Commission. (Previously described in #4 on the original list of 48 experiments released by DOE in June 1994)

**References**

Middlesworth, L.Van. "Radioactive Iodide Uptake of Normal Newborn Infants." *AMA American Journal of Diseases of Children*. Vol. 88, October 1954, pp. 439B442. "

**OT-10. Radioactive Isotope Studies at Tulane**

In the late 1940s and early 1950s, a series of metabolic experiments was conducted at Charity Hospital and Tulane University School of Medicine, New Orleans, LA. The focus of the experiments was to investigate the role of electrolytes in normal humans and in patients with congestive heart failure. The total number of subjects is not specified, but as many as 269 people could have been included in the study. Some of these subjects may have participated in more than one study. The radioisotope studies examined retention times, excretion rates, biologic decay rates, and a variety of other physiological parameters. The radioisotopes used included: mercury-203 (Hg203), mercury-205 (Hg205), chlorine-36 (Cl36), sodium-22 (Na22), sodium-24 (Na24), rubidium-86 (Rb86), potassium-39, (K39), and potassium-42 (K42). One subject received only X rays to determine the effects of radiation on humans. (Previously described in #8 on the original list of 48 experiments released by DOE in June 1994)

**References**

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Burch, G.E., R.S. Sohal, S. Sun, G.C. Miller, and H. L. Colcolough. "Effects of Radiation on the Human Heart." *Archives of Internal Medicine*. Vol. 221, 1968, pp. 230B234.

Burch, G.E., S.A. Threefoot, and P.B. Reaser. "Some Aspects of Renal Excretion of Na24 by Normal Subjects and by Patients with Congestive Heart Failure." *Stanford Medical Bulletin*. Vol. 6, No. 1, 1948, pp. 81B87.

Burch, G.E., S.A. Threefoot, and P.B. Reaser. "Aspects of the Biological Decay Periods of Sodium in Normal and Diseased Men." *Science.* Vol. 107, 1948, pp. 91B92. "

**OT-11. Iron Metabolism in Human Pregnancy as Studied With the Radioactive Isotope Iron-59**

From 1945 through 1949, Vanderbilt University Hospital conducted studies on iron absorption in pregnant women. Participants in the study were part of a larger nutrition survey conducted by the hospital. In all, 829 normal, healthy, pregnant women ingested radioactive iron-59 (Fe59) in an amount ranging from 1.8 to 120 milligrams. The Fe59 was administered at various times in the gestation period ranging from fewer than 10 to more than 35 weeks. Radioactivity in the blood was measured 2 weeks and, again, 3 weeks after administration. The study showed that iron uptake is related to both dosage level and gestation period. The percentage of absorption decreased as the amount administered went up, while the actual amount of iron absorbed increased. Also, uptake increased later in the gestation period. At 30 weeks, three times as much iron was absorbed as at 15 weeks. This research was supported by the Nutrition Foundation, Inc., The Rockefeller Foundation, and the Tennessee State Department of Health.

From 1964 to 1967, Vanderbilt University School of Medicine conducted a follow-up study on the children born to these women. The study included 679 children of mothers who had been fed Fe59 and 705 children of mothers in the original study control population. One case of leukemia and two cases of sarcoma were discovered in the Fe59 population. There were no malignancies in the control population. Compared to an expected incidence of less than one, the three cases are statistically significant. There were no differences in malignancies among the mothers, congenital defects among the children, or congenital defects among subsequent children between the two populations. This follow-up work was supported by the U.S. Public Health Service and the U.S. Atomic Energy Commission. (Previously described in #1 on the original list of 48 experiments released by DOE in June 1994)

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Hahn, P.F., E.L Carothers, W.J. Darby, M. Martin, C.W. Sheppard, R.O. Cannon, A.S. Beam, P.M. Densen, J.C. Peterson, and G.S. McClellan. "Iron Metabolism in Human Pregnancy as Studied with the Radioactive Isotope, Fe59." *American Journal of Obstetrics and Gynecology*. Vol. 61, No. 3, March, 1953, pp. 477B486.

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**OT-12. Sodium-24 Used to Study Exchangeable Sodium in Relation to the Menstrual Cycle**

This study was conducted in 1969 at Vanderbilt University. Six healthy female volunteers, between the ages of 19 to 44 years, with no history of hypertension and with normal blood pressure, were fed a constant sodium diet for 30 to 45 days. After administration of a 10 microcuries oral dosage of sodium-24 (Na24), exchangeable sodium spaces were measured during the follicular phase and the luteal phase of the menstrual cycle. The subjects were followed daily at the Clinical Research Center for excretion of sodium, potassium and creatinine, urine volume, body weight, and basal body temperature. This research was funded by grants from the Public Health Service, the American Heart Association, and the U.S. Atomic Energy Commission.

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**OT-13. Chromium-50-Labeled Red Cell Studies in Newborn Infants With Hyaline Membrane Disease**

In 1969, at Vanderbilt University, chromium-50 (Cr50) was used to label red cells in studies of newborn infants with the hyaline membrane disease. The studies were performed with a twofold purpose: (1) to determine the blood volume in these children, and (2) to determine, for those who died, whether hemorrhage had occurred prior to or after Cr50 labeling. Measurements of red blood cell volumes were made on 86 newborn infants with respiratory distress. Of these infants, 28 were found to have intracranial hemorrhage at autopsy and 22 had their major bleeding episode after they were tagged with the Cr50. Large quantities of blood were drawn from these infants for extensive diagnostic studies and the replacement transfusions of donor blood was labeled with Cr50.

The researchers also conducted further studies on one infant and three adult patients using dual tracers of chromium-51 (Cr51) and Cr50 and measuring blood volume. This study was supported in part by an Atomic Energy Commission contract and in part by a grant from the National Heart Institute.

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**OT-14. Testicular Irradiation of Washington State Prison Inmates**

From 1963 to 1973, the University of Washington conducted studies on the effects of radiation on human testicular function using inmates at the Washington State Prison in Walla Walla, WA, as subjects. Initially, 232 healthy volunteers were accepted into the study program. Sixty were subsequently irradiated with acute doses of x rays, ranging from 7.5 to 400 rads to the testes. Four other participants went through an identical procedure, but received no radiation. Forty-three were released from the program for a variety of reasons. The remaining 125 inmates served as control subjects in the study. Each inmate selected for the study had expressed a desire to undergo a vasectomy at the conclusion of the study. Fifty-three subjects received post-study vasectomies. The other 11 subjects either declined the procedure or did not receive vasectomies. Tissue samples were analyzed at the Biology Division of Oak Ridge National Laboratory, whose participation was reviewed and approved by an institutional review board.

These studies showed that doses of 7.5 rads had no adverse affect on testicular function, that doses of 27 rads inhibited generation of sperm cells, that doses of 75 rads destroyed existing sperm cells, and that doses of 100 to 400 rads produced temporary sterility. All subjects of the study eventually recovered to their normal preirradiation condition prior to vasectomy. Study results showed that adult males are very radiosensitive to temporary sterility, but also radioresistant to complete sterility. This work was supported by the U.S. Atomic Energy Commission. (This experiment was referenced in the Markey report.)

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**OT-15. Radioactive Iron in Humans**

In the early 1950s, a study was conducted at University Hospital at the University of Washington on the iron metabolism and the production of red blood cells. Iron-55 (Fe55) and iron-59 (Fe59) were injected into either normal subjects or anemic subjects. Approximately 20 subjects received Fe55; another 60 to 80 received Fe59 in amounts ranging from 5 to 10 microcuries. Blood samples were drawn at different times and counted to determine radioiron content. This study was supported by the U.S. Atomic Energy Commission. (Previously described in #40 on the original list of 48 experiments released by DOE in June 1994)

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Letter. C.A. Finch to S. Marks. July 17, 1984. Pacific Northwest Laboratory General Human Subjects, Box Alan Rither, PNLB9055BDEL. "

**OT-16. Study of Blood Labeled With Chromium-51 in Normal Volunteer Subjects**

Chromium-51 was used to tag red blood cells, which were then injected in normal volunteers in amounts similar to those used clinically in blood volume determinations. The number of volunteers was estimated to be 50. These studies led to the use of adenine as a blood preservative. The University of Washington, Seattle, conducted the study prior to 1964 with funding from the U.S. Atomic Energy Commission. (Previously described in #39 on the original list of 48 experiments released by DOE in June 1994)

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Letter. C.A. Finch to S. Marks. July 17, 1984. Pacific Northwest Laboratory General Human Subjects, Box Alan Rither, PNLB9055BDEL. "

**OT-17. Total-Body Neutron Activation Analysis**

Between 1970 and 1973, studies on the potential usefulness of total body neutron activation analysis as a diagnostic tool were conducted at University Hospital, University of Washington, Seattle. In the first stage, 40 to 50 females were studied to develop the technique. All were over the age of 55 years and were afflicted with known bone-wasting diseases, such as osteoporosis. In the second stage, which used this new technique with human subjects, 25 chronically ill adults suffering from kidney failure were studied to evaluate calcium balance. Females in the second stage were beyond childbearing years. All subjects were exposed to uniform low-flux, high-energy neutrons. The total body dose to study participants was estimated to be 0.2 rad (neutrons). Initial subject were given a 1-year examination, but no longer-term follow-up was conducted. This study was funded by the U.S. Atomic Energy Commission. (Previously described in #38 on the original list of 48 experiments released by DOE in June 1994)

**References**

Letter. W.B. Nelp to S. Marks. August 30, 1984. Pacific Northwest Laboratory, General Human Subjects, Box Alan Rither, PNLB9055BDEL. "

**OT-18. Utah Strontium-85 Metabolism Study**

The University of Utah Radiobiology Laboratory conducted a strontium-85 (Sr85) metabolism study on human subjects in 1956 to determine the uptake, retention, and excretion of Sr85 in man. The study was conducted to learn more about the likely metabolism of strontium-90 (Sr90) fallout from atomic testing. Subjects consisted of seven male patients at the Salt Lake Veterans Administration Hospital and two male staff members. Five of the patients had normal bone metabolism and two had osteoporosis. After intravenous injection of approximately 5 microcuries of Sr85, measurements were made over time to determine concentrations of Sr85 in blood plasma, urine, and feces. Bone tissue biopsy samples obtained from two osteoporotic patients and from two normal subjects were analyzed for Sr85 and calcium. In addition, several bone samples were obtained at autopsy from a tenth injected patient who was not bioassayed along with the other patients. This work showed that strontium cleared more efficiently than calcium from the blood and was excreted primarily in urine rather than feces. This study was part of Project Sunshine and was supported by the U.S. Atomic Energy Commission.

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Van Dilla, M. A., S. Wallach, and J. S. Arnold. ASr-85 Tracer Studies in Humans." *Semiannual Progress Report*. Salt Lake City: Radiobiology Laboratory, University of Utah, September 30, 1956. "

**OT-19. Radioisotope Studies at the Fernald State School, Massachusetts**

In the early to mid-1950s, various radiation-related studies were carried out at the Fernald State School in Waverly, MA, using students as subjects. In a study addressing calcium metabolism, nine adolescent males, institutionalized for mental inadequacy but otherwise physically normal, ranging in age from 10 to 15 years, and one 21-year-old male participated as subjects. The adolescents received 0.7 microcurie of calcium-45 (Ca45). The subjects were divided into two groups. One group was administered the Ca45 intravenously, the other received it orally. One month later, 0.74 microcurie was administered, but the means of administration was reversed between the groups. Two years later, 2.02 microcuries were administered to the 21-year-old subject. The studies showed that calcium is retained in the body for some time and that it is eventually excreted more through urine than feces.

A second study addressed thyroid function in Down's syndrome subjects and their parents. Twenty-one male and female Down's syndrome students ranging in age from 5 to 26 years participated, as did 5 female and 2 male normal parents of these students. The students were orally administered 70 microcuries of iodine-131 (I131). The parents received 100 microcuries. Thyroid uptake, turnover, and urinary excretion were subsequently measured. Additionally, thyroxine metabolism was studied in two Down's syndrome students after intravenous injection of 55 microcuries of thyroxine labeled with I131. These studies showed that iodine uptake was in the low-normal range and did not differ significantly from normal values; that the iodine turnover rate was significantly faster than normal; that the thyroxine turnover rate was normal; and that the uptake, turnover, and excretion rates in parents of Down's syndrome children was normal. These studies were supported in part by the U.S. Atomic Energy Commission.

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**OT-20. Uptake of Iodine-131 by Premature Infants in Detroit**

In 1954, the uptake of iodine-131 by the thyroid gland of premature infants was studied by the Pediatric Division and the Radioisotope Laboratory of Harper Hospital, Detroit, MI. Sixty-five premature infants ranging in birth weight from 2.1 to 5.5 lb were included in the study; 7 full-term infants were used for the control group. The premature infants were given 5 microcuries of I131 orally. I131 concentrations were then measured in the thyroid gland. It was found that the range of uptake of I131 in this series of infants was within the limits of normal as measured in studies of full-term children and adults. (Previously described in #4 on original 48 experiments released by DOE in June 1994)

**References**

Martmer, E.E., K.E. Corrigan, H.P. Charbeneau, and A. Sosin. "A Study of the Uptake of Iodine (I131) by the Thyroid of Premature Infants." *AMA American Journal of Diseases of Children*. Vol. 17, 1955, pp. 503B509. "

**OT-21Testicular Irradiation of Oregon State Prison Inmates**

From August 1963 to May 1971, the Pacific Northwest Research Foundation in Seattle, WA, conducted studies on the effects of radiation on human testicular function using as subjects inmates at the Oregon State Prison in Salem, OR. The purposes of the study were to determine the effects of ionizing radiation on sperm production and to determine minimum dose levels for initial effect and permanent damage. Sixty-seven healthy volunteers ranging in age from 24 to 52 years were irradiated by x rays at least once during the course of the study. Of these 67 subjects, 6 received a second irradiation, 1 received 3 irradiations, and 1 received a series of 11 weekly irradiations. Testicular absorbed doses ranged from 8 to 640 rads. Postirradiation studies included analysis of blood, urine, and seminal fluid, and biopsy of sperm-producing tissues. Subjects were compensated for their participation and for each biopsy. All subjects who had not been previously vasectomized agreed to undergo a vasectomy at the conclusion of the study. All did so and received additional compensation for the procedure. All subjects were volunteers. Inmates could withdraw from participation at any time. The study was reviewed at 3-month intervals by a review board, and three additional reviews were provided by a national ad hoc committee.

This study showed that a single testicular dose of 600 rads caused temporary disruption of testicular function. Recovery time was dose dependent: The higher the dose, the longer the time required for recovery. Subjects who were irradiated a second or third time had responses that were similar to their initial responses. This work was supported by the U.S. Atomic Energy Commission. (This experiment was referenced in the Markey report.)

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**OT-22. Distribution of Zinc-65 in Blood and Organs of Man**

In 1947, researchers in Boston administered zinc-65 (Zn65) to a 67-year-old male suffering from myelogenous leukemia and to a nonleukemic, healthy subject. The purpose of this study was to determine how the content and distribution of zinc in blood and organs of the normal subject compared with the zinc content and distribution in the leukemia patient. Zn65 was injected intravenously as zinc chloride daily for several days and ranged in amounts ranging from 2 milligrams per day to Afar in excess of this amount." Analysis occurred over a long period of time to monitor Zn65 retention.

This experiment showed that zinc plays an important role in the metabolism of tissues and blood cells. The work was supported by the U.S. Atomic Energy Commission. (Previously described in #32 on the original list of 48 experiments released by DOE in June 1994)

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Vallee, B.L., R.G. Fluharty, and J.G. Gibson. *Distribution of Zinc in Normal Blood and Organs Studied by Means of Zn65*. 1947. Oak Ridge Operations Office, (RHTG) Classified Docs 1944B1994, Records Holding Area--Bldg 2714BH Vault, Box RHA H108B5, 1 of 2, Folder Advisory Committee.

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