728040

REPOSITORY DOE-OHRE

COLLECTION PLUTONIUM INJECTION

BOX NO. 1

FOLDER Centers For Human Radiobiology (40-012)

8001360

HP-6

PRIVACY ACT MATERIAL REMOVED

MICROFILMED

Name

Hospital No Strong Mem. 239322

FEB 22 1971

Date of birth

Date of injection Feb. 1, 1946 3.3 μg ^{239}Pu (IV) citrate

Age at injection

Date of death

Age at death Time after injection

Death certificate No.

Hp-6

This patient, a forty-five year old white male with a history of Addison's disease since January 1945, was admitted to the hospital on December 14, 1945, for treatment of numerous infected lesions of the eyelids and toes. He responded to conservative treatment and studies began during convalescence. On readmission in June 1947, his condition was essentially unchanged.

LA-1151

PRIVACY ACT MATERIAL REMOVED

STATUS VERIFIED UNCLASSIFIED

BN 8/16/96

AUTHORIZED DERIVATIVE CLASSIFIER DATE

8001362

PRIVACY ACT MATERIAL REMOVED

f^ 6 2-1-46

23-93-22 145 W. Ivy St 2. Rock Samples 523d ~ 6-8-47

Live 12-7-71 Rosalia (wife) 1610 d ~ 6-30-50

Addison's disease, diabetes, arteriosc. heart disease as of 1-13-68

5/63 Chronic cholecystitis, chole lithiasis

age 61 in 1963

PRIVACY ACT MATERIAL REMOVED

STATUS VERIFIED UNCLASSIFIED

AUTHORIZED DERIVATIVE CLASSIFIER

8/12/96

DATE

8001363

ARGONNE NATIONAL LABORATORY

PRIVACY ACT MATERIAL REMOVED

MICROFILMED

INTRA-LABORATORY MEMO

January 4, 1973

TO: R. E. Rowland

FROM: A. F. Stehney

SUBJECT: Phone call from P. Durbin on 12-20-72

I've rewritten my notes of the above date when Dr. Durbin talked to me after being unable to reach you. A summary of the conversation about some patients exposed to radioactive materials is given below for your information.

I. Death certificates on 12 "HP" cases (11 at Rochester, 1 at Oak Ridge.

Dr. Durbin has 5 DC's; 3 persons are living in Rochester; 2 persons died at home, probably in Albany County. 1 person is presently unknown, was in Monroe County Home, but no record of his death in Monroe County to 1957. 1 person is HP12, to be traced.

II. Clinical tests at Rochester.

1. Dr. Christine Waterhouse sees one man (HP6) and one woman (HP3) regularly in her clinic. The other woman (HP8) is in her 70's and lives crosstown; it may be difficult to get her in for a metabolic study. The other 2 persons probably can be brought in anytime; if not, an outpatient study might be tried.

   Note: HP6 has Addison's and has already lived 15 years beyond expectancy. 40-012

   HP8 has schleraderma and has already lived 20 years beyond expectancy. 40-014

   HP3 is in normal health. 40-009

2. The ward cost will be only $90 per day per person, because of USPHS support for the ward. This includes routine hematology, creatinine clearance and liver function.

STATUS VERIFIED UNCLASSIFIED
AUTHORIZED DERIVATIVE CLASSIFIER
DATE

JAN 4 1973

RECEIVED
CHR RECORDS

PRIVACY ACT MATERIAL REMOVED

8001364

6 (11-68)

II. 3. Dr. Waterhouse wants us to provide the following:

a. A list of what we want done:

(1) Metabolic study.
(2) Medical exam.

b. Containers and shipping instructions for excreta.

c. A billing account number with the Strong Memorial Hospital.

4. Possible medical procedures:

a. Iliac crest biopsy for material for autoradiographs.

b. Blood chromosomes, Dr. Waterhouse may want to do this study.

c. Skeletal X-rays - Dr. Waterhouse may want to do only a partial survey.

d. Correlation of enzymes vs. Pu in blood(?). Dr. Durbin will contact Utah; we may need 25 ml blood for study at Utah and ANL.

5. Other persons:

a. Dr. Newell Stannard's secretary, Rose Steinberg, may be able to help us as a day to day contact person at Rochester.

b. We should contact Bill Moss at LASL to let him know we may be sending samples for analysis soon.

Cindy

dk

cc: A. M. Brues, M.D.
P. M. Failla
J. E. Farnham
M. S. Littman, M.D.
J. H. Marshall
B. C. Patten
J. Rundo
H. A. Schultz

40-312

November 14, 1985

Mr. Randall Beck
The Knoxville Journal
P.O. Box 911
Knoxville, TN 37901

Re: 1104630[illegible]
1104[illegible]
1104[illegible]
1104[illegible]

Dear Mr. Beck:

Your October 30, 1985, Freedom of Information requests (copies enclosed) addressed to the U.S. Department of Energy were received on November 8, 1985, and have been sent to our Freedom of Information Officers at our Chicago, Oak Ridge, Richland and San Francisco Operations Offices. They will correspond directly with you about your requests.

In compliance with the Freedom of Information Act, the 10 day response period will begin when the offices designated above have received your requests. If you need further assistance, please contact Jane Hombert, Chicago Operations Office, 9800 South Cass Avenue, Argonne, IL 60439, (312) 972-2076; Wayne Range, Oak Ridge Operations Office, P.O. Box E, Room 1012, Oak Ridge, TN 37831, (615) 576-0885; Gail M. Bonkan, Richland Operations Office, 825 Jadwin Avenue, P.O. Box 550, Richland, WA 99352, (509) 376-8274; Elsie Mutobe, San Francisco Operations Office, 1333 Broadway, Wells Fargo Building, Oakland, CA 94612, (415) 273-4358.

We have assigned the above referenced numbers to your requests and ask that you refer to these in any future correspondence.

Sincerely,

Original signed by John H. Carter

John H. Carter
Chief of FOI and Privacy Acts
Office of Administrative Services

cc: Official File Copy
Action Officer &
Official File (RF)
Doc. [illegible]932
MA-232.1:JBO:sjb:26025:11/13/85

STATUS VERIFIED UNCLASSIFIED
DEC 04 1985
BN
AUTHORIZED DERIVATIVE CLASSIFIER
5/16/96
DATE

8001367

File type = PDS

@CØDED, 850507, GAA,

Page 1 of 1

@M, 40-012, Name, Mouss0, @GRØUP,

PRIVACY ACT MATERIAL REMOVED

Description	@M	@A,T	M	E	F	D
Cerebral hemorrhage-massive OC	40-012	4551	3850	0000	0000	8405C
Cerebral arteriosclerosis OC		4551	5200		0000	
Generalized arteriosclerosis OC		3000	0000		9132	
Addison's disease		9300			4639	14050
acute diarrhea		5000			7225	8405D

PRIVACY ACT MATERIAL REMOVED

Abstracted by GA Date 5/7/85 Coded by GA Date 5/7/85

8001368

40-012

THE UNIVERSITY OF ROCHESTER
SCHOOL OF MEDICINE AND DENTISTRY
AND
STRONG MEMORIAL HOSPITAL
260 CRITTENDEN BOULEVARD
ROCHESTER, NEW YORK 14642

December 26, 1975

Dr, J. Rundo
Radiological and Environmental
Research Division
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

Dear Dr, Rundo:

Thank you very much for sending the pre-print of your paper to me, as well as the results which appear in your annual report.

Concerning our patients here, _____ expired in a Nursing Home here, within the past month. There was no autopsy. She had metastatic carcinoma of larynx as well as the far-advanced scleroderma. I think it would be possible to get further samples on _____ and _____, particularly if these were done on an out-patient basis. 40-014

Kindly let me know if and when and how you would like us to do this. With best wishes.

Sincerely yours,

Christine Waterhouse

Christine Waterhouse, M.D.
Professor of Medicine

CW:dg

PRIVACY ACT MATERIAL REMOVED

U of C-AUA-USAEC

ARGONNE NATIONAL LABORATORY

October 18, 1974

Dr. G. W. Dolphin
National Radiological Protection Board
Building 556
Harwell, Didcot
Berks OX11 ORQ
England

Dear Goeff,

My fascination with the urinary excretion (and other) data from 40-009 and 40-012 also continues. In answer to your question, I can only say that at ages 77 and 72 respectively, one would expect there to be osteoporosis to some extent, and that it would be greater in the female (40-009) than in the male. In addition, I believe that there is evidence of clinical osteoporosis in case 40-009, i.e., it is considerably greater than the average for her age, but I have not been able to confirm this. You may remember that I mentioned at Seattle that the excretion rates of the three subjects (these two plus 40-003 or Cal-3) decreased in the same order as their expected degrees of osteoporosis.

Tony James' findings seem to be slightly different from Pat Durbin's with americium, the excretion rate of which seemed to show a slow but steady increase from about 400 days of age (290 days post injection) to 850 days of age. She also observed a decrease in ash weight of some bones (tibiae, lumbar vertebrae) over about the same time range, and in a recent phone conversation she described this as evidence of osteoporosis.

The importance of our results for 40-009 and 40-012 notwithstanding, I do not think they tell us that we cannot use Langham's equations for the case of, say, a 50-year old man who acquired his plutonium at age 25, since osteoporosis has hardly got underway at age 50. The urinary excretion rate of plutonium by case 40-003 was not in violent disagreement (about a factor of two lower) with Langham's prediction. This case was 62 at the time of our study and he is black; negro males have very little osteoporosis.

I hope this helps, rather than confuses, the issue!

Yours sincerely,

PRIVACY ACT MATERIAL REMOVED

J. Rundo
Center for Human Radiobiology

hmb

9700 South Cass Avenue, Argonne, Illinois 60439 · Telephone 312-739-7711 · TWX 910-258-3285 · WUX LB, Argonne, Illinois

PRIVACY ACT MATERIAL REMOVED

February 19, 1946

Dr. Wright Langham
% Dr. Louis Hempelmann
P. O. Box 1663
Santa Fe, New Mexico

Dear Dr. Langham:

There are a few corrections which I regret to have to make especially since I feel they are the result of inadequate supervision on my part.

(1) The urine specimen on H.p. 6 was short 152 ml. during the 24 hr. period 2/11 - 2/12/46. Special renal function tests were performed on 2/11/46 and specimens used for the test were discarded.

(2) Twenty-four hour specimens were collected on H.p. 4 on the following dates.

(a) 2/12 to 2/13
(b) 2/13 to 2/14
(c) 2/14 to 2/15
(d) 2/15 to 2/16
(e) 2/16 to 2/17

Specimens (a) to (d) inclusive, were labeled incorrectly H.p. 3. You have not received any urine specimens from H.p. 3 since Jan. 11, 1946.

One specimen of blood was taken from H.p. 4 on 2/11/46.

One specimen of feces has been sent on H.p. 4 covering the interval 8 A.M., 2/13/46, to 8 A.M., 2/17/46. It may be of interest to you to know that the iron deficiency anemia from which H.p. 4 suffered when we made our previous observations, was corrected while at home by the administration of ferrous sulphate. The hemoglobin on this admission was 15 gm./100 ml. of blood. This subject received intramuscular injections of penicillin during this admission because

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW
SINGLE REVIEW AUTHORIZED BY: DOE/HQ/ltr 1/1/96
REVIEWER (ADD): NAME: DATE: 5/10/96
DETERMINATION (CIRCLE NUMBER(S)):
1. CLASSIFICATION RETAINED
2. CLASSIFICATION CHANGED TO:
3. CONTAINS NO DOE CLASSIFIED INFO
4. COORDINATE WITH:
5. CLASSIFICATION CANCELLED
6. CLASSIFIED INFO BRACKETED
7. OTHER (SPECIFY):

RECEIVED CAIR
JUN 27 1977
RECORDS ROOM

PRIVACY ACT MATERIAL REMOVED

Classification Cancelled
Or Changed To
By Authority Of Auth. of Classifier
By JKHeckel/06 Date 5/10/79

8001371

of a urinary tract infection. The diet was fairly high in calcium but not otherwise remarkable.

(3) We still have some trouble separating the urine and feces in the case of H.p. 7. Small amounts of urine are sometimes voided with the feces. It has been impossible to get an accurate estimate of just how much is added to the stools but it probably may be estimated as from 40 to 75 ml. a day.

I expect to have H.p. 8 underway sometime this week and H.p. 9 the week beginning Feb. 24.

I have your receipt for recent letter on cods, received by you on Feb. 8, 1946. Have also returned bone photos.

No further information on P.p. 5 has come to my attention. I begin to think my prognosis in this case was too gloomy.

Sincerely yours,

Samuel H. Bassett

P. S. Your letter mentioning the presence of fig skins in the stool specimens arrived this morning. Neither patient is receiving figs. The diet of P.p. 7 contains canned peas which, if not well chewed, may appear in the stools. Daily menus are as follows:

Item	H.p.6 gms.	Item	H.p. 7 gms.
Banana	100	Grape fruit juice	239
Cornflakes	15	Oatmeal	20
Milk	300	Cream	60
Bread	40	Egg	50
Butter	20	Toast	30
Cocoa	107	Butter	15
Tenderloin	120	Steak	130
Potato	100	Potato	100
Spinach	100	Peas	100
Carrots	50	Celery	30
Peaches	100	Cream cheese	20
Ground meat	100	Banana	100
Macaroni	25	Rice	25
Tomatoes	100	Tomatoes	100
Orange sections	100	Ground meat	100
Lettuce	25	Cauli flower	75
Cup custard	100	Lettuce	20
Orange Juice	200	Applesauce	100
Lactose	20	Orange Sections	100
Graham Crackers	2	Sugar	15

In each instance, diets have been given since Jan. 24.

40-018

8 February 1946

Dr. Wright Langham
P.O. Box 1663
Santa Fe, New Mexico

Dear Dr. Langham:

In confirmation of our recent telephone conversation, I am setting down the code relating to specimens and subjects:

SUBJECT	UNIT NUMBER	CODE NUMBER
	#237854	H.P.1
	#27899	H.P.2
	#239876	H.P.3
	#180331	H.P.4
	#202444	H.P.5
	#239322	H.P.6
	#230465	H.P.7

H.P.6 was started at 1:40 P.M. on 1 February 1946, and H.P.7 at 2:00 P.M. on 8 February 1946.

H.P. 6 is a man of 44 years of age with Addison's Disease. He is in the hospital because of a mild infection of the right great toe. His adrenal insufficiency is being countered in part by pellets of desoxy-corticosterone acetate implanted subcutaneously. The clinical examination of the urine is normal and the urea clearance

1st hour - standard clearance - 103% of normal
2nd hour - standard clearance - 95% of normal

His blood count and hemoglobin are below normal.

R.B.C. 3.98 million, Hb. 13 grams.
W.B.C. 3,000 to 3,300.
Differential: Polys. 54. Lymphocytes: 45
Monocytes: 1
Total Serum Protein: 5.0 gm.%
A.G. 3.6/1.4 gm.%
Fasting Sugar - 56 mg.%
Chlorides: 593 mg.% (on serum)
N.P.N. 20 to 22 mg.%
Blood Pressure: Systolic 110-120; Diastolic: 65 to 80.

PRIVACY ACT MATERIAL REMOVED

7205

SECRET

THIS DOCUMENT CONSISTS OF 1 PAGE(S)
NO 1 OF 2 COPIES, SERIES A

STATUS VERIFIED UNCLASSIFIED
Denn. W Murphy - DOE - GW 6/7/96 DATE

Urinary Excretion of Plutonium by Rb-6

Injected with 5.3 (500,500 c/m)

Date and Period	Hours Per Period	c/m per Period	c/m per 24 hrs.	% Injection Dose per 24 hours
6/5/47 8 a.m. to 6/6/47 8 a.m.	24	3.1	3.1	0.002
6/6/47 8 a.m. to 6/7/47 8 a.m.	24	5.0	5.0	0.002
6/7/47 8 a.m. to 6/8/47 8 a.m.	24	3.0	3.0	0.002
6/8/47 8 a.m. to 6/9/47 8 a.m.	24	7.8	7.8	0.002

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW
SINGLE REVIEW AUTHORIZED BY: DOE/HQ/CO Appt 1/1/96
REVIEWER (ADD): Denn
DATE: 6/6/96
DETERMINATION (CIRCLE NUMBER(S)):
1. CLASSIFICATION RETAINED
2. CLASSIFICATION CHANGED TO:
3. CONTAINS UNCLASSIFIED INFO
4. COORDINATE WITH
5. CLASSIFICATION CANCELLED
6. CLASSIFIED INFO BRACKETED
7. OTHER (SPECIFY):

Classification Cancelled
Or Changed To
By Authority Of DOE Classification
By JM Hartsock 1/96 Date 6/10/96

RECEIVED CHR
JUN 27 1977
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PRIVACY ACT MATERIAL REMOVED

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HISTORICAL

8001375

40-012

This is a Joint Report from the Los Alamos Scientific Laboratory of the University of California and the Atomic Energy Project of the University of Rochester School of Medicine and Dentistry.

The Report covers a Cooperative Research Project initiated under the supervision of the Manhattan Engineer District and completed under Contract No. W-7401-Eng-49 and Contract No. 7405-Eng-36 for the Atomic Energy Commission.

September 20, 1950

LA - 1151

DISTRIBUTION AND EXCRETION OF PLUTONIUM ADMINISTERED INTRAVENOUSLY TO MAN

Work Performed By:

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Jeanne Carritt
Robert Fink
W. W. Foreman
David Goldring
Joe W. Howland
Leonard S. Kogan
Wright H. Langham
Elizabeth Maxwell
Arthur Murray, III
Anne Perley
Hannah Silberstein
Helen E. Van Alstine
Christine Waterhouse

Report Written By:

Wright H. Langham*
Samuel H. Bassett**
Payne S. Harris***
Robert E. Carter*

* Los Alamos Scientific Laboratory of the University of California, Los Alamos, New Mexico

** Formerly of the University of Rochester, presently with the Atomic Energy Project, University of California, Berkeley Hill, California

*** Formerly Med Corps, U.S.A., Stationed at Los Alamos, New Mexico

HEALTH AND BIOLOGY

ACKNOWLEDGEMENT

The authors wish to acknowledge the invaluable aid and interest of a number of persons who directly or indirectly contributed to the execution of these studies and the completion of this report.

Dr. Stafford L. Warren was primarily responsible for the initiation of the program under the Manhattan Engineer District.

Drs. W. S. McCann, A. H. Dowdy, W. F. Bale, Harold Hodge and L. H. Hempelmann participated in the early planning of the work and frequently made general and specific decisions which contributed much to the success of the program.

Dr. Hymer Friedell and Dr. Fred Bryan were of great assistance as representatives of the office of the Medical Director of the Manhattan District.

Drs. J. G. Hamilton, Jack Schubert, E. P. Russell, Austin Brues and R. M. Parker contributed some of the information used in this report and in some cases reviewed parts or all of the manuscript.

Drs. L. H. Hempelmann, T. N. White, Frederick Reines, E. C. Anderson, J. T. Brennan and G. W. Taylor reviewed the report and contributed many constructive criticisms.

Fig. 1 Nuclear Track Autoradiograph Showing Localization of Plutonium in the Bone of the Rat. (A. Williams, J. Wellnitz; Photomicrography by Los Alamos Photographic Laboratory).

D-3?-5?

DISTRIBUTION AND EXCRETION OF PLUTONIUM
ADMINISTERED INTRAVENOUSLY TO MAN

I. INTRODUCTION

It is now a well established fact that the deposition of radioactive material (Ra, its isotopes and daughter products) in the skeletal system of radium dial painters was responsible for the bone necrosis, radiation osteitis, osteogenic sarcoma and other pathological changes in bone which characterize the condition commonly known as chronic radium poisoning.

Hamilton and co-workers (1) were the first to demonstrate that plutonium, like radium, concentrates in the skeletal system of the rat. Numerous reports have emphasized that bone is a major site of plutonium deposition regardless of the animal species, the valence state of the material or the route of administration (2), (3a, b, c). Autoradiographic studies of the mode of deposition of plutonium in bone (4), (5), (6), (7) showed that it was deposited in a pattern quite different from that of radium. The latter element tends to be incorporated into the bone salts exclusively and becomes buried in the calcified structure in the manner to be expected from a member of the calcium family in the periodic table. Plutonium, however, shows some deposition in soft tissues (especially in the liver) and a remarkable affinity for the non-calcified, non-cartilaginous areas of bone. The material is highly localized in the epiphyseal line, the periosteum and the endosteum so that localization is predominately in regions of trabecular bone (See Fig. 1, frontpiece). The general conclusion was that the mode of deposition of plutonium made it potentially more hazardous than radium. Although there is only limited proof that the above conclusion is justified, it must be considered when evaluating the potential chronic toxicity of the material.

Subsequent experiments with rodents by Brues, Lisco and Finkel (8) and others (9) have demonstrated that plutonium is quite effective in producing pathological changes in bone including osteogenic sarcoma (See Fig. 2).

Brues (10) compared the relative chronic toxicity of equivalent microcurie amounts of plutonium and radium by following 1000 rats, 600 mice throughout life and 32 rabbits for over 400 days. A comparison of survival time, radiographically determined bone damage, pathological fractures and bone tumors in these animals appeared to bear out a plutonium-radium chronic toxicity ratio of 12-15/1 on the basis of injected dose or about 4-5/1 on the basis of retained material.

The above observations and the experiences of the radium dial industry have emphasized the necessity of employing extremely rigid control over all plutonium operations. The major health problem associated with plutonium processing is, of course, the possibility that small amounts of plutonium accumulated in the skeletal systems of workers may, over a period of from ten to thirty years, cause bone changes similar to those observed in chronic radium poisoning. The possibility is serious enough to justify the adoption of a rigid maximum permissible body burden as is currently done with radium.

Only recently the subcommittee on internal radiation tolerances of the National Bureau of Standards established a tentative maximum permissible body content of 0.5 μg (0.032 μc) for plutonium. This value was adopted immediately by the Division of Biology and Medicine of the Atomic Energy Commission as the official maximum permissible tolerance for plant personnel (11).

Adequate information as to the fixation and excretion of plutonium by man is essential to the evaluation and interpretation of the maximum permissible body tolerance. More specifically such studies seem highly important for the following purposes:

1. To minimize the degree of uncertainty inherent in extrapolating the vast amount of animal experimental data to man.

2. To provide the best possible quantitative basis for the diagnosis of degree of exposure of personnel to plutonium.
3. To determine the degree of fixation of plutonium by man and establish criteria for the period of retirement from further exposure of workers having received a maximum permissible dose.
4. To provide more extensive and quantitative data on the deposition and excretion of plutonium by man as a basis for future consideration of maximum permissible body tolerance.

Need for the above information was recognized several years ago. It was also recognized that such information could be obtained only by administering small tracer amounts of plutonium to persons with a relatively short life expectancy. The first tracer study was initiated April 10, 1945 (12). Shortly thereafter, both the Chicago and Berkeley groups initiated similar studies (13), (14).

This report is the final presentation of the results of twelve plutonium tracer cases studied as a joint project of the Los Alamos Scientific Laboratory of the University of California and the Atomic Energy Project of the University of Rochester School of Medicine and Dentistry.

The results of the studies conducted by the Berkeley and Chicago groups are correlated with the present ones providing a collection of data from sixteen cases.

In addition to the twelve tracer cases mentioned above, the Los Alamos Scientific Laboratory has had approximately six years experience with exposure problems associated with the processing of large amounts of plutonium.

Wherever applicable, the Laboratory's experiences with the exposure of personnel are used to enlarge and supplement the data collected from the plutonium tracer studies presented in this report.

II. METHODS

A. Selection and Description of Subjects

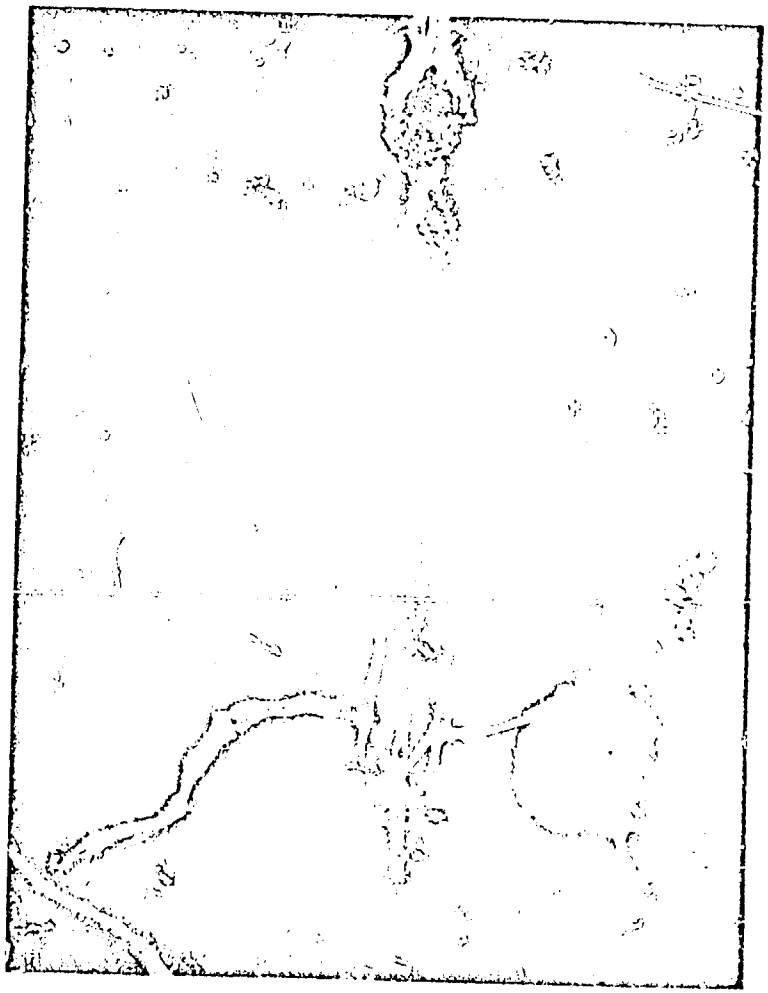
The life expectancy of the individual was carefully considered as a basis of selection of subjects for study. As a rule, the subjects chosen were past forty-five years of age and suffering from chronic disorders such that survival for ten years was highly improbable. By adhering to these criteria, the possibility of late radiation effects developing would be avoided. Furthermore, an opportunity to obtain post-mortem material within a few months, or at most a few years, would be much greater.

Of twelve patients chosen, ten were past the age of forty-five. One was only eighteen years old, and has since died of Cushing's Syndrome. Up to the time of this report, and approximately five years since the initiation of the first study, five subjects are known to have died of their diagnosed illness. Autopsies and tissue samples were obtained from only three of the five terminated cases.

Brief summaries of the medical histories of the subjects of these studies are as follows:

Hp-1

This patient, a sixty-seven year old white male with a nine year history of peptic ulcer, was admitted to the hospital following a severe gastrointestinal hemorrhage. The presence of a duodenal ulcer was confirmed by x-ray examination and a traction diverticulum of the esophagus was noted. Clinical diagnoses included duodenal ulcer, gastrointestinal hemorrhage with secondary anemia, and esophageal diverticulum.



Hp-2

This patient, a forty-nine year old white male, was a known hemophiliac and entered the hospital on this occasion for the thirty-eighth time. Symptoms referable to hypertension had been present for three years. Clinical diagnoses on this admission included hemophilia, essential hypertension with hypertensive cardiovascular disease and coronary insufficiency, and chronic arthritis.

Hp-3

This patient, a forty-nine year old white female, was admitted to the hospital with complaints of pigmentation of the skin, pruritic dermatitis and dependent edema. Initial clinical studies were carried out in November and December 1945, at which time diagnoses of hepatitis of unknown etiology and hypoproteinemia were made. She was admitted for follow-up examination in October 1946, when she appeared in good health.

Hp-4

This patient, an eighteen year old white female, had a history of Cushing's Syndrome since 1941. Her admission in October 1945 was the fifth period of hospitalization. Chief complaints on this occasion were referable to hypertension and osteoporosis. The clinical diagnoses were basophile adenoma of the pituitary gland with hypertension, hypertensive heart disease, nephropathy with uremia, osteoporosis, and a staphylococcic infection of the urinary tract. The patient ran a down hill course until death in uremia occurred in April 1947. Diagnoses at autopsy included basophile adenoma of the pituitary gland, atrophy of the thyroid gland, hypertrophy of the adrenals, hypertrophy of the left ventricle, hypoplasia of the uterus and ovaries, osteoporosis of the spine and pelvis, and chronic nephritis.

Hp-5

This patient, a fifty-six year old white male, was admitted to the hospital in November 1945 with complaints of generalized weakness and difficulty in walking and swallowing of three years duration. The clinical diagnosis was amyotrophic lateral sclerosis. Death occurred in April 1946. The diagnoses at autopsy included amytrophic lateral sclerosis, bronchopneumonia, generalized arteriosclerosis, renal cysts and adenoma of the right kidney.

Hp-6

This patient, a forty-five year old white male with a history of Addison's disease since January 1945, was admitted to the hospital on December 14, 1945, for treatment of numerous infected lesions of the eyelids and toes. He responded to conservative treatment and studies began during convalescence. On readmission in June 1947, his condition was essentially unchanged.

Hp-7

This patient, a fifty-nine year old white female who had been previously treated for heart disease and hyperthyroidism, was hospitalized on January 2, 1946, for cardiac decompensation. The clinical diagnoses were rheumatic heart disease with mitral insufficiency and auricular fibrillation, and toxic nodular goiter. She expired in October 1946. Permission for autopsy was withheld, but the probable cause of death was lobar pneumonia.

Hp-8

This patient, a forty-one year old white female, had a history of scleroderma since January 1945, and a duodenal ulcer first diagnosed in 1944. The clinical diagnoses on this admission were scleroderma and duodenal ulcer.

8001380

Hp-9

This patient, a sixty-six year old white male, was admitted to the hospital in March 1946 with a history of generalized dermatitis and weakness of eighteen months duration. A diagnosis of dermatomyositis was made. The patient expired in July 1947. Diagnoses at autopsy included generalized muscular atrophy, dermatitis, purulent bronchitis and bronchopneumonia, hypertrophy and dilatation of the heart, and chronic passive congestion of the liver and spleen.

Hp-10

This patient, a fifty-two year old negro male, was admitted to the hospital on March 24, 1946, in acute congestive heart failure. A history of heart disease since 1926 was obtained, and his history included both rheumatic fever and luetic infection. The clinical diagnoses on this admission included rheumatic heart disease, latent treated syphilis and ethmoidal and frontal sinusitis.

Hp-11

This patient, a sixty-eight year old white male with history of alcoholism and dietary inadequacies for many years, was admitted to the hospital on December 12, 1945, with complaints of dyspnea and abdominal swelling. He expired on February 26, 1946, and diagnoses at autopsy were cirrhosis of the liver, ascites, and thrombosis of the portal vein.

Hp-12

This patient, a fifty-three year old colored male, was hospitalized on March 25, 1945, following an automobile accident in which he sustained comminuted fractures of the left femur and right patella and a transverse fracture of the right radius and ulna. Physical findings of note included a left lenticular cataract and marked hypertrophic and atrophic arthritic changes in both knees, together with osteochondromatosis of the left knee.

B. Management of Subjects and Collection of Samples

Ten of the twelve patients were cared for in the special metabolic ward of Strong Memorial Hospital. The general management of the ward patients was as follows:

A control period of about ten days was utilized to instruct the patient in the quantitative collection of urine and fecal specimens. During this period all necessary adjustments to ward routine and all necessary modifications in diet were completed. After the patient had proven himself capable of cooperation, a series of control urine and fecal samples were collected for the purpose of "blank" determinations by the method of plutonium analysis. Preceding the injection of plutonium and again at termination, physical and laboratory examinations were conducted on each subject.

Blood samples were drawn into dry sodium citrate as an anticoagulant. Samples of 15 ml were taken before administration of plutonium and at four hours, one day, three days, six days, ten days, fifteen days, etc., post injection.

Urine samples were collected directly into half-gallon fruit jars and preserved with formaldehyde. The urine was usually collected in 24 hour periods except on the day the plutonium was given. During the first day it was collected in two 12 hour periods.

Fecal samples were collected in three-liter beakers. The patient was instructed to empty the bladder before defecation to avoid admixture of urine and feces. As a rule feces were pooled during intervals of four days, except immediately after the plutonium was given when the first two stools were collected separately. All samples were preserved by boiling for ten minutes with 8 N HCl.

Tissue samples of from 25 to 150 g were obtained at autopsy and preserved in 80 per cent alcohol.

C. Administration of Plutonium

The plutonium solution used in these studies was prepared by dissolving 5.0 mg of spectrographically pure plutonium metal in 1.0 ml. of 2 N HNO_3. The solution was assayed for plutonium by alpha counting. An appropriate aliquot of the plutonium solution was placed in a 10 ml volumetric flask and diluted to volume with sterile 0.4% per cent sodium citrate·$2H_2O$. The solution prepared in the above manner had a pH of approximately 5.5 and the plutonium was in the form of Pu^{+4}-complex.

The technique of injection and the method of assay of the injected dose were as follows: One syringe was filled with sterile saline and a 22-gauge needle attached. The other syringe was filled with 0.5 ml of the plutonium solution and the needle used for filling the syringe was discarded. The needle of the syringe containing sterile saline was introduced into a cubital vein and the saline slowly injected to insure unrestricted entry into the vein. The syringe was then carefully detached from the needle, which was still in the vein, and the syringe containing the plutonium injection solution was substituted. The plutonium solution was injected rapidly after which the syringe was rinsed once by drawing it full of the patient's blood and discharging the blood back into the vein.

The same syringe and needle used to inject the patient was used to measure 0.5 ml aliquots of the plutonium solution into each of four volumetric flasks. The washing of the syringe and the other essential steps of the injection technique were duplicated. The contents of each flask was diluted to volume with 2 N HCl and a suitable aliquot of each evaporated directly on platinum discs and assayed for alpha activity. The average of the four assays was taken as the amount of plutonium administered to the patient. The average standard deviation for each set of four results was 3.0 per cent. The amount of material received by each subject and the date of injection are presented in Table 1.

TABLE 1

AMOUNT OF PLUTONIUM ADMINISTERED TO SUBJECTS VIA INTRAVENOUS INJECTION* AND THE DATE OF ADMINISTRATION

Designation of Subject	Date of Injection	μg Pu Injected**
Hp- 1	October 16, 1945	4.0
Hp- 2	October 23, 1945	5.1
Hp- 3	November 27, 1945	4.9
Hp- 4	November 27, 1945	4.9
Hp- 5	November 30, 1945	5.1
Hp- 6	February 1, 1946	5.3
Hp- 7	February 8, 1946	6.3
Hp- 8	March 9, 1946	6.5
Hp- 9	April 3, 1946	6.3
Hp-10	July 16, 1946	6.1
Hp-11	February 20, 1946	6.5
Hp-12	April 10, 1945	4.7

* Pu was administered as Pu^{+4}-citrate in 0.5 ml of 0.4% solution sodium citrate·$2H_2O$.

** Average standard deviation of determination of dose was 2.0 per cent.

D. Analytical Procedures

All urine samples were analyzed for plutonium using the cupferron extraction procedure developed at the Los Alamos Scientific Laboratory for the determination of exposure of laboratory personnel (15).

Fecal samples were analyzed by a modification of the cupferron procedure published earlier (16).

Blood and other tissue samples were "ashed" either in a muffle furnace or with conc. HNO_3 and H_2O_2. The ash solution was analyzed for plutonium by the cupferron extraction procedure in exactly the same manner employed for the analysis of urine ash solutions.

III. RESULTS

A. Clinical Observations

Acute toxic effects from the small doses of plutonium administered in these studies were neither expected nor observed.

As seen from the summaries of case histories (Pages 10 - 14), the subjects used in this study were suffering from a variety of conditions. In most cases, however, kidney and liver function appeared to be essentially normal. There were two notable exceptions.

Hp-4 was suffering from Cushing's Syndrome and chronic nephritis. The highly abnormal condition of this subject was accompanied by higher plutonium content in blood and urine and apparently a slower rate of plutonium fixation in bone. In fact, several of the urine analyses were ruled non-representative on the basis of the Chauvenet criterion.

Hp-11 was moribund at the time plutonium was administered. Therefore, no plutonium excretion values were obtained. Anatomical diagnosis revealed cirrhosis of the liver with associated ascites, which indicated marked impairment of liver function.

The data in Table 2 summarize some of the clinical laboratory observations. These data show no consistent trends in hemoglobin, red blood cell count, white blood cell count and differential count as a result of the injection of approximately 5 μg of plutonium. The rise in hemoglobin and red blood cell count in Hp-12 probably was a result of therapeutic measures. The observations in Table 2 were quite in accord with those made by Russell and Nickson (13) who collected excellent clinical laboratory data from two cases following administration of plutonium. One individual received 6.5 μg of plutonium and was followed for 155 days. Another subject received 95 μg of plutonium, and was followed for six days. No alterations attributable to plutonium were found in the constituents of the peripheral blood of either patient.

In the present series clinical evidence suggestive of liver damage did not appear. While specific tests of liver function were not as a rule listed in the protocols, the possibility that injury to this organ might appear was considered.

Admittedly the observations made during this study provide no evidence of what may happen in 10-30 years. It may be said, however, that these studies and those of other investigators indicate that the intravenous injection of a single dose of 5 to 100 μg of plutonium was without acute subjective or objective clinical effects.

B. Deposition of Plutonium in the Body

Since the beginning of this study, four of the subjects (Hp-4, 5, 7 and 9) have died as a result of their diagnosed illness. Another subject, Hp-11, was in the terminal phase at the time of injection. Autopsy and tissue samples were obtained in only three of the five cases. Two bone specimens were obtained from Hp-12 during open reduction of fractures and a number of his teeth were obtained at a later date. Blood samples were obtained from all

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TABLE 2

CLINICAL DATA ON SUBJECTS RECEIVING INTRAVENOUS INJECTION OF APPROXIMATELY 5 μg OF PLUTONIUM AS Pu^{+4} CITRATE

PATIENT CODE	SEX	AGE	WT Kg	Pu ADMIN AMT μg	DATE	LABORATORY STUDIES* DATE	HGB	RBC x 10^{-6}	WBC x 10^{-3}	PMS %	LYMPHS %	EOS %	BASO %	MONO %	UREA Cl.	BUN	NPN
Hp- 1	M	67	70.3	4.6	10 IV	10 4	13.9	4.47	7.1	52	39	1	0	7	96	21	
						10 19	13.7	4.50	7.0	54	34	4	1	7	90	23	
Hp- 2	M	49	69.0	5.7	10 27	10 6	15.0	4.7	9.65	57	28	8	0	7			
						11 7	14.5	4.1	7.85	68	22	8	0	2		25	
Hp-3	F	48	69.9	4.9	11 27	11 2	14	4.3	5.2	30	32	2	0	6	46	23	
						12 16		5.0	6.8	69	25	0	1	5			34
Hp- 4	F	18	55.5	4.9	11 27	10 30	15.0	5.3	10.6	77	20	0	1	2			31
						3 21	16.0		6.9	76	22	0	0	4			
Hp- 7	F	59	68.0	6.3	2 8	1 23	12.0	3.20	4.75	64	24	3	0	6			
						2 27			5.25	64	25	0	0	6	94		20
Hp- 8	F	41	54.4	6.3	3 9	2 22	13.3	4.7	9.5	71	22	0	0	7			
						8 27	14.5	4.05	11.9	88	12	0	0	0	85	30	30
Hp- 9	M	66	63.0	6.3	4 3	7 13	12.3	3.9	6.25	70	17	0	0	13			
						1 25	12.3	4.1	7.4	61	5	17	1	15	72		
Hp 10	M	72	70	6.1	7 16	7 9	13.3		5.65	31	52	5	2	7	57	33	27
						8 13				42	45	3	2	8	92		
Hp 12	M	53	-	4.7	4 9	4 4	8.9	2.65	5.6	74	18			4			
						7 3	13.9	4.51	4.3	32	64			4		36	44
																32	37

*Explanation of Symbols: HGB, Hemoglobin; RBC, Red Blood Cell Count; WBC, White Blood Cell Count; PMS, Polymorphonuclear Cells; LYMPHS, Lymphocytes; EOS, Eosinophiles; BASO, Basophiles; MONO, Monocytes; BUN, Blood Urea Nitrogen; NPN, Non-Protein Nitrogen; UREA Cl., Urea Clearance Expressed as Per Cent of Normal at One Hour.

subjects before plutonium injection and at frequent intervals thereafter. All tissue samples were analyzed for plutonium by the cupferron extraction procedure subsequent to ashing.

The data in Table 3 show the results of analyses of the various samples for plutonium. The results obtained by Russell and Nickson (13) (referred to as Cal. I, II, III) and Hamilton et al (14) (referred to as Cal. 1) are presented also. Two important points must be kept in mind when considering these data: (1) The samples of human tissues were, for obvious reasons, rather unsatisfactory. In most cases they were too small, poorly representative and were usually what could be obtained under the circumstances rather than what were desired. (2) The subjects were chronically ill and/or elderly and the results may not represent exactly the distribution of plutonium in tissues of healthy persons of average working age. These data, however, are all that are available and, therefore, must provide the basis for our present concept of the distribution of plutonium in the organs and tissues of man. They must also provide a basis for comparison with the results obtained from the numerous studies of plutonium deposition in experimental animals.

1. Deposition in the Skeleton

Animal experiments (1) (2) reveal that approximately 60 per cent of plutonium injected as PuO_3^{++} and Pu^{+4} citrate is localized in bone. If the vertebra, sternum and whole ribs are taken as representative bones of the skeleton, and the average plutonium content (dpm/g K...

TABLE 3

DISTRIBUTION OF PLUTONIUM IN HUMAN TISSUES FOLLOWING INTRAVENOUS INJECTION OF PLUTONIUM SALTS

Tissue[2]	Subject[1] and % of Injected Dose/g of Tissue								Rel. Pu Affinity[3]	Org. Wt., g[4]	Calc. % Organ
	Hp-5	Hp-9	Hp-11	Chi. I	Chi. II	Hp-12	Cal. I	Av. % g			
Bone Marrow	..	..	.0096	.0153	.0210	..	.0290	.0187	10 *	3,000	(56.1)[6]
Radius (Prox. head)	..	..	..	..	..	.0187	..	..	..	..	..
Liver	.0320	.0144	.0053	.0139	.0024	..	..	.0136	9.7	1,700	23.1
Rib (Cortex)	..	..	..	.0015	.0190	..	.0170	.0127	9.1	..	..
Patella	..	..	..	..	..	.0109	..	..	..	..	..
Vertebra	.0071	.0040	.0070	..	..	..	..	.0073	5.2	NOT GIVEN	..
Sternum	.0070	..	.0100	.0044	..	..	..	.0071	5.1	10,000	= 65.7[5]
Rib (Whole)	.0050	.0038	.0068	..	..	..	..	.0052	3.7		..
Periosteum (Ri	..	..	..	.0043	.0019	..	.0048	.0037	2.6	..	..
Spleen	.0007	.0015	.0048	.0024	.0014	..	.0019	.0021	1.5	200	0.4
Kidney	.0002	.0002	.0015	.0004	.0034	..	..	.0015	1.0	300	0.4
Thyroid	.0001	..	.0009	..	.0034	..	..	.0014	1.0	30	..
Adrenal	.0004	..	.0022	..	..	..	..	.0013	1.0	14	..
Lung	.0005	..	.0016	.0008	.0016	..	..	.0011	0.8	950	1.0
Pancreas	.0002	.0002	..	..	.0022	..	..	.0009	0.6	85	..
Gonads	.0003	..	.0012	.0013	.0009	..	..	.0007	0.5	..	..
Lymph Node	..	..	..	.0014	.0001	..	..	.0007	0.5	700	0.5
Teeth (Av. of 7)	..	..	..	..	..	.0003	..	..	..	..	..
Heart	.0000	.0000	..	.0003	.0011	..	..	.0003	0.2	350	0.1
Large Intestine	.0002	..	.0004	..	.0001	..	..	.0002	0.1	2,300	0.5
Small Intestine	.0001	..	.0005	..	.0001	..	..	.0002	0.1	..	..
Muscle and Skin	.0000	..	.0002	.0002	.0001	..	..	.0001	0.1	38,500	3.9
Blood	..	..	..	..	..	..	..	..	..	5,400	0.2[8]
Balance	..	..	..	..	..	..	..	.0001[7]	..	9,600	0.9
Total	..	..	..	..	..	..	..	..	..	70,000	96.7

[1] The various subjects received the following doses of plutonium: Hp-5 5 μg, Hp-9 - 6.3 μg, Hp-11 - 6.5 μg, Chi. I - 6.5 μg, Chi. II - 94.9 μg, Hp-12 4.7 μg, Cal. I - 103 μg

[2] Tissues were examined at the following times after injection: Hp-5 151 days, Hp-9 456 days, Hp-11 5 days, Chi. I 155 days, Chi. II 16 days, Hp-12 5 days, Cal. I 4 days

[3] Calculated by dividing % g of tissue by % g of body weight if a unit dose of Pu was equally distr. in a 70 Kg. man.

[4] Hermann Lisco, Memorandum to AEC, July 21, 1947, Project Standard Man

[5] Assumption made that vertebra, sternum and whole rib represent average bone of skeletal system.

[6] Bone marrow not included in total recovery because bone samples were not freed of marrow before analysis

[7] Balance assumed to have same Pu content as muscle

[8] Value for blood taken at 30 day point, Fig. 3

multiplied by the skeletal weight of the "Standard Man" (17), then 65.7 per cent of the injected dose is the estimated amount of plutonium in the skeleton of a 70 kg man. Although the latter value was established rather arbitrarily, it is in good agreement with the value expected from animal experiments.

The data in Table 3 indicate a rather high plutonium content in bone marrow. The average of four determinations from three different laboratories was 0.0187 per cent of the injected dose per gram of marrow. On the basis of 3000 g of bone marrow, there would be 56 per cent of the injected dose concentrated in the marrow of a 70 kg man. Animal studies do not show appreciable concentrations of plutonium in the marrow. The major areas of plutonium concentration in rats and mice are the endosteum, periosteum and the epiphyseal line.' It is quite possible that the samples of human marrow were too small to be representative, contained endosteum or spicules, or that the high deposition was an indication of an age factor related to the fact that the epiphyses of man unite at maturity.

2. Deposition in the Liver

The average plutonium deposition in the liver for the five cases was 0.0136 per cent of the injected dose per gram, which corresponds to 23.1 per cent of the dose in a 1700 gram liver (Standard Man). Table 4 presents the liver data in more detail, including the two cases reported by the Chicago investigators (13).

TABLE 4

LIVER DEPOSITION OF PLUTONIUM ADMINISTERED INTRAVENOUSLY TO MAN

Subject	Days After Injection	Liver Wt. in Grams	% of Dose per Gram	% of Dose per Organ
Hp-5	151	1340	.0320	42.8
Hp-9	456	1600	.0144	23.0
Hp-II[1]	5	2325	.0053	12.3
Chi. I[3]	155	2050	.0139	28.5
Chi. II[2,3]	16	1110	.0024	2.7
AVERAGE	156	1641	.0136	21.9

[1] Hp-II was in terminal phase of illness; plutonium deposition probably low because of severe cirrhosis of the liver.

[2] Chi.-II was in terminal phase of adenocarcinoma; plutonium deposition probably low because of metastases to the liver.

[3] Russell, E.R. and Nickson, J.J. (13)

Two cases (Hp-II and Chi.-II) were in the terminal phase of illness at the time plutonium was administered. Both showed advanced liver disease. The values for plutonium deposition in the liver of these cases is highly questionable. The results in the other three cases, however, were rather striking. As pointed out by Russell and Nickson (13), the content of

plutonium in the liver was much higher than was to be expected from results in experimental animals. Even though one of their cases survived 155 days after receiving plutonium in the +6 valence state (a form known to give low liver deposition in rats (1) (2)), 28.5 per cent of the injected dose was found in the liver. Subject Hp-5 had 42.8 per cent of the plutonium injected as Pu^{+4}-citrate deposited in the liver after 151 days. The third case (Hp-9) survived 456 days and had 23.0 per cent of the injected material deposited in the liver. Considering the elapsed time after injection, the plutonium content of the liver in the two latter cases was even higher than that observed by Russell and Nickson (13). The apparent higher deposition in the latter cases might indicate the destruction of the Pu^{+4}-citrate complex by the human liver. The results compare favorably with those obtained when rats were injected with uncomplexed quadrivalent plutonium ion (1), (2), (3). The limited data presented in Table 4 indicated rather strongly that the retention of plutonium by the liver may be much greater for man than for rats and mice, and may be of the order of 20 - 40 per cent of the injected dose during the first year. A comparison of the survival times and the amounts of plutonium deposited in the livers of Hp-5 and Hp-9 seems to indicate a "plutonium retention half-time" in the liver of one year or greater for man as compared to 40 - 60 days for rats.

3. Concentration in Blood

The data in Table 5 show the concentration of plutonium in blood at various times after the intravenous injection of approximately 5 μg of plutonium as Pu^{+4}-citrate. The results are expressed in per cent of the injected dose in the total blood volume. The blood was assumed to be 7.7% per cent of the total body weight (17).

The individual observations varied widely, especially during the first four days. The mean values, however, fell on a smooth curve (shown in Fig. 3).

The drop in blood plutonium content was very rapid at first, and reflected the very rapid rate of fixation of the material in the body. The mean blood concentration 4 hours after injection was 35.7 per cent, at one day 15.7 per cent, at 10 days 1.2 per cent. Thirty days after injection the blood concentration of plutonium read from the curve in Fig. 3 was only 0.3 per cent of the injected dose in the total blood volume. The extremely small amount of plutonium in the circulating blood eliminates blood analysis by the usual counting procedures as a means of diagnosing the degree of exposure of personnel. The application of techniques employing the counting of alpha tracks registered by alpha sensitive nuclear track photographic emulsions may prove possible.

4. Deposition in Other Organs

The amounts of plutonium deposited in organs and tissues other than skeleton, liver and blood were rather small. When the per cent per organ was calculated, based on the organ weight of the "Standard Man", the results were in reasonable agreement with what was anticipated from animal experiments. The data showing the per cent of dose per gram of organ and per cent per organ are given in Table 3 (Page 18). The kidney and spleen each had an estimated average plutonium content of 0.4 per cent of the injected dose per organ.

The relative affinity of the various tissues for plutonium was calculated by dividing the per cent of the dose per gram of organ by the per cent of the dose per gram of body weight when the material was assumed to be equally distributed in a 70 kg man.

The bone, bone marrow and liver were the only tissues that showed a relative plutonium affinity appreciably greater than unity. The spleen was 1.5; all other tissues and samples were 1.0 or less. Obviously the skeletal system and liver are the tissues of major interest when considering the plutonium tolerance, as these two organs alone account for 90 per cent or more of the total plutonium in the entire body.

TABLE 5

PLUTONIUM CONTENT OF BLOOD SAMPLES* FOLLOWING INTRAVENOUS INJECTION OF APPROXIMATELY 5 μg OF PLUTONIUM AS Pu^{+4}-CITRATE

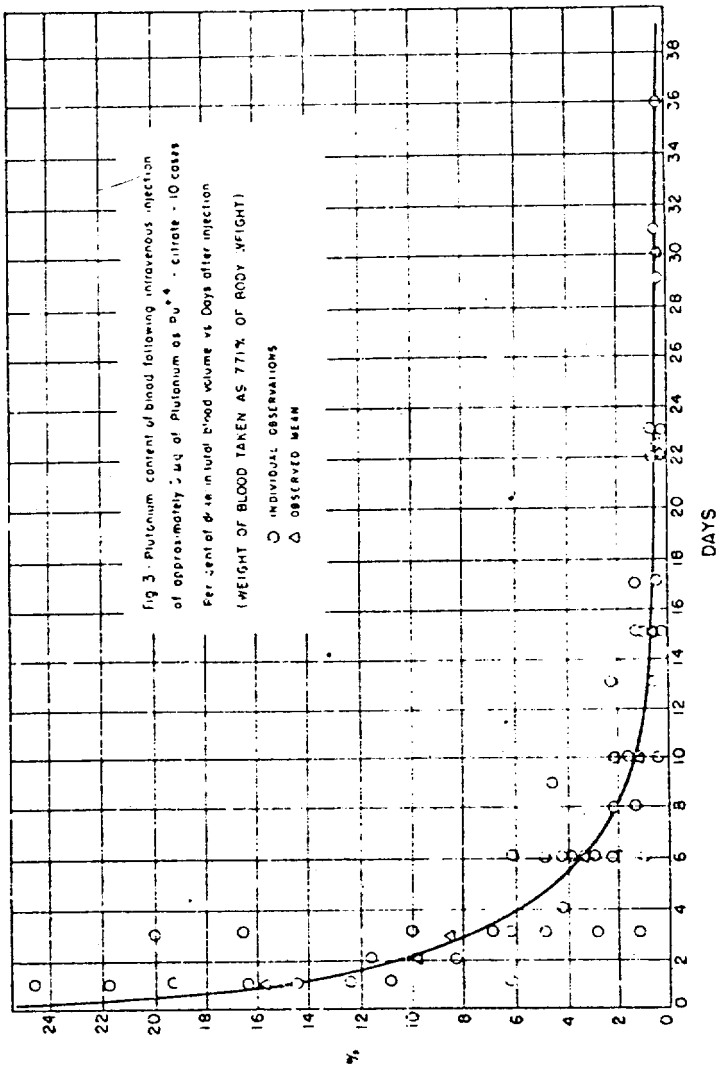
DAYS AFTER INJECTION	PATIENT CODE AND PER CENT OF INJECTED DOSE IN TOTAL BLOOD VOLUME*											
	Hp-1	Hp-2	Hp-3	Hp-4	Hp-5	Hp-6	Hp-7	Hp-8	Hp-9	Hp-10	Hp-12	AVERAGE
1/6	46.02	-	28.32	83.31	31.51	36.70	32.57	37.64	40.83	51.57	5.31	39.7
1	21.83	19.35	-	-	6.23	10.97	16.40	14.51	12.39	24.66	-	15.7
2	-	8.38	11.56	-	-	-	-	-	-	-	-	9.97
3	-	10.03	-	10.84	1.10	2.04	6.97	4.84	6.23	20.06	-	8.02
4	-	-	4.22	-	-	-	-	-	-	-	-	-
5	-	-	-	-	0.66	-	-	-	-	-	-	-
6	3.30	4.25	2.17	6.14	-	1.06	2.06	2.07	2.91	4.51	-	3.4
8	-	2.32	1.42	-	-	-	-	-	-	-	-	1.9
9	-	-	-	4.60	-	-	-	-	-	-	-	-
10	1.42	-	-	-	0.39	0.38	1.13	1.37	2.21	1.72	-	1.2
13	-	-	0.61	2.34	-	-	-	-	-	-	-	1.5
15	-	-	-	-	0.11	1.20	0.66	0.71	1.42	1.02	-	0.9
17	-	-	0.51	1.45	-	-	-	-	-	-	-	0.9
22	-	0.79	-	-	0.16	0.25	-	-	-	-	-	0.3
23	-	-	0.25	0.72	-	-	-	-	-	-	-	0.4
29	-	-	-	-	-	-	0.31	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	0.36	-	-
31	-	-	-	-	-	-	-	-	-	-	0.51	-
36	-	-	-	-	-	-	-	-	0.42	-	-	-
42	-	-	-	-	-	-	-	0.17	-	-	-	-
46	-	-	-	-	-	-	-	-	-	-	0.41	-

*Total Weight of Blood Taken as 7.7% of Total Body Weight

C. Excretion of Plutonium

1. Urinary Excretion

The urinary excretion of plutonium was studied in eleven of the subjects following the intravenous injection of approximately 5 μg of plutonium as Pu^{+4} in 0.4 per cent solution of sodium citrate·$2H_2O$. With the exception of the first day, urine from all subjects was collected in 24 hour samples through 22 days post injection. After 22 days the collection of 24 hour urine samples was continued as long as the patients were available for study. It was not possible to retain the subjects as long as was desired and the major weakness in these results is the short time interval over which the studies were continued. Two subjects were followed 22 days, one for 23 days, one for 27, and the remainder for 30 days or longer after injection. The Chicago cases (13) were followed for 16, 140, and 186 days and the California case (14) was followed for a period of 341 days. Because of the great importance of measurements at longer time intervals, the Chicago and California data have been incorporated with



D.S.I.-9

the data from these studies. The results of all urine analyses through 138 days post-injection are given in Table 6. Results are expressed as per cent of injected dose excreted per day.

The means, revised means, and standard deviations for the daily urinary excretion of plutonium from 0 to 138 days post-injection are given in Table 7. The equation of best fit for the observed means is a logarithmic function:

$$Y = aX^{-b} \qquad [1]$$

where Y is the amount of plutonium (expressed as per cent of injected dose) excreted in a single day, X is the time of observation in days post-injection, and a and b are constants derived from the observed data by the method of least squares. Solution gives the following expression for the best curve of fit for the urinary excretion of plutonium utilizing all available data from 0 to 138 days post-injection:

$$Y_U = 0.23\,X^{-0.77} \qquad [2]$$

The agreement between observed mean values and the derived expression for the urinary excretion of plutonium through 138 days post-injection is illustrated graphically in Fig. 4. In this graph the circles represent the observed means and the solid line represents the derived expression. The agreement is fairly good. The overall standard error of estimate, S_{YX}, (determined by the usual methods of correlation analysis) was ± 32 per cent. The largest contributions to the standard error of estimate come from the 0 to 10 day portion of the curve and from the latter portion where there is an increased scatter of points because of the decrease in number of observations. Actually, attempts at curvilinear regression have fitting, indicate that the function $Y = aX^{-1}$ is the best curve for the 0 to 10 day period rather than the logarithmic curve presented. We believe this difference in functional relationship may be due to the clearance of the injected plutonium from the blood during this early period after injection.

Extrapolation of the derived expression beyond 138 days introduces increasing uncertainty with increasing values of X. In order to interpret the excretion results in standard terms, i.e. "biological half-life", despite the fact that the data are not fitted by a single exponential curve, we have chosen to determine $T_{1/2}$ by assuming exponential excretion beyond the limits of observation and estimating $T_{1/2}$ from the last point on the excretion curve (a single value of the urinalysis). One may then assume the slope of the excretion curve to be zero at this point and calculate an absolute minimum value for the "biological half-life". For the above reasons it is important to supplement the urinary excretion data beyond 138 days to the greatest possible extent. Three additional groups of samples were obtained from two of the cases after the close of the experiment. One group of four consecutive daily urine samples was obtained from Hp-6 beginning on the 523rd day and another group beginning on the 1610th day after injection. The average daily urinary excretion of plutonium at 523 days was 0.002 per cent, and at 1619 days 0.0011 per cent of the injected dose. Four daily samples collected from Sp-3 beginning at 1545 days after injection showed an average daily urinary excretion of 0.0008 per cent of the injected dose.

In addition to the three groups of samples mentioned above a number of urine plutonium assays were made on workers at the Los Alamos Laboratory. A few of these individuals accumulated measurable amounts of plutonium during wartime operations. They were removed from further exposure to plutonium and occasional urine assays were made over a period of the next several months. The urine assays on three members of this group are given in Table 8. Since these individuals received unknown exposure doses via the usual routes of entry over an indefinite time, the results are not analogous to a single intravenous injection of a known amount of plutonium. However, the inclusion of these individuals has been attempted in order to extend the excretion curve. An attempt has been made to interpret their

TABLE 6

INDIVIDUAL URINARY EXCRETION VALUES OF PLUTONIUM FOLLOWING INTRAVENOUS ADMINISTRATION[1] TO HUMAN SUBJECTS (EXPRESSED AS PER CENT OF DOSE EXCRETED PER DAY)

DAYS POST INJECTION	PER CENT OF INJECTED DOSE EXCRETED PER DAY														
	Hp-1	Hp-2	Hp-3	Hp-4	Hp-5	Hp-6	Hp-7	Hp-8	Hp-9	Hp-10	Hp-13	Chi.-I[2]	Chi.-II[2]	Chi.-III[2,4]	Cal.-I[3]
1	.181	.472	.569	.640	.296	-	.217	.377	.183	.414	.101	.857	2.531*	.14	.480
2	.146	.294	.289	.336	.169	.318	.212	.232	.065	.350	.163	.182	.153	.[illegible]	.150
3	.134	.174	.112	.221	.077	.127	.137	.128	.069	.215	.068	.063	.784	.08	.120
4	.094	.123	.107	.133	.052	.111	.096	.140	.066	.170	.078	.077	.133	.0[illegible]	.51
5	.069	.116	.078	.116	.030	.076	.068	.083	.047	.089	.066	.026	.032	.[illegible]	.217
6	.066	.061	.043	.119*	.020	.057	.059	.076	.053	.060	.044	.0154	.029	.042	-
7	.042	.062	.043	.077	.032	.044	.045	.066	.050	.079	.[illegible]	.0234	.024	.034	-
8	.055	.048	.049	.061	.028	.043	.037	.057	.[illegible]	.065	.040	.0227	.023	.025	.018
9	.061	.048	.022	.095*	.027	.[illegible]2	.[illegible]5	.047	.032	.051	.043	-	.027	.018	.069
10	.045	.039	.027	.041*	.022	.031	.023	.050	.[illegible]5	.044	.036	.0082*	.034	.030	.[illegible]5
11	.040	.043	.027	.075*	.021	-	.018	.044	.026	.041	.038	.0091	.047	.018	.038
12	.038	.[illegible]*	.015	.072*	.026	.026	.019	.033	.030	.038	.[illegible]7	.0093	.047	.014	.[illegible]29
13	.034	.[illegible]	.020	.[illegible]7*	.023	.033	.[illegible]9	.037	.027	.029	.030	.0736	.[illegible]8	.034	-
14	.035	.036	.020	.[illegible]58*	.018	.030	.[illegible]3	.[illegible]0	.030	.029	.038	.007	.034	.009	-
15	.[illegible]4	.[illegible]9	.028	.050	.015	.022	.[illegible]2	.[illegible]9	.030	.025	.[illegible]29	.[illegible]053	.[illegible]236	.[illegible]16	.[illegible]13
16	.026	.034	.024	.033	.020	.017	.[illegible]12	.[illegible]A	.[illegible]049*	.[illegible]021	.[illegible]023	.0168	.[illegible]12	.004	.[illegible]018
17	.027	.027	.021	.033	.030	.[illegible]13	.[illegible]11	.[illegible]032	.[illegible]038	.[illegible]023	.[illegible]029	-	.028	-	.[illegible]0056
18	.[illegible]*	.[illegible]070	.[illegible]017	.[illegible]037	.020	.[illegible]015	.[illegible]011	.[illegible]028	.027	.[illegible]021	.[illegible]016	-	.026	-	.[illegible]010
19	.[illegible]2	.[illegible]019	.[illegible]018	.032	.[illegible]018	.[illegible]015	.[illegible]010	.[illegible]031	.[illegible]029	.[illegible]017	.[illegible]029	.0022	.[illegible]19	-	.[illegible]008
20	.[illegible]17	.[illegible]031	.[illegible]13	.[illegible]025	.[illegible]031	.[illegible]015	.[illegible]008	.[illegible]032	.[illegible]029	.[illegible]018	.[illegible]032	.[illegible]0063	.[illegible]038	-	.[illegible]0048
21	.[illegible]17	.[illegible]017	.[illegible]019	.[illegible]028	.[illegible]030	.[illegible]012	.[illegible]010	.[illegible]029	.[illegible]032	.[illegible]022	.[illegible]025	.[illegible]0078	.[illegible]033	-	.[illegible]0071
22	.[illegible]08	.[illegible]015	.[illegible]014	.[illegible]025	.[illegible]018	.[illegible]013	.[illegible]013	.[illegible]031	.[illegible]032	.[illegible]016	.[illegible]025	.[illegible]0145	.[illegible]027	-	.[illegible]0050
23	.[illegible]025	.[illegible]016	.[illegible]014	.[illegible]014	-	-	.[illegible]008	.[illegible]021	.[illegible]032	.[illegible]019	.[illegible]038	.[illegible]0151	.[illegible]029	-	.[illegible]0081
24	.[illegible]021	.[illegible]014	-	-	-	-	.[illegible]08	.[illegible]*[illegible]5	.[illegible]032	.[illegible]018	.[illegible]023	.[illegible]0128	.[illegible]020	-	.[illegible]0078
25	.[illegible]013	.[illegible]014	-	.[illegible]011	-	-	.[illegible]006	.[illegible]023	.[illegible]029	.[illegible]018	.[illegible]021	.[illegible]0138	.[illegible]148*	-	.[illegible]011
26	-	.[illegible]017	-	.[illegible]011	-	-	.[illegible]007	.[illegible]022	.[illegible]032	.[illegible]018	.[illegible]023	.[illegible]0175	.[illegible]034	-	.[illegible]0022
27	-	.[illegible]006	-	.[illegible]006	-	-	.[illegible]004	.[illegible]028	.[illegible]032	.[illegible]014	.[illegible]017	.[illegible]0151	.[illegible]043*	-	.[illegible]1.44
28	-	.[illegible]009	-	-	-	-	.[illegible]00[illegible]	.[illegible]023	.[illegible]026	.[illegible]013	.[illegible]024	.[illegible]0197	.[illegible]034	-	.[illegible]0076
29	-	.[illegible]009	-	-	-	-	.[illegible]006	.[illegible]015	.[illegible]025	.[illegible]014	.[illegible]023	.[illegible]0138	.[illegible]042	-	.[illegible]0043
30	-	.[illegible]008	-	-	-	-	.[illegible]008	.[illegible]021	.[illegible]023	.[illegible]014	.[illegible]021	.[illegible]0151	.[illegible]034	-	.[illegible]0089
31	-	.[illegible]007	-	-	-	-	.[illegible]005	.[illegible]017	.[illegible]025	-	.[illegible]021	.[illegible]010	.[illegible]027	-	.[illegible]0077
32	-	.[illegible]007	-	-	-	-	.[illegible]007	.[illegible]016	.[illegible]024	-	.[illegible]012	.[illegible]010	.[illegible]020	-	.[illegible]0063
33	-	.[illegible]008	-	-	-	-	.[illegible]008	.[illegible]015	.[illegible]022	-	.[illegible]037*	.[illegible]017	.[illegible]011	-	.[illegible]0073
34	-	.[illegible]009	-	-	-	-	.[illegible]006	.[illegible]015	.[illegible]020	-	.[illegible]020	.[illegible]0139	.[illegible]008	-	.[illegible]0084
35	-	-	-	-	-	-	.[illegible]004	-	.[illegible]012	-	.[illegible]026	.[illegible]0127	.[illegible]009	-	.[illegible]0060
36	-	-	-	-	-	-	.[illegible]00[illegible]	.[illegible]015	.[illegible]022	-	.[illegible]018	.[illegible]0188	.[illegible]015	-	.[illegible]0079
37	-	-	-	-	-	-	.[illegible]006	.[illegible]011	-	-	.[illegible]022*	.[illegible]0111	.[illegible]011	-	.[illegible]0083
38	-	-	-	-	-	-	-	.[illegible]*[illegible]8	-	-	.[illegible]016	.[illegible]0174	.[illegible]009	-	.[illegible]0085
39	-	-	-	-	-	-	-	.[illegible]012	-	-	.[illegible]021	.[illegible]0118	.[illegible]008	-	.[illegible]0064
40	-	-	-	-	-	-	-	.[illegible]017	-	-	.[illegible]019	.[illegible]0073	.[illegible]008	-	.[illegible]0072
41	-	-	-	-	-	-	-	.[illegible]010	-	-	.[illegible]013	.[illegible]0092	.[illegible]011	-	.[illegible]0080
42	-	-	-	-	-	-	-	.[illegible]016	-	-	.[illegible]013	.[illegible]0127	-	-	.[illegible]0081
43	-	-	-	-	-	-	-	.[illegible]016	-	-	.[illegible]015	.[illegible]0095	.[illegible]017	-	.[illegible]0076
44	-	-	-	-	-	-	-	.[illegible]014	-	-	.[illegible]015	.[illegible]0033	-	-	.[illegible]0055
45	-	-	-	-	-	-	-	.[illegible]013	-	-	.[illegible]011	.[illegible]013	.[illegible]018	-	.[illegible]0083
46	-	-	-	-	-	-	-	.[illegible]018	-	-	-	.[illegible]013	-	-	.[illegible]0073
47	-	-	-	-	-	-	-	.[illegible]014	-	-	.[illegible]015	-	.[illegible]020	-	.[illegible]0059
48	-	-	-	-	-	-	-	.[illegible]014	-	-	.[illegible]017	.[illegible]0084	-	-	.[illegible]0058
49	-	-	-	-	-	-	-	.[illegible]018	-	-	.[illegible]015	.[illegible]0042	-	-	.[illegible]0083
50	-	-	-	-	-	-	-	.[illegible]016	-	-	-	.[illegible]3084	.[illegible]016	-	.[illegible]0078
51	-	-	-	-	-	-	-	.[illegible]018	-	-	-	.[illegible]077	-	-	.[illegible]0082
52	-	-	-	-	-	-	-	-	-	-	.[illegible]035	.[illegible]0073	-	-	.[illegible]0086
53	-	-	-	-	-	-	-	.[illegible]13	-	-	.[illegible]018	.[illegible]0023	-	-	.[illegible]0076
54	-	-	-	-	-	-	-	.[illegible]013	-	-	.[illegible]043	-	-	-	.[illegible]0077
55	-	-	-	-	-	-	-	.[illegible]018	-	-	.[illegible]*[illegible]3*	.[illegible]0073	.[illegible]014	-	.[illegible]0096
56	-	-	-	-	-	-	-	.[illegible]013	-	-	.[illegible]036	.[illegible]003	-	-	.[illegible]0094
57	-	-	-	-	-	-	-	.[illegible]013	-	-	.[illegible]018	.[illegible]0078	-	-	.[illegible]0090
58	-	-	-	-	-	-	-	.[illegible]018	-	-	.[illegible]036	.[illegible]0094	-	-	.[illegible]0058
59	-	-	-	-	-	-	-	.[illegible]013	-	-	-	.[illegible]011	-	-	.[illegible]0098
60	-	-	-	-	-	-	-	.[illegible]011	-	-	-	.[illegible]0083	.[illegible]023	-	.[illegible]0087
61	-	-	-	-	-	-	-	.[illegible]012	-	-	-	.[illegible]0068	-	-	.[illegible]0086
62	-	-	-	-	-	-	-	.[illegible]010	-	-	-	.[illegible]0082	-	-	.[illegible]0058
63	-	-	-	-	-	-	-	.[illegible]008	-	-	-	.[illegible]0094	-	-	.[illegible]0077
64	-	-	-	-	-	-	-	.[illegible]012	-	-	-	.[illegible]0071	-	-	.[illegible]0043
65	-	-	-	-	-	-	-	.[illegible]011	-	-	-	.[illegible]0059	.[illegible]034	-	.[illegible]0043
66	-	-	-	-	-	-	-	-	-	-	-	.[illegible]C18	-	-	.[illegible]0047
67	-	-	-	-	-	-	-	-	-	-	-	.[illegible]034	-	-	.[illegible]0084
68	-	-	-	-	-	-	-	-	-	-	-	.[illegible]011	-	-	.[illegible]0068
69	-	-	-	-	-	-	-	-	-	-	-	.[illegible]011	-	-	.[illegible]0070
70	-	-	-	-	-	-	-	-	-	-	-	.[illegible]014	-	-	.[illegible]0100
71	-	-	-	-	-	-	-	-	-	-	-	.[illegible]C46	-	-	.[illegible]0072
72	-	-	-	-	-	-	-	-	-	-	-	.[illegible]0049	.[illegible]014	-	.[illegible]0092
73	-	-	-	-	-	-	-	-	-	-	-	.[illegible]0[illegible]5	-	-	.[illegible]0049

TABLE 6 (Contd)

INDIVIDUAL URINARY EXCRETION VALUES OF PLUTONIUM FOLLOWING INTRAVENOUS ADMINISTRATION[1] TO HUMAN SUBJECTS (EXPRESSED AS PER CENT OF DOSE EXCRETED PER DAY)

DAYS POST INJECTION	PER CENT OF INJECTED DOSE EXCRETED PER DAY														
	Hp-1	Hp-2	Hp-3	Hp-4	Hp-5	Hp-6	Hp-7	Hp-8	Hp-9	Hp-10	Hp-13	Chi.-I[2,4]	Chi.-II[2]	Chi.-III[2]	Cal.-I[3]
74	-	-	-	-	-	-	-	-	-	-	-	.510	-	-	.0078
75	-	-	-	-	-	-	-	-	-	-	-	.013	-	-	.0078
76	-	-	-	-	-	-	-	-	-	-	-	.0061	-	-	.0061
77	-	-	-	-	-	-	-	-	-	-	-	.0043	-	-	.0065
78	-	-	-	-	-	-	-	-	-	-	-	.016	-	-	.0[illegible]
79	-	-	-	-	-	-	-	-	-	-	-	.0052	-	-	.0068
80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
81	-	-	-	-	-	-	-	-	-	-	-	.0046	.034	-	.0048
82	-	-	-	-	-	-	-	-	-	-	-	.0043	-	-	.0055
83	-	-	-	-	-	-	-	-	-	-	-	.002	.018	-	.0043
84	-	-	-	-	-	-	-	-	-	-	-	.0041	-	-	.0061
85	-	-	-	-	-	-	-	-	-	-	-	.0079	-	-	.0021
86	-	-	-	-	-	-	-	-	-	-	-	.001	-	-	-
87	-	-	-	-	-	-	-	-	-	-	-	.0048	-	-	.0109
88	-	-	-	-	-	-	-	-	-	-	-	.0078	-	-	.[illegible]2
89	-	-	-	-	-	-	-	-	-	-	-	.0086	-	-	.[illegible]3
90	-	-	-	-	-	-	-	-	-	-	-	.0049	-	-	.001[illegible]
91	-	-	-	-	-	-	-	-	-	-	-	.0033	.[illegible]17	-	.0077
92	-	-	-	-	-	-	-	-	-	-	-	.0078	-	-	.0063
93	-	-	-	-	-	-	-	-	-	-	-	.016	-	-	.0071
94	-	-	-	-	-	-	-	-	-	-	-	.006	-	-	.0060
95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.0071
96	-	-	-	-	-	-	-	-	-	-	-	.0063	.017	-	.0052
97	-	-	-	-	-	-	-	-	-	-	-	.011	.018	-	.0[illegible]2
98	-	-	-	-	-	-	-	-	-	-	-	.0[illegible]2	-	-	.0057
99	-	-	-	-	-	-	-	-	-	-	-	.013	.013	-	.0053
100	-	-	-	-	-	-	-	-	-	-	-	.006	-	-	.0070
101	-	-	-	-	-	-	-	-	-	-	-	.0006	-	-	.0061
102	-	-	-	-	-	-	-	-	-	-	-	.005	*	-	.0[illegible]
103	-	-	-	-	-	-	-	-	-	-	-	.005	.006	-	.0040
104	-	-	-	-	-	-	-	-	-	-	-	.008	-	-	.0070
[illegible]	-	-	-	-	-	-	-	-	-	-	-	.0068	-	-	.0061
106	-	-	-	-	-	-	-	-	-	-	-	.018	-	-	.0048
107	-	-	-	-	-	-	-	-	-	-	-	.0075	-	-	.0068
108	-	-	-	-	-	-	-	-	-	-	-	.0096	-	-	.0060
109	-	-	-	-	-	-	-	-	-	-	-	.0063	.008	-	.0052
110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.0044
111	-	-	-	-	-	-	-	-	-	-	-	.0056	-	-	.0[illegible]
112	-	-	-	-	-	-	-	-	-	-	-	.0068	-	-	.0042
113	-	-	-	-	-	-	-	-	-	-	-	.018	-	-	.[illegible]5
114	-	-	-	-	-	-	-	-	-	-	-	.0098	.007	-	.0058
115	-	-	-	-	-	-	-	-	-	-	-	.011	-	-	.0029
116	-	-	-	-	-	-	-	-	-	-	-	.0148	.008	-	.0063
117	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.0047
118	-	-	-	-	-	-	-	-	-	-	-	.0085	-	-	.0033
119	-	-	-	-	-	-	-	-	-	-	-	.0035	-	-	.0029
120	-	-	-	-	-	-	-	-	-	-	-	.0068	-	-	.0036
121	-	-	-	-	-	-	-	-	-	-	-	.0051	.007	-	.0035
122	-	-	-	-	-	-	-	-	-	-	-	.0041	-	-	.0047
123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.0039
124	-	-	-	-	-	-	-	-	-	-	-	.0118	-	-	.0034
125	-	-	-	-	-	-	-	-	-	-	-	.0068	-	-	.0039
126	-	-	-	-	-	-	-	-	-	-	-	.0106	.008	-	.0036
127	-	-	-	-	-	-	-	-	-	-	-	.0037	-	-	.0032
128	-	-	-	-	-	-	-	-	-	-	-	.008	.011	-	.0040
129	-	-	-	-	-	-	-	-	-	-	-	.0073	-	-	.0018
130	-	-	-	-	-	-	-	-	-	-	-	.0052	-	-	.0044
131	-	-	-	-	-	-	-	-	-	-	-	.0084	-	-	.0016
132	-	-	-	-	-	-	-	-	-	-	-	.0078	-	-	.0011
133	-	-	-	-	-	-	-	-	-	-	-	.0055	.008	-	.0018
134	-	-	-	-	-	-	-	-	-	-	-	.0048	-	-	.0037
135	-	-	-	-	-	-	-	-	-	-	-	.0081	-	-	.0027
136	-	-	-	-	-	-	-	-	-	-	-	.011	.007	-	.0039
137	-	-	-	-	-	-	-	-	-	-	-	.0056	-	-	.0036
138	-	-	-	-	-	-	-	-	-	-	-	.0071	-	-	.0032
	-	-	-	-	-	-	-	-	-	-	-	.0073	.009	-	.0010

Values eliminated from revised mean on basis of the Chauvenet Criterion.

(1) All cases except Chi-I, 2, 3 and Cal-I received Pu^{+4} in .4 per cent $Na_2C_6H_5O_7 \cdot 2H_2O$ solution. The latter cases received PuO_2^{++}.

(2) Russell, E. R., Nichols, J. J., Argonne National Laboratory Report CR-3807 and unpublished data.

(3) Hamilton, J. G., et al, Report No. CB-3188.

CONFIDENTIAL

TABLE 7

MEANS*, REVISED MEANS, AND STANDARD DEVIATIONS OF URINARY, FECAL, AND URINARY PLUS FECAL EXCRETION OF PLUTONIUM FOLLOWING INTRAVENOUS ADMINISTRATION TO HUMAN SUBJECTS (EXPRESSED AS PER CENT OF INJECTED DOSE)

DAYS POST INJECTION	URINARY EXCRETION			FECAL EXCRETION			URINARY & FECAL EXC.
	Mean %/Day	Revised Mean %/Day	Standard Deviation	Mean %/Day	Revised Mean %/Day	Standard Deviation	Mean %/Day
1	.5178	.3628	.614	.1553	.1988	.1168	.5816
2	.1974	-	.070	.2458	-	.1230	.4252
3	.1266	-	.052	.2275	-	.0905	.3541
4	.0962	-	.041	.1842	-	.1135	.2804
5	.0652	-	.030	.1582	-	.0857	.2234
6	.0540	.5490	.026	.1096	-	.0440	.1586
7	.0501	-	.022	.0766	-	.0401	.1267
8	.0440	-	.022	.0717	-	.0412	.1157
9	.0424	.0384	.023	.0647	-	.0415	.1031
10	.0355	.0341	.018	.0538	-	.0385	.0860
11	.0350	.0319	.018	.0566	-	.0360	.0885
12	.0300	.0270	.016	.0568	-	.0351	.0838
13	.0307	.0279	.013	.0512	-	.0354	.0791
14	.0274	.0250	.014	.0453	.0386	.0201	.0636
15	.0253	-	.012	.0438	.0370	.0236	.0623
16	.0219	.0199	011	.0617	.0296	.1080	.0495
17	.0236	-	.0092	.0402	.0265	.0411	.0521
18	.0219	-	.0078	.0377	.0268	.0394	.0487
19	.0190	-	.0084	.0278	-	.0188	.0486
20	.0200	-	.0101	.0274	-	.0169	.0474
21	.0195	-	.0093	.0263	-	.0183	.0458
22	.0186	-	.0083	.0243	-	.0182	.0431
23	.0203	-	.0105	.0224	-	.0156	.0427
24	.0179	-	.0077	.0211	.0167	.0141	.0346
25	.0279	.0159	.0142	.0199	.0145	.0160	.0304
26	.0172	-	.0088	.0211	.0160	.0156	.0332
27	.0178	.0149	.0126	.0163	.0119	.0120	.0268
28	.0180	-	.0092	.0153	.0122	.0140	.0302
29	.0153	-	.0074	.0180	-	.0146	.0333
30	.0154	-	.0072	.0179	-	.069	.0333
31	.0150	-	.0086	.0191	-	.0119	.0341
32	.0128	-	.0067	.0188	-	.021	.0316
33	.0155	.0125	.0102	.0192	-	.011	.0317
34	.0125	-	.0056	.0192	-	.011	.0317
35	.0138	-	.0083	.0201	-	.012	.0339
36	.0143	-	.0056	.0151	-	.0091	.0294
37	.0114	.0091	.0062	.0183	-	.0119	.0274
38	.0138	-	.0043	.0181	-	.0121	.0319
39	0119	-	.0055	.0079	-	.0044	.0198
40	.0119	-	.0058	.0088	-	.0031	.0207
41	.0120	-	.0044	.0087	-	.0032	.0207
42	.0120	-	.0027	.0082	-	.0040	.0202
43	.0130	-	.0040	.0079	-	.0031	.0209
44	.0094	-	.0059	.0094	-	.0015	.0188
45	.0135	-	.0050	.0087	-	.0049	.0222
46	.0114	-	.0041	.0088	-	.0053	.0202
47	.0137	-	.0058	.0064	-	.0072	.0221

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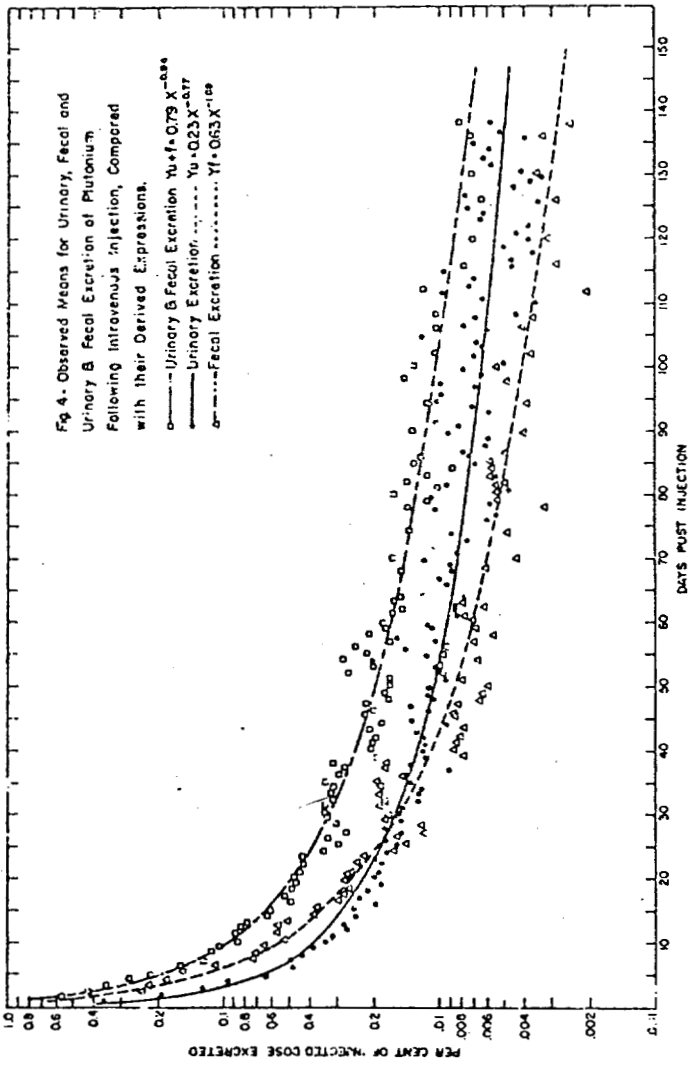
TABLE 7 (Contd)

MEANS*, REVISED MEANS, AND STANDARD DEVIATIONS OF URINARY, FECAL, AND URINARY PLUS FECAL EXCRETION OF PLUTONIUM FOLLOWING INTRAVENOUS ADMINISTRATION TO HUMAN SUBJECTS (EXPRESSED AS PER CENT OF INJECTED DOSE)

DAYS POST INJECTION	URINARY EXCRETION			FECAL EXCRETION			URINARY & FECAL EXC.
	Mean %/Day	Revised Mean %/Day	Standard Deviation	Mean %/Day	Revised Mean %/Day	Standard Deviation	Mean %/Day
43	.0108	-	.0056	.0067	-	.0016	.0175
49	.0114	-	.0062	.0064	-	.0026	.0178
50	.0113	-	.0059	.0060	-	.0028	.0173
51	.0094	-	.0032	.008	-	-	.0174
52	.0173	-	.0154	.010	-	-	.0273
53	.0104	-	.0071	.010	-	-	.0204
54	.0212	-	.0189	.0069	-	.0047	.0281
55	.0178	.0115	.0144	.010	-	-	.0215
56	.0146	-	.0149	.010	-	-	.0246
57	.0106	-	.0058	.0070	-	-	.0176
58	.0161	-	.0136	.0057	-	.0019	.0217
59	.0109	-	.010	.0070	-	-	.0176
60	.0115	-	.0074	.0070	-	-	.0185
61	.0085	-	.0029	.0080	-	-	.0165
62	.0083	-	.0021	0084	-	.0023	.0147
63	.0087	-	.0007	008	-	-	.0167
64	.0078	-	.0041	.008	-	-	.0158
68	.0089	-	.0028	.0063	-	-	.0152
70	.0120	-	.0028	.0045	-	-	.0165
74	.0090	-	.0022	.0050	-	-	.0140
78	.0107	-	.0050	.0033	-	-	.0140
79	.0059	-	.0022	.0055	-	.0007	.0114
80	.0111	-	.0110	.0055	-	.0007	.0166
81	.0048	-	.0010	.0055	-	.0007	.0103
82	.0093	-	.0061	.0051	-	.0009	.0144
83	.0055	-	.0022	.0060	-	-	.0115
84	.0028	-	.0010	.0060	-	-	.0088
85	.0070	-	-	.0060	-	-	.0130
86	.0073	-	.0036	.0050	-	-	.0123
90	.0093	-	.0071	.0042	-	-	.0133
94	.0071	-	-	.0040	-	-	.0111
98	.0101	-	.0044	.0050	-	-	.0151
100	.0079	-	.0028	.0056	-	-	.0135
102	.0070	-	.0026	.0038	-	-	.0108
106	.0081	-	.0022	.0042	-	-	.0104
108	.0066	-	.0021	.0038	-	-	.0106
112	.0101	-	.0071	.0021	-	-	.0122
116	.0047	-	-	.0029	-	-	.0076
120	.0039	-	.0023	.0032	-	-	.0071
126	.0035	-	.0010	.0030	-	-	.0065
130	.0034	-	.0028	.0037	-	-	.0071
136	.0041	-	.0022	.0034	-	-	.0075
138	.0058	-	.0042	.0025	-	-	.0083

*Cases of Russell and Nickson and Hamilton, et al used in computing means where applicable.



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chronic variable exposure dose in terms of an effective single dose given at some effective time between the limits of exposure. This interpretation was accomplished by fitting the slopes of the urinary excretion curves of these individuals to the slope of the 138 day curve in the following manner: If $Y_u = 0.23\,X^{-0.77}$ gives the per cent (Y_u) of a single dose excreted on day X, then $0.0023\,DX^{-0.77}$ is the expression for the measured activity, i.e., counts per minute, excreted on day X when the single dose (D) is expressed in the same units. If the assumption is made that a chronic variable exposure dose may be represented by a single effective dose (D_E) then the activity (Y_q) in the sample excreted q effective days after this single dose is given by the expression

$$Y_q = 0.0023\,D_E\,q^{-0.77} \qquad [3]$$

The activity (Y_{q+a}) of the sample excreted on q+a days after the single dose (there being no exposure between q and q+a) is given by the expression

$$Y_{q+a} = 0.0023\,D_E\,(q+a)^{-0.77} \qquad [4]$$

Dividing 3 by 4 and solving for q gives

$$q = \frac{a}{\left(\frac{Y_q}{Y_{q+a}}\right)^{1.30} - 1} \qquad [5]$$

q then is the effective time of exposure and its substitution in [3] gives the effective dose D_E, as follows:

$$Y_q = 0.0023\,D_E\left[\frac{a}{\left(\frac{Y_q}{Y_{q+a}}\right)^{\frac{1}{0.77}} - 1}\right]^{-0.77}$$

$$D_E = 434.8\,Y_q\left[\frac{a}{\left(\frac{Y_q}{Y_{q+a}}\right)^{1.30} - 1}\right]^{0.77} \qquad [6]$$

This expression gives an approximation of the total body burden of a person chronically exposed to plutonium. The body burden is expressed in terms of a single effective dose as determined from two urinary excretion measurements (Y_q and Y_{q+a}) taken sufficiently far apart (with no exposure between) so that the two measurements are significantly different.

The method of interpretation given above was applied to the urinary plutonium excretion data from three Los Alamos personnel and their average total plutonium body content approximated in terms of an effective dose at some effective time (q). The effective doses for W. B. G., W. A. B. and D. L. W. were estimated at 1.3 μg, 1.2 μg, and 1.0 μg respectively at respective effective times of 37, 53, and 42 days before the first urine assay used in the calculation. Assuming the above doses, all urinary excretion data (Table 8) collected from these persons were used to adjust the experimental urinary excretion curve [2] extending it to 1750 days again using least squares analysis. The adjusted expression is

$$Y_{ua} = 0.20\,X^{-0.74} \qquad [7]$$

TABLE 8

PLUTONIUM URINE ASSAYS ON LOS ALAMOS PERSONNEL AFTER REMOVAL FROM FURTHER PLUTONIUM EXPOSURE

W.B.G.			W.A.B.			D.L.W.		
Days[1]	c/m/24-hr.[2]	P.Error[3]	Days[1]	c/m/24-hr.[2]	P.Error[3]	Days[1]	c/m/24-hr.[2]	P.Error[3]
1	8.4	0.53	1	21.3	0.60	1	13.8	0.58
27	6.9	0.51	20	11.6	0.54	21	8.4	0.52
104	5.5	0.50	48	8.2	0.52	94	3.9	0.48
205	6.4	0.51	193	7.7	0.51	118	3.8	0.48
251	4.6	0.48	370	0.7	0.50	185	3.3	0.49
315	3.7	0.48	1460[4]	1.2	0.17			
387	3.8	0.48						
450	3.2	0.48						
498	2.4	0.47						
652	1.4	0.46						
707	1.8	0.47						
734	1.4	0.46						
788	0.9	0.46						
831	1.3	0.46						
847	2.1	0.47						
1022	0.9	0.46						
1044	1.9	0.47						
1167	1.3	0.46						
1203	1.1	0.46						
1294	1.3	0.47						
1322	0.8	0.46						
1348	0.8	0.46						
1378	0.7	0.46						
1448	0.7	0.46						
1574	0.3	0.45						
1638	0.6	0.46						
1698	1.1	0.46						

W.A.B. - D_E[5] = 1.2 μg
W.B.G. - D_E = 1.3 μg
D.L.W. - D_E = 1.0 μg

[1] Days after removal from further plutonium exposure.
[2] Alpha counts per minute per 24-hour urine sample at 50 per cent counting geometry.
[3] Probable error calculated from empirical formula derived specifically for the cupferron extraction procedure for determining plutonium in urine (15).
[4] Result due to H.M. Parker in private communication to N.E. Bradbury, July 7, 1948.
[5] Estimated by equation [6] Page 29.

Figure 5 shows the adjusted curve through 1750 days represented as a heavy broken line. The points representing the three sets of data collected from Hp-3 and Hp-6 beyond 138 days after injection are shown on the graph as triangles. Points originating from the urine assays of the three Los Alamos workers are shown as circles and the theoretical curve [2] through 135 days is given as a heavy solid line for comparison. The standard error of estimate for the adjusted expression is 42 per cent due largely to the poorer fit during the first few days and to the small number of observations during the later time period.

Integration of the expression $Y_{u2} = 0.20\ X^{-0.74}$ between the limits of $X = 1/2$ and $X = (n+1/2)$ gives the area (A_{ua}) under the urinary excretion curve which represents the total per cent of the injected dose of plutonium excreted in the urine up to and including the nth day after injection.

$$A_{ua} = 0.20 \int_{1/2}^{n+1/2} X^{-0.74}\, dX = \frac{0.20}{0.26}\left[(n+1/2)^{0.26} - (1/2)^{0.26}\right]$$

$$= 0.77\,(n+1/2)^{0.26} - 0.64 \qquad [8]$$

When $n = 1750$ days, A_{ua} (the total amount of plutonium excreted in the urine through 1750 days) is only 6.3 per cent of the total injected dose.

2. Fecal Excretion

The same cases used for urinary excretion studies were used for the study of fecal elimination of plutonium following intravenous administration of Pu^{+4} - citrate. Fecal samples were collected daily for the first few days. Later stools were pooled at four day intervals because of the uncertainty of obtaining representative 24-hour samples. Plutonium analyses were made on aliquots of each specimen using methods described earlier. The results of analysis of individual fecal specimens are given in Table 9. Results are expressed as per cent of the administered dose excreted per day. Fecal excretion data could be obtained for only one of the cases (Chi.-1) reported by Russell and Nickson (13). The original data were no longer available and it was necessary to read individual values from the graph given in their report. The original fecal excretion data were not available for the one case studied

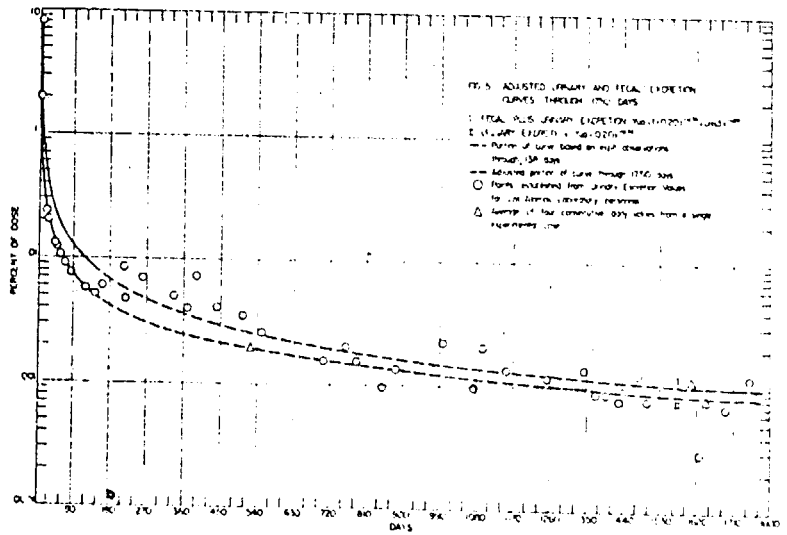

TABLE 8

INDIVIDUAL FECAL EXCRETION VALUES OF PLUTONIUM FOLLOWING INTRAVENOUS ADMINISTRATION[1] TO HUMAN SUBJECTS (EXPRESSED AS PER CENT OF DOSE EXCRETED PER DAY)

DAYS POST INJECTION	PER CENT OF INJECTED DOSE EXCRETED PER DAY											
	Hp-1	Hp-2	Hp-3	Hp-4	Hp-5	Hp-6	Hp-7	Hp-8	Hp-9	Hp-10	Hp-12	Chi-1[2]
1	.052*	.204	.015*	.134	.004*	.085	.147	.178	.333	.087	.370	.350
2	.221	.204	.157	.274	.311	.085	.120	.266	.389	.037	.370	.466
3	.241	.204	.157	.274	.311	.170	.087	.210	.389	.087	.297	.294
4	.050	.317	.095	.306	.185	.179	.080	.080	.131	.110	.297	.380
5	.105	.317	.099	.306	.110	.179	.055	.080	.131	.110	.183	.223
6	.046	-	.070	.126	.110	.179	.055	.080	.131	.110	.183	.116
7	.021	-	.070	.126	.110	.037	.055	.080	.131	.110	.020	.083
8	.021	.120	.070	.126	.064	.037	.055	.070	.131	.034	.020	.112
9	.021	.120	.070	.126	.051	.037	.032	.070	.131	.034	.020	-
10	.021	.084	.027	.117	.051	.037	.032	.070	.131	.034	.020	.021
11	.046	.084	.027	.117	.052	.023	.032	.070	.118	.034	.020	-
12	.046	.084	.027	.117	.052	.023	.032	.045	.118	.034	.020	.083
13	.046	.084	.027	.117	.032	.023	.023	.045	.118	.034	.020	.045
14	.046	.062	.023	.085	.032	.023	.023	.045	.118*	.022	.020	.044
15	.035	.062	.023	.085	.032	.015	.023	.045	.118*	.022	.023	.042
16	.035	.062	.023	.040	.017	.015	.023	.032	.414*	.022	.023	.634
17	.035	.062	.023	.040	.017	.015	.018	.032	.157*	.022	.023	-
18	.035	.055	.018	.040	.017	.015	.018	.025	.157*	.022	.023	.031
19	.015	.055	.018	.028	.017	.015	.018	.025	.055	.012	.053	.027
20	.015	.055	.018	.028	.020	.015	.018	.025	.055	.012	.053	.019
21	.015	.055	.018	.028	.020	.010	.008	.025	.055	.012	.053	.019
22	.015	.022	.006	.028	.020	.010	.008	.045	.055	.012	.053	.018
23	.017	.022	.006	.028	-	-	.008	.045	.052	.012	.026	.010
24	.017	.022	-	-	-	-	.008	.009	.052*	.012	.026	.023
25	-	.022	-	-	-	-	.011	.009	.052*	.006	.026	.018
26	-	.021	-	-	-	-	.011	.009	.052*	.006	.026	.053
27	-	.021	-	-	-	-	.011	.009	.043*	.006	.018	.0083
28	-	-	-	-	-	-	.011	.009	.043*	.006	.018	.0089
29	-	-	-	-	-	-	-	.009	.043	.006	.018	.0158
30	-	-	-	-	-	-	-	.018	.043	.006	.018	.0063
31	-	-	-	-	-	-	-	.018	.035	-	.018	.0076
32	-	-	-	-	-	-	-	.018	.035	-	.018	.0062
33	-	-	-	-	-	-	-	.018	.035	-	.018	.0079
34	-	-	-	-	-	-	-	.018	.035	-	.018	.0079
35	-	-	-	-	-	-	-	.018	.035	-	.022	.0054
36	-	-	-	-	-	-	-	.018	-	-	.022	.0054
37	-	-	-	-	-	-	-	.028	-	-	.022	.0050
38	-	-	-	-	-	-	-	.028	-	-	.022	.0042
39	-	-	-	-	-	-	-	.011	-	-	-	.0047
40	-	-	-	-	-	-	-	.011	-	-	-	.0066
41	-	-	-	-	-	-	-	.011	-	-	-	.0066
42	-	-	-	-	-	-	-	.011	-	-	-	.0053
43	-	-	-	-	-	-	-	.011	-	-	.008	.0047
44	-	-	-	-	-	-	-	.011	-	-	.008	.0092
45	-	-	-	-	-	-	-	.014	-	-	.008	.0042
46	-	-	-	-	-	-	-	.014	-	-	.008	.0033
47	-	-	-	-	-	-	-	.014	-	-	-	.0028

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TABLE 8 (Contd)

INDIVIDUAL FECAL EXCRETION VALUES OF PLUTONIUM FOLLOWING INTRAVENOUS ADMINISTRATION[1] TO HUMAN SUBJECTS (EXPRESSED AS PER CENT OF DOSE EXCRETED PER DAY)

DAYS POST INJECTION	PER CENT OF INJECTED DOSE EXCRETED PER DAY											
	Hp-1	Hp-2	Hp-3	Hp-4	Hp-5	Hp-6	Hp-7	Hp-8	Hp-9	Hp-10	Hp-12	Chi-1[2]
48	-	-	-	-	-	-	-	.008	-	-	-	.0054
49	-	-	-	-	-	-	-	.008	-	-	-	.0047
50	-	-	-	-	-	-	-	.008	-	-	-	.0040
51	-	-	-	-	-	-	-	.008	-	-	-	-
52	-	-	-	-	-	-	-	.010	-	-	-	-
53	-	-	-	-	-	-	-	.010	-	-	-	-
54	-	-	-	-	-	-	-	.010	-	-	-	.0036
55	-	-	-	-	-	-	-	.010	-	-	-	-
56	-	-	-	-	-	-	-	.010	-	-	-	-
57	-	-	-	-	-	-	-	.007	-	-	-	-
58	-	-	-	-	-	-	-	.007	-	-	-	.0043
59	-	-	-	-	-	-	-	.007	-	-	-	-
60	-	-	-	-	-	-	-	.007	-	-	-	-
61	-	-	-	-	-	-	-	.008	-	-	-	-
62	-	-	-	-	-	-	-	.008	-	-	-	.0048
63	-	-	-	-	-	-	-	.008	-	-	-	-
64	-	-	-	-	-	-	-	.008	-	-	-	-
68	-	-	-	-	-	-	-	-	-	-	-	.0063
70	-	-	-	-	-	-	-	-	-	-	-	.0045
74	-	-	-	-	-	-	-	-	-	-	-	.0050
78	-	-	-	-	-	-	-	-	-	-	-	.0033
79	-	-	-	.006	-	-	.005	-	-	-	-	-
80	-	-	-	.006	-	-	.005	-	-	-	-	-
81	-	-	-	.006	-	-	.005	-	-	-	-	-
82	-	-	-	.006	-	-	.005	-	-	-	-	.0042
83	-	-	-	-	-	-	.006	-	-	-	-	-
84	-	-	-	-	-	-	.006	-	-	-	-	-
85	-	-	-	-	-	-	.006	-	-	-	-	-
88	-	-	-	-	-	-	-	-	-	-	-	.0050
90	-	-	-	-	-	-	-	-	-	-	-	.0042
94	-	-	-	-	-	-	-	-	-	-	-	.0040
98	-	-	-	-	-	-	-	-	-	-	-	.0050
100	-	-	-	-	-	-	-	-	-	-	-	.0056
102	-	-	-	-	-	-	-	-	-	-	-	.0038
106	-	-	-	-	-	-	-	-	-	-	-	.0043
108	-	-	-	-	-	-	-	-	-	-	-	.0038
112	-	-	-	-	-	-	-	-	-	-	-	.0021
116	-	-	-	-	-	-	-	-	-	-	-	.0029
120	-	-	-	-	-	-	-	-	-	-	-	.0032
126	-	-	-	-	-	-	-	-	-	-	-	.0030
130	-	-	-	-	-	-	-	-	-	-	-	.0037
136	-	-	-	-	-	-	-	-	-	-	-	.0034
138	-	-	-	-	-	-	-	-	-	-	-	.0025

*Values eliminated from revised mean on basis of the Chauvenet Criterion.

[1]All cases except Chi-1 received Pu^{+4} in 0.4 per cent $Na_3C_6H_5O_7 \cdot 2d_2O$ Solution.

[2]Russell, E.R., Nickson, J.J., Argonne National Laboratory Report CH-3607.

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by Hamilton and co-workers (14) and it was not feasible to include their results. The present report of the fecal elimination of plutonium is, therefore, confined to twelve cases.

The means, revised means, and standard deviations for the daily fecal excretion of plutonium from 0 to 138 days post injection are given in Table 7 (Page 26). The best curve of fit for the observed means was established by the method of least squares and was found to be:

$$Y_f = 0.63\,X^{-1.09} \qquad [9]$$

with a standard error of estimate of 28 per cent. In the above expression Y_f is the amount of plutonium excreted in the feces on a specific day (expressed as per cent of the injected dose) and X is the day of measurement in days after injection. The agreement between the observed values and the derived expression is shown graphically in Fig. 4 (Page 28). In this figure the derived expression is represented by a heavy broken line and the observed points are represented as open triangles. The fecal excretion of plutonium in per cent of the injected dose excreted per day is plotted against time in days.

No representative fecal excretion data beyond 138 days were available from Los Alamos personnel because of small but significant contamination of feces from swallowed material removed from the lungs of the workers by ciliary action. One may ask why the small amount of lung contamination does not prevent the use of the urinary excretion results from these workers to adjust the 138 day urinary excretion curve to 1750 days. This material does not reach the absorbing area of the lung and is not absorbed appreciably from the gastrointestinal tract (probably less than 0.01 per cent). The small amount of material which has reached the alveoli is being absorbed into the blood at an infinitesimal rate. Of the amount absorbed only a fraction of a per cent contributes to the daily urinary excretion.

Studies of the excretion of plutonium by mice, rats, rabbits and dogs (1), (2), (18), (19) showed the urinary excretion of all species was quite uniform. The plutonium excretion in the urine thirty to fifty days after injection was 0.01 - 0.02 per cent of the administered dose per day. The urinary/fecal excretion ratio varied widely, however, for the various species. The ratio was 1/10 - 15 for the rat and only 1/2 - 3 for the dog.

Russell and Nickson (13) reported a plutonium urinary/fecal excretion ratio of 3/1 in man based on the observation of one case through 140 days. The California group (14) reported an excretion ratio of 3-4/1 by one subject followed for 341 days.

The adjusted urinary excretion curve for 0 to 1750 days and the fecal excretion curve for 0 to 138 days may be solved for the urinary to fecal excretion ratio:

$$\frac{Y_{ua}}{Y_f} = \frac{0.20\,X^{-0.74}}{0.63\,X^{-1.09}} = 0.32\,X^{0.35} \qquad [10]$$

The urinary/fecal ratio is 1 8/1 at 138 days post injection and 4.4/1 at 1750 days when calculated from the above expression. Unfortunately no applicable fecal excretion data are available from the Los Alamos personnel to permit adjustment of the expression for fecal excretion beyond 138 days. If the urinary/fecal ratios at 138 and 1750 days are calculated from the unadjusted expressions (Y_u and Y_f) for both urinary and fecal excretion, the values are 1.7/1 and 3.9/1 respectively. Although extrapolation beyond 138 days is subject to increasing uncertainty with increasing values of X, the above values lead to the conclusion that the urinary/fecal plutonium excretion ratio is not constant, over the range (0-138 days) measured, but approaches 4/1 as a limit at some later time. The results obtained by Hamilton (14) on the case followed for 341 days seem to support the above conclusion.

The expression $Y_f = 0.63\,X^{-1.09}$ gives the amount of plutonium (expressed as per cent of injected dose) excreted in the feces on a particular day (X) after injection. Integration of the expression between the limits of X = 1/2 and X = n+1/2 gives the total per cent (A_f)

of the injected dose excreted through day n:

$$A_f = .63 \int_{1/2}^{n+1/2} X^{-1.09}\,dX = -7.00\left[(n+1/2)^{-0.09} - (1/2)^{-0.09}\right]$$
$$= -7.00\,(n+1/2)^{-0.09} + 7.45 \qquad [11]$$

From the above expression A_f = 2.86 per cent through the first 138 days.

3. Total Excretion (Urine plus Feces)

From the practical point of view the total urinary plus fecal excretion rate of plutonium is extremely important. The summed elimination rate determines how long a worker should avoid further exposure to plutonium after having reached an accepted maximum permissible body level.

The observed mean urinary plus fecal plutonium excretion values are given in Table 7 (Page 26). Results are expressed as per cent of injected dose excreted per day. The means were obtained from the individual urinary excretion data from fifteen cases and the individual fecal excretion data from eleven. The results reported by the Chicago and California groups were used when available and applicable.

Application of the method of least squares gives the expression

$$Y_{u+f} = 0.79\,X^{-0.94} \qquad [12]$$

as the best curve of fit for the urinary plus fecal excretion data for 0 to 138 days. The standard error of estimate of the computation is 17 per cent. Y_{u+f} is the total plutonium excreted in feces plus urine on a particular day (expressed as per cent of injected dose) and X is the time after injection in days.

The observed means and derived expressions are compared graphically in Fig. 4 (Page 28). Observed values are represented by squares and the derived expression by the heavy broken line designated Y_{u+f}.

The expression $Y_{u+f} = 0.79\,X^{-0.94}$ represents the total excretion of plutonium only through the 138th day. Adjustment can be made, however, for urinary excretion measurements through 1750 days by summing the expression for fecal elimination [9] and the adjusted expression for urinary excretion [7].

$$Y_{ua+f} = Y_{ua} + Y_f = 0.20\,X^{-0.74} + 0.63\,X^{-1.09} \qquad [13]$$

This equation is adjusted to include all urinary excretion results from Los Alamos Laboratory personnel through 1750 days, and gives the total per cent of an injected dose of plutonium which may be excreted on a given day (X) after the time of injection.

The adjusted expression for total elimination rate (Y_{ua+f}) through approximately five years and the observed means are presented graphically in Fig. 5 (Page 31) for comparison with the adjusted urinary excretion rate (Y_{ua}) for the same time interval.

Integration of the adjusted expression for total elimination rate between X = 1/2 and X = n+1/2 days, gives the total amount of plutonium expected to be excreted up to and including day n

$$A_{ua+f} = 0.20 \int_{1/2}^{n+1/2} X^{-0.74}\,dX + .63 \int_{1/2}^{n+1/2} X^{-1.09}\,dX$$
$$= 0.77\,(n+1/2)^{0.26} - 7.00\,(n+1/2)^{-0.09} + 6.81 \qquad [14]$$

Table 10 compares the observed and calculated values of total plutonium excretion for various time intervals using the integrated expression [14] .

These results emphasize the relatively slow rate of elimination of systemically deposited plutonium by man. According to these data only 8.7 per cent of a single injected dose is excreted in 1750 days (approximately 5 years).

TABLE 10

OBSERVED AND DERIVED TOTAL URINARY PLUS FECAL PLUTONIUM EXCRETION VALUES FOR VARIOUS TIMES AFTER ADMINISTRATION OF A SINGLE DOSE OF PLUTONIUM TO MAN

TIME AFTER INJECTION	PER CENT OF INJECTED DOSE	
	Observed	Calculated *
10 days	2.43	2.56
20 days	3.06	3.17
30 days	3.41	3.53
40 days	3.70	3.81
50 days	3.90	4.03
60 days	4.11	4.21
70 days	4.27	4.38
80 days	4.42	4.50
90 days	4.54	4.62
100 days	4.67	4.74
120 days	4.87	4.93
140 days	5.01	5.10
1 year		6.26
2 years		7.22
3 years		7.83
4 years		8.30
5 years		8.68
10 years		9.96
20 years		12.17

* Calculated from the integrated expression for adjusted urinary plus fecal excretion [14] . The calculated values appear higher than the observed values by a constant amount because of the decision to accept a poor curve fit during the first ten days (See Page 23).

IV. DISCUSSION

A. Distribution of Plutonium in Tissues and Organs of Man

Table 3 (Page 18) contains all available data (up to the time of this report) on the distribution of plutonium in the tissues and organs of man. These data were the results of analysis of a miscellaneous group of samples collected from seven human subjects. The subjects were elderly persons or persons suffering from an incurable chronic disease. The samples were often small and poorly representative and not obtained from the seven cases at comparable times after injection of the plutonium. These unavoidable difficulties must be recognized and accepted when considering the results. Despite the above difficulties, the data are extremely valuable as a supplement to a much greater and more reliable mass of data

concerning the distribution of plutonium in the tissues and organs of laboratory animals. The data on man are in good agreement with results of similar studies in rats, mice, rabbits, and dogs. The good agreement permits the conclusion that there are no major differences in the quantitative distribution of plutonium in the tissues and organs of man and those of common laboratory animals with perhaps one exception - the liver. The results indicate that the retention of plutonium in the liver following its intravenous injection as Pu^{+4} - citrate complex and as plutonyl ion may be 20 - 40 per cent for man as compared to 10 per cent or less for rats. The "biological half-time" of plutonium in the liver of man is probably much greater than that for rats.

The average amount of plutonium found in vertebra, sternum and rib was 0.0068 per cent of the injected dose per gram of whole bone. Assuming vertebra, sternum and rib as representative of the entire skeleton, 66 per cent of the injected dose would be deposited in a 10 kg skeletal system (7 kg of bone, 3 kg of marrow) of a 70 kg man.

The observed concentration of plutonium in bone may be used to estimate the radiation dose received per gram of skeletal system when a "standard man" has accumulated the official maximum permissible plutonium body content of 0.5 μg (0.032 μc). Using the dosage rate formula: rep/day = 54 CE (where C = concentration of radioisotope in μc/g, E = energy of the radiation in Mev, and the rep = 93 ergs/g), the radiation dosage received per gram of skeleton from 0.032 μc of plutonium is as follows:

$$\text{rep/day} = 54 \times 6.6 \times 10^{-5} \times 0.032\ \mu c \times 5.15\ \text{Mev} = .00057$$

A similar calculation for the official maximum permissible radium content of 0.1 μc may be made for comparison. If 50 per cent of the radon from radium decay is retained in the body, then approximately 15 Mev of energy will be released in the body by the alpha particles per decay. If 100 per cent of the radium is deposited in a 10 kg skeletal system, then the radiation dosage in rep per day is given as follows:

$$\text{rep/day} = 54 \times 1 \times 10^{-5} \times 15 = 0.0081$$

According to the above calculation, the radiation dosage per gram of skeleton delivered by 0.1 μg of radium would be 14 times that delivered by the maximum permissible dose of plutonium if the two materials were distributed in a comparable manner in the skeleton. Autoradiographic studies show conclusively, however, that radium and plutonium do not distribute in a comparable manner. Plutonium is more localized and concentrates in the endosteal and periosteal surfaces. The choice of a more conservative body tolerance dose for plutonium was made to allow for its more specific localization in the skeletal system. It should be noted, however, that radium does not distribute uniformly throughout bone and Evans (20) has reported that analyses of bone samples from radium cases showed the radium to be unevenly distributed by as much as a factor of 10. It may be necessary, therefore, for plutonium to be concentrated by a factor of 140 over radium in order that 0.5 μg will give radiation intensities comparable to that which may occur with 0.1 μg of radium. Evans (21) has also pointed out that the presence of mesothorium in the radium responsible for the early radium poisoning cases may account for an additional safety factor of 5 in the 0.1 μg radium tolerance.

The above discussion supports the possibility that the 0.5 μg maximum permissible tolerance dose for plutonium is extremely conservative.

B. "Biological Half-Time" of Plutonium in Man

The "biological half-time" of plutonium in man can be estimated from the excretion data presented in this report. Although the adjusted urinary plus fecal excretion curve is (empirically at least) logarithmic in nature, it appears that the curve approaches an exponential for longer times. Such an exponential curve would be in keeping with the assumption that

metabolic processes are primarily first order reactions. Whatever the true process is, from the data and curves given in this report, it is possible to calculate the absolute minimum half-time of plutonium in the body. It is assumed (not unreasonably) that the excretion of the plutonium measured in terms of the amount in the body at a given time does not increase at some time. If one takes the last point on the combined urinary plus fecal excretion curve (a single value of the ordinate in Fig. 5) and assumes exponential excretion thereafter, an absolute minimum value is obtained for the biological half-time. On this figure, which is a plot of $\Delta C / C_0$ versus Δt exponential excretion would be represented by a straight line with zero slope. Examination of the adjusted curve shows that $0.001 \pm .00035$ per cent per day is excreted at 1750 days (approximately 5 years) after exposure. Up to five years 8.7 per cent of the total has been excreted. The time required to excrete an additional 41.3 per cent (assuming exponential excretion beyond 1750 days) is

$$\frac{41.3}{0.001 \pm 0.00035} = 41{,}300 \text{ days} = 113 \text{ years with limits of 84 and 175 years.}$$

Thus, the mean minimal biological half-time estimate is 118 years. From the above, one may conclude that the excretion coefficient is too small to be of any practical significance in elevating the maximum permissible dose of plutonium or in permitting the return to work of an individual who has reached the maximum permissible body burden. Once a worker is retired from work with plutonium because of a maximum tolerance exposure, it must be assumed that he is retired from such work for the balance of his lifetime.

C. Determination of Plutonium Body Burden from Urinary Excretion

In the determination of exposure doses by the use of excretion data, one is primarily concerned with three different situations. First is the case of a single acute exposure dose occurring at a known time. Second is the case of a variable chronic or subacute dose with only the total exposure time being known. Third is the case of a chronic invariant (usually low level) exposure dose with the time limits known.

The evaluation of the single acute exposure dose occurring at a known time is the basis of this paper. A urinary excretion curve through 138 days after a single acute exposure is given in Fig. 4 (Page 28). This curve has been extended beyond the observation limit to 1750 days (Fig. 5) by applying data collected on exposed personnel from the Los Alamos Laboratory. The method used to apply these data was explained earlier (Pages 23 and 28). It is worth noting that the difference between the adjusted curve and the extrapolated 138-day curve at 1750 days is less than the standard error of estimate of the former. This finding allows more confidence in further extrapolation beyond 1750 days post exposure. The calculation of the body burden from a single acute exposure is simple.

Since

$$Y_{ua}(\%) = 0.20\, X^{-0.74}$$

$$Y(c/m) = 0.0020\, D_E\, X^{-0.74}$$

Then

$$D_E = 500\, Y(c/m)\, X^{0.74} \qquad [15]$$

Thus, a single urine count, Y, made X days after an unknown single acute exposure, D_E, determines D_E in counts per minute. The exposure dose in μc or μg is easily determined if the counting geometry, etc., is known.

In the Los Alamos exposures, we have an illustration of the variable chronic exposure case with known time of exposure. Only under conditions of stress when safety factors of design may be exceeded will this type of exposure be seen. There are three methods of

estimating the total exposure *per se* under such conditions. Past practice at the Los Alamos Laboratory was to assume that an individual contracted his total exposure dose on the last day of the exposure period. His total body burden was then determined by substitution in the urinary excretion formula as shown above. In this case, zero time is the last day of exposure. Obviously this method gives too low a value for the exposure dose as the estimated dose is directly proportional to time. A second method which has been used is exactly the same as the previous one except that zero time is taken as the first day of exposure which assumes that all of the dose was accumulated on exposure day one. It is evident that this estimate of total exposure is too high. The third method, which was used in this paper to determine the adjusted urinary excretion curve, is believed to more closely approximate the true situation. In this method it has been assumed that the total exposure dose may be represented by a single effective dose occurring at some effective time intermediate to the limits of exposure. The equations and steps to be followed with this method are shown on Pages 23 and 29. Ordinarily the first urine count is used to determine whether an individual should or should not be withdrawn from exposure. It is not used as one of the two significantly different dose determining counts. This is due to the fact that the initial withdrawal count may reflect the high urinary excretion resulting from the previous ten days exposure, and to the relatively high per cent excretion during the first 10 days post-exposure period. The high rate of elimination resulting therefrom may relatively obscure any exposure doses accumulated previous to that time.

The case of chronic invariant exposure is probably of primary interest. This is the type of exposure (within limits) that occurs in processing procedures in the plutonium industry in which air concentrations, etc., are rigidly controlled and the work is routine. An analysis of the general case is presented as follows:

If m = time of exposure in days, and

n = days from the beginning of an exposure to the time a urine analysis is made with n > m (preferably by more than 10 days)

then the counts per minute in the urine excreted on day n is:

$$Y_n = 0.0020 \left[D_1 n^{-0.74} + D_2 (n-1)^{-0.74} + D_3 (n-2)^{-0.74} + \ldots + D_m \left[n-(m-1) \right]^{-0.74} \right]$$

where D_1 is the exposure dose in counts per minute on exposure day 1,

D_2 is the exposure dose in counts per minute on exposure day 2,

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D_m is the exposure dose in counts per minute on exposure day m.

Considering the case in which we are interested, namely, $D_1 = D_2 \ldots = D_m = D_j$ (the constant daily exposure dose), then

$$Y_n = 0.002 D_j \left[n^{-0.74} + (n-1)^{-0.74} + \ldots + \left[n-(m-2) \right]^{-0.74} + \left[n-(m-1) \right]^{-0.74} \right]$$

Thus

$$D_j = \frac{Y_n}{0.0020 \left[n^{-0.74} + (n-1)^{-0.74} + \ldots + \left[n-(m-2) \right]^{-0.74} + \left[n-(m-1) \right]^{-0.74} \right]}$$

Considering the bracketed term in the denominator:

$$n^{-0.74} + (n-1)^{-0.74} + \ldots + \left[n-(m-1) \right]^{-0.74} =$$

$$(n-m+1)^{-0.74} + (n-m+2)^{-0.74} + \ldots + n^{-0.74}$$

This term is similar to the infinite series r^{-1} where r has the limiting values $(n-m+1)$ and (n) and t = -0.74. The sum of the series $r^{-0.74}$ may be written:

$$\sum_{r=1}^{r=R} \frac{1}{r^{-0.74}} = \frac{1}{1^{0.74}} + \frac{1}{2^{0.74}} + \frac{1}{3^{0.74}} + \cdots + \frac{1}{R^{0.74}}$$

Thus we may write:

$$(n-m+1)^{-0.74} + (n-m+2)^{-0.74} + \cdots + n^{-0.74} = \sum_{r=(n-m+1)}^{r=n} \frac{1}{r^{0.74}}$$

$$= \sum_{r=1}^{r=n} \frac{1}{r^{0.74}} - \sum_{r=1}^{r=(n-m)} \frac{1}{r^{0.74}} = \sigma(n) - \sigma(n-m)$$

and on substitution

$$D_j = \frac{Y_n}{0.002\left[\sigma(n) - \sigma(n-m)\right]}$$

The following empirical formula* is good to 2 parts in 50 for r = 1 and to better than 1 part in 1000 for r > 5:

$$\sigma(r) = 3.8462\,(r+1/2)^{0.26} - 3.2880 \qquad [16]$$

Thus, on substitution we have:

$$D_j = \frac{Y_n}{0.002\left[3.8462(n+1/2)^{0.26} - 3.8462(n-m+1/2)^{0.26}\right]}$$

or

$$D_j = \frac{130\,Y_n}{\left[(n+1/2)^{0.26} - (n-m+1/2)^{0.26}\right]}$$

Since the total exposure dose = $mD_j = T_{D_m}$

$$T_{D_m} = \frac{130\,mY_n}{\left[(n+1/2)^{0.26} - (n-m+1/2)^{0.26}\right]} \qquad [17]$$

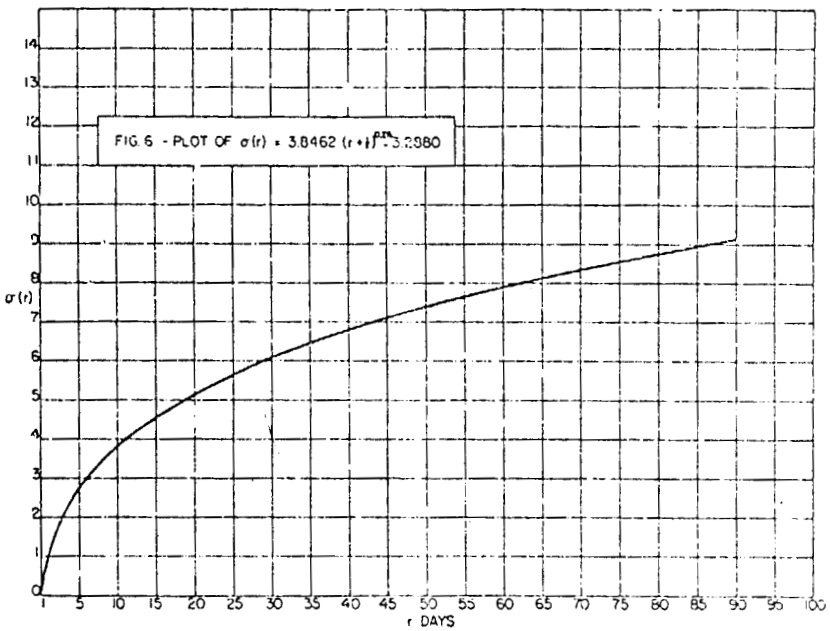
In addition to the empirical formula for $\sigma(r)$ a plot of the real values of $\sigma(r)$ versus (r) for values of r up to 90 days has been included (Fig. 6) from which the values of the sums may be read directly.

In the equation for T_{D_m} seven exposure days per week are assumed. The formula for T_{D_m} may be adjusted for six exposure days per week as follows:

We assume that exposure begins on the first working day of a week for simplicity.

Obviously the only days not contributing to exposure are those on which $D_j = 0$. In the six day week, therefore, $D_7 = D_{14} = D_{21} = \cdots = D_{7a} = 0$ where a = number of weeks worked by the subject. Thus, the terms corresponding to D_7, D_{14}, D_{21} ..... etc., must be subtracted from the dose equation.

*Determined by Bengt Carlson of the Los Alamos Theoretical Division.



Hence:

$$D_j = \frac{Y_n}{0.002\left\{\left[\sigma(n) - \sigma(n-m)\right] - \left[(n-6)^{-0.74} + (n-13)^{-0.74} + (n-20)^{-0.74} + \cdots + (n-7a+1)^{-0.74}\right]\right\}}$$

And designating the total exposure dose for the six day week as $T_{D_{m_6}}$ then

$$T_{D_{m_6}} = \frac{500\,mY_n}{3.8462\left[(n+1/2)^{0.26} - (n-m+1/2)^{0.26}\right] - \left[(n-5)^{-0.74} + (n-13)^{-0.74} + (n-20)^{-0.74} + \cdots + (n-7a+1)^{-0.74}\right]} \qquad [18]$$

Similarly for 5 exposure days per week

$$D_6 = D_7 = D_{13} = D_{14} = D_{20} = D_{21} = \cdots = D_{7a-1} = D_{7a} = 0$$

the total exposure dose $T_{D_{m_5}}$ =

$$\frac{500\ mY_n}{3.8462\left[(n+1/2)^{0.26}-(n-m+1/2)^{0.26}\right]-\left[(n-5)^{-0.74}+(n-6)^{-0.74}+(n-12)^{-0.74}+(n-13)^{-0.74}+\ldots\right.}$$

$$\left.\ldots+(n-7a+2)^{-0.74}+(n-7a+1)^{-0.74}\right]$$

In the preceding formulae exposure conditions were assumed to consist of an equal and constant daily exposure dose D_1 equivalent to a single injected dose. Also, the constants 0.0020 and -0.74 were empirically established on the basis of data available at the time of this report. These values may change as more data become available.

A specific example of the application of the above dosage calculation is given below, using the expression for seven exposure days per week. In fact, the seven day exposure formula may be valid for either the five or six day week. Such would be the case if one considers that absorption from the lung is the primary source of contamination and that the equilibrium between the alveolar and blood plutonium concentration is not radically altered by the one or two day period of no exposure each week.

For purposes of presenting a specific example we may assume the following conditions:

Duration of exposure (m) = 330 days
Duration of time from beginning of exposure until urine sample taken (n) = 360 days
Counts per minute of urine sample (Y_n) = 2 c/m
The total body dose T_{D_m} may be calculated from the formula:

$$T_{D_m} = \frac{130 \times m \times Y_n}{\left[(n-1/2)^{0.26}-(n-m-1/2)^{0.26}\right]}$$

On substitution:

$$T_{D_m} = \frac{130 \times 330 \times 2}{\left[(360.5)^{0.26}-(30.5)^{0.26}\right]} = \frac{8.58 \times 10^4}{2.19} = 3.9 \times 10^4\ c/m$$

Assuming a 50 per cent counting geometry was used (1 μg = 7×10^4 c/m)

$$T_{D_m} = 0.56\ \mu g$$

V. SUMMARY

The distribution and excretion of plutonium administered intravenously to man has been studied. The data from twelve subjects have been correlated with similar data collected by other investigators, making a total of sixteen cases considered. The data have been supplemented further with observations made on three Los Alamos Laboratory personnel who absorbed measurable amounts of plutonium in the course of their work. The results of these studies may be summarized as follows:

1. Clinical observations and clinical data collected on the various subjects indicate that the intravenous injection of a single dose of 5 to 100 μg of plutonium is without acute subjective or objective clinical effects.
2. The analysis of tissues following the intravenous injection of plutonium showed that there was little difference in the mode of deposition of plutonium in man

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and in the common laboratory animals. As in the case of rats and other laboratory animals the skeletal system was the major site of plutonium deposition. Retention of plutonium by the liver of man seemed to be higher and the "biological half-time" in liver longer than for the more common laboratory animals.

3. Concentration of plutonium in the blood following intravenous injection drops very rapidly; only 0.3 per cent of the total injected dose was fixed in the total blood volume thirty days after injection.
4. The urinary excretion of intravenously administered plutonium was not exponential. Curvilinear regression line fitting showed that the urinary excretion through 138 days was best expressed by the fractional logarithmic function

$$Y_u = 0.23\ X^{-0.77}$$

In this expression Y_u is the per cent of the injected dose excreted in a single day and X is the time of observation in days post-injection. The standard error of estimate is 32%.

5. The above expression for the urinary excretion through 138 days was adjusted by including data collected on Los Alamos Laboratory personnel. This adjustment permitted the development of an expression for the urinary excretion of plutonium through 1750 days. The adjusted expression is:

$$Y_{ua} = 0.20\ X^{-0.74}$$

The standard error of estimate of the adjusted expression is 42 per cent.

6. The excretion of plutonium in the feces likewise was not exponential. Application of the method of least squares showed the best curve of fit for the fecal excretion of plutonium through 138 days was:

$$Y_f = 0.63\ X^{-1.09}$$

In this expression Y_f is the per cent of the injected dose excreted on a specific day and X is the time of measurement in days post-injection. The standard error of estimate of the above expression is 28 per cent.

7. The urinary to fecal plutonium excretion ratio obtained by solution of the above expressions for urinary and fecal excretion showed the urinary to fecal ratio was not constant. It was essentially 1:1 at 30 days and approached 4:1 at approximately five years.
8. The total (urine and fecal excretion) through 156 days was best expressed by the equation:

$$Y_{u+f} = 0.79\ X^{-0.94}$$

9. The total urine plus fecal excretion through 1750 days could be approximated by adding the expression for the fecal excretion through 138 days and the adjusted expression for the urinary excretion through 1750 days. The expression for the combined excretion is:

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$$Y_{ua+f} = 0.20\,X^{-0.74} + 0.63\,X^{-1.09}$$

in which Y_{ua+f} represents the per cent of the injected dose excreted in the urine plus feces on a specific day, and X designates the time of observation in days post-injection.

10. Integration of the above expression between the limits of 1/2 and n+1/2 days post-injection gives the following expression:

$$A_{ua+f} = 0.77\,(n+1/2)^{0.26} - 7.00\,(n+1/2)^{0.09} + 6.81$$

which represents the integrated amount of plutonium in per cent of the injected dose (A_{ua+f}) excreted up to and including the nth day after injection. Substitution in this expression showed that only 8.7 per cent of a single injected dose was excreted in approximately five years.

11. Application of the data of this report to the calculation of the "biological half-time" of plutonium in man gives a mean minimal "biological half-time" estimate of 118 years, with a variation of from 84 to 175 years.

12. The urinary excretion data of this report were applied to the diagnosis of exposure of personnel to plutonium. Three sets of exposure conditions were considered:

    (a) The application of plutonium urine analysis to estimate the total body dose following a single acute exposure occurring at a known time,

    (b) The application of plutonium urine analysis to estimate the total body burden of plutonium following variable chronic or sub-acute exposure with only the total exposure time being known and,

    (c) The application of urine analysis to estimate the total body burden following chronic invariant exposure (such as may occur in a carefully controlled routine plant process) with time of exposure known.

    Expressions for the calculation of body dose under the conditions set forth in (a), (b) and (c) are included in this report.

REFERENCES

(1) Hamilton, J. G., Metallurgical Project Report 2383.

(2) Langham, W., et al, LA-549, J. Biol. Chem., 171, 273 (1947).

(3) (a) Finkle, R. D., et al, Metallurgical Project Report CN-3167; (b) Snyder, R. H., et al, Metallurgical Project Report CH-3763; (c) Painter, E. E., et al, Metallurgical Project Report CH-3858.

(4) Bloom, Wm., et al, Metallurgical Project Report CN-2212.

(5) Hamilton, J. G., Radiology 49, 325 (1947); New England J. Med., 240, 863 (1949).

(6) Copp, H. D., Axelrod, D. J. and Hamilton, J. G., Am. J. Roentgenol, 48, 10 (1947).

(7) Carter, R. E., Langham, W. H., unpublished studies, Los Alamos Sci Lab.

(8) Brues, A. M., Lisco, Hermann, Finkel, Miriam, USAEC Report MDDC-145; ibid, Radiology 49, 361 (1947).

(9) Carter, R. E., Langham, W.H., unpublished studies for Los Alamos Sci. Lab.

(10) Brues, A. M., Private Communication to W. Langham, Jan. 25, 1950.

(11) Warren, Shields, Communication to Carroll L. Tyler, Mar. 13, 1950.

(12) Langham, W. H., Metallurgical Project Report CN-3167.

(13) Russell, E. R., and Nickson, J. J., Argonne Ntl. Lab. Report CH-3607.

(14) Hamilton, J. G., Argonne Ntl. Lab. Report CH-3589.

(15) Langham, W. H., USAEC Report MDDC-1555.

(16) Maxwell, E., Fryxell, R., Langham, W. H., J. Biol. Chem. 172, 185 (1948).

(17) Lisco, Hermann, "Project Standard Man", Communication to AEC, July 21, 1947.

(18) Finkle, R. D., Jacobson, L. D., et al, Report No. CH-3783.

(19) Russell, E. R., Report No. CN-3167.

(20) Evans, R. D., Private Communication to W. Langham, Jan. 13, 1950.

(21) Evans, R. D., Private Communication to K. Z. Morgan, Feb. 4, 1950.

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Bob
Dear Dr. Thomas:

With respect to your telephone inquiry relating to plutonium studies in the Environmental Health Section (previously Center for Human Radiobiology), I refer you back to the factsheet furnished Dr. Thiessen in 1984 (copy enclosed).

I had follow-up completed on cases Cal-III and HP-6. Case Cal-III died in 1984 of causes not reasonably relatable to plutonium. Case HP-6 is living as of several days ago. Both the interviewer who contacted the household, and a review of the case file, suggest that the functioning of this subject is such that direct contact is contraindicated. I hope this is of some assistance to you.

Best personal wishes.

Sincerely yours,

James H. Stebbings, Sc. D.
Epidemiology Group Leader

JHS:llf

Enclosures

cc w/enc.: H. Drucker, BIM
E. Huberman, BIM
D. T. Goldman, DOE-CH

8001399

40-012

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439
Telephone 312/972-4146

July 23, 1984

Dr. Jacob Thiessen
Mailstop E-201, Human Health Studies
Office of Health and Environmental Research
Office of the Environment
U.S. Department of Energy
Washington, D. C. 20545

SUBJECT: Congressional Investigation into Health and Safety Policies of the Department of Energy (DOE)

Dear Dr. Thiessen:

In response to Dr. C. W. Edington's memorandum of June 27, 1984, on the above subject, I have enclosed a factsheet on "Plutonium Studies at the Center for Human Radiobiology (CHR)." The factsheet is in the format requested by Dr. Edington.

Please let me know if you need more information or documentation.

Sincerely yours,

A. F. Stehney
Environmental Research Division

AFS:pat
Enclosures

cc: H. Drucker
H. J. Rauch
P. Failla
P. F. Gustafson
E. Huberman
J. Rundo

Project Name:
Plutonium Studies at the Center for Human Radiobiology (CHR)

Date Started: 2 January 1973
Date Terminated: Ongoing

Principal Investigators: R. E. Rowland, A. F. Stehney

Objectives of Test:

1. To determine the excretion rate of plutonium 27 years after injection.
2. To determine the retention and body distribution of plutonium.

Short Description:

In 1945-1947, 18 hospital patients of limited life expectancy were injected with plutonium in order to obtain information about the retention and organ distribution of plutonium. An important objective was to determine the relationship between the body content and the rate of excretion in order to provide data for estimating the body content of plutonium from measurements of plutonium in excreta (bioassay). The results of this study were described in Report LA-1151 (1950).[1]

The data in LA-1151 were reviewed in a manuscript prepared by P. W. Durbin for publication in the 1972 volume, Radiobiology of Plutonium.[2] Tissue and bone samples had been obtained at autopsy from six of the cases at times ranging from 5 days to 456 days after injection, and the longest collection time for excreta was about 5 years. In addition to preparing the manuscript, Durbin traced the later history of the cases and discovered that four were still living in 1972.

The Center's direct knowledge of the plutonium injection cases dates from December 13, 1972, when Dr. Durbin brought her records to CHR for possible further follow-up. The Center then undertook to determine excretion rates in study subjects who were still alive and to exhume deceased subjects in order to determine the amounts and body distribution of plutonium. During 1973, CHR obtained metabolism samples from three living patients, obtained permission to exhume from next of kin of three deceased patients, and disinterred and transferred to CHR the remains of one of these deceased. The metabolism samples (blood and excreta) were taken at Strong Memorial Hospital (SMH), Rochester, New York.

In 1974, the U.S. Atomic Energy Commission (AEC) reviewed the origins and subsequent follow-up of the plutonium studies. On December 31, 1974, the AEC authorized CHR to proceed with the program of study of the living patients who were injected with plutonium during 1945-1947 and of the bodies of deceased individuals from that group for whom legal consent for examination is obtained.

Follow-up Data:

Table 1 summarizes CHR follow-up activities and last known status (July 5, 1984) for each of the plutonium injection cases.

CHR personnel have published 10 reports on results obtained by study of these cases.[3-12] Copies of these reports are attached.

Table 1. Plutonium injection cases: Summary of CHR activities and last known status (July 5, 1984).

Old Case Number	CHR Case Number	CHR Activities	Status
Cal-I	40-001	10/16/75: Exhumed cremains Aug 78: Returned	Died 1/9/66
Cal-II	40-002	No contacts; said to have died in Australia	Died 1/6/47
Cal-III	40-003	6/11/73: Examined at CHR 6/23-26/77: Metabolism study at SMH	Living 10/19/83
Chi-1	40-004	6/10/75: Exhumed Apr 78: Returned	Died 10/3/45
Chi-2	40-005	No contacts; cremation ashes scattered	Died 1/13/46
Chi-3	40-006	No contacts; case unidentified	Lost to study, 1946
HP-1	40-007	1973: Next of kin refused permission to exhume	Died 1/12/60
HP-2	40-008	1973: Next of kin refused permission to exhume	Died 4/4/48
HP-3	40-009	1/28-2/18/73: Metabolism study and radioactivity measurement at SMH 1/23-24/79: Metabolism study at SMH	Died after 6/5/81
HP-4	40-010	9/24/73: Exhumed Jul 75: Returned	Died 4/29/47
HP-5	40-011	1973: Next of kin refused permission to exhume	Died 4/29/46
HP-6	40-012	2/14/73: Metabolism study at SMH 6/21-7/1/73: Metabolism study at SMH	Living 12/30/74
HP-7	40-013	1973 and 1977: Next of kin refused permission to exhume	Died 10/27/46
HP-8	40-014	No contacts	Died 11/22/75
HP-9	40-015	5/18/78: Exhumed Jul 81: Returned	Died 7/2/47
HP-10	40-016	No contacts	Died 6/2/57
HP-11	40-017	No contacts	Died 2/26/46
HP-12	40-018	No contacts	Died 4/13/53

References:

1. W.H. Langham, S.H. Bassett, P.S. Harris and R.E. Carter. Distribution and excretion of plutonium administered to man. Los Alamos Scientific Laboratory, LA-1151 (September 1950).

2. P.W. Durbin. Plutonium in man: a new look at the old data. In The Radiobiology of Plutonium, B.J. Stover and W.S.S. Jee (eds.), The J.W. Press, Salt Lake city, UT, pp. 469-537 (1972).

3. J. Rundo, P.M. Starzyk, J. Sedlet, R.P. Larsen, R.D. Oldham and J.J. Robinson. The excretion rate and retention of plutonium 10,000 days after acquisition. In Diagnosis and Treatment of Incorporated Radionuclides, Proc. Seminar, Vienna, 8-12 December 1975, IAEA, Vienna, pp. 15-22 (1976).

4. R.E. Rowland and P.W. Durbin. Survival, causes of death, and estimated tissue doses in a group of human beings injected with plutonium. In The Health Effects of Plutonium and Radium, Proc. Symp. Sun Valley, Idaho, 6-9 October 1975, W.S.S. Jee (Ed.), The J.W. Press, Salt Lake City, UT, pp. 329-342 (1976).

5. R.A. Schlenker, B.G. Oltman, and H.T. Cummins. Microscopic distribution of ^{239}Pu deposited in bone from a human injection case. In The Health Effects of Plutonium and Radium, Proc. Symp. Sun Valley, Idaho, 6-9 October 1975, W.S.S. Jee (Ed.), The J.W. Press, Salt Lake City, UT, pp. 437-450 (1976).

6. J. Rundo and F.H. Ilcewicz. Blood content and excretory plasma clearance of plutonium 10^4 days after injection. Abstracts of Papers-22nd Ann. Mtg. Health Phys. Soc., Atlanta, 3-8 July 1977, Pergamon Press, NY, p.26 (1977); Health Phys. 33, 668 (1977).

7. R.E. Rowland. The risk of bone sarcoma from plutonium-239. In Biological Implications of Radionuclides Released from Nuclear Industries, Proc. Symp., Vienna, 26-30 March 1979, Vol. II, IAEA, Vienna, pp. 211-224 (1979).

8. R.P. Larsen, R.D. Oldham, and R.E. Toohey. Macrodistribution of plutonium in the human skeleton. In Actinides in Man and Animals, Proc. Snowbird Actinide Workshop, 15-17 October 1979, M.E. Wrenn (Ed.), RD Press, Salt Lake City, UT, pp. 191-197 (1981).

9. J. Rundo. The late excretion of plutonium following acquisition of known amounts. In Actinides in Man and Animals, Proc. Snowbird Actinide Workshop, 15-17 October 1979, M.E. Wrenn (Ed.), RD Press, Salt Lake City, UT, pp. 253-260 (1981).

10. R.A. Schlenker and B.G. Oltman. Plutonium microdistribution in human bone. In Actinides in Man and Animals, Proc. Snowbird Actinide Workshop, 15-17 October 1979, M.E. Wrenn (Ed.), RD Press, Salt Lake City, UT, pp. 199-206 (1981).

11. R.A. Schlenker and B.G. Oltman. Uranium concentrations in human bone. In Actinides in Man and Animals, Proc. Snowbird Actinide Workshop, 15-17 October 1979, M.E. Wrenn (Ed.), RD Press, Salt Lake City, UT, pp. 473-476 (1981).

12. R.E. Toohey, C.G. Cacic, R.P. Larsen, and R.D. Oldham. The concentration of plutonium in hair following intravenous injection. Health Phys. 40, 881-886 (1981).

Attachments:
Reprints of references 3-12 are attached.

40-012

Department of Energy
Argonne Area Office
9800 South Cass Avenue
Argonne, Illinois 60439

NOV 21 1985

Please respond

Dr. Alan Schriesheim, Director
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, Illinois 60439

Dear Dr. Schriesheim:

SUBJECT: FREEDOM OF INFORMATION ACT (FOIA) REQUEST DATED OCTOBER 30, 1985, DOCKET NO. 11048504D

The enclosed FOIA request is for a copy of a memo from R. E. Rowland to H. A. Schultz dated December 21, 1972, which discusses records of 18 plutonium research subjects. The requestor is also asking for any supporting documentation and any subsequent memos regarding the subject.

Due to statutory time limitations for responding to FOIA requests, we must have your response no later than December 2, 1985.

Sincerely,

Thomas J. Balcerski
for David T. Goldman
Area Manager

Enclosure:
As Stated

cc: A. Zilberstein, ANL, w/enclosure
R. E. Rowland, Princeton, KY, w/enclosure 502-365-2979
[redacted] w/enclosure

8001405

40-012

THE KNOXVILLE JOURNAL

A GANNETT NEWSPAPER
P.O. BOX 911
KNOXVILLE, TENNESSEE 37901

1985 NOV -4 PM 3:39

Oct. 30, 1985

Mr. Ronald Turner
MA-232.1
U.S. Department of Energy
Freedom of Information and Privacy Act Branch
1000 Independence Ave. S.W.
Washington, D.C. 20585

To the FOI Officer:

This request is made under the federal Freedom of Information Act, 5 U.S.C.'552.

Please send me copies of Memorandum, dated 12-21-72, from Dr. R.E. Rowland to H.A. Schultz, senior staff assistant, Records and Data Processing, Center for Human Radiobiology, Argonne National Lab. Memo discusses instructions from Rowland to Schultz on records of 18 plutonium research subjects. Records were transferred to Schultz for his disposition. Please include any supporting documentation and any subsequent memos regarding this subject.

As you know, the FOI Act provides that if portions of a document are exempt from release, the remainder must be segregated and disclosed. Therefore, I will expect you to send me all nonexempt portions of the records which I have requested, and ask that you justify any deletions by reference to specific exemptions of the FOI Act. I reserve the right to appeal your decision to withhold any materials.

I promise to pay reasonable search and duplication fees in connection with this request. However, if you estimate that the total fees will exeed $50, please notify me so that I may authorize expenditure of a greater amount.

I am prepared to pay reasonable search and duplication fees in connection with this request. However, the FOI Act provides for waiver or reduction of fees if disclosure could be considered as "primarily benefiting the general public." I am a journalist employed by The Knoxville Journal and intend to use the information I am requesting as the basis for a planned article. Therefore, I ask that you waive all search and duplication fees. If you deny this request, however, and the fees will exceed $50, please notify me of the charges before you fill my request so that I may decide whether to pay the fees or appeal your denial of my request for a waiver.

DEC 04 1985

As I am making this request as a journalist and this information is of timely value, I will appreciate your calling me by telephone, rather than by mail, if you have any questions. Thanks and I will look forward to your reply within 10 business days, as required by law.

8001406

Sincerely,

Randell B [illegible], reporter
(615) 522-4141, Ext. 423

40-012

DOE F 1325.8
(7-79)

U.S. DEPARTMENT OF ENERGY

memorandum

DATE November 12, 1985

REPLY TO ATTN OF MA-232.1 – Joan Ogbazghi

SUBJECT Freedom of Information Request #110485050

TO Jane Monhart, CH Operations Office

ATTN Bernie Russ

The attached Freedom of Information (FOI) request is being sent to you for action as the records requested appear to be principally within the purview of your organization. If our determination is incorrect, please inform me immediately to whom you are forwarding this request.

If other divisions, offices or field organizations also have records relevant to this request, you as the appropriate FOI Office are responsible for requesting their participation and for coordinating the response. It is important that an appropriate response be forwarded to the requester within 10 working days as failure to act can be deemed a denial.

On the reverse side of this memorandum, a "Reminder of Procedures for Handling FOI Requests" should assist your staff. If you have any questions, I can be reached on FTS 252-5955.

John H. Carter
Chief of FOI and Privacy Acts
Activities Branch
Division of Reference and
Information Management

Attachment

DEC 04 1985

8001407

ARGONNE
NATIONAL
LABORATORY

RECEIVED

JUL

J. R.

INTRA-LABORATORY MEMO

July 3, 1984

TO: G. J. Hamilton

FROM: A. F. Stehney

SUBJECT: Updates on Series 40 Cases

Please try to get an update on the current status and whereabouts of cases 40-003, 40-009, and 40-012. I would appreciate receiving this information by July 10.

GSA

AFS:pat

cc: J. Rundo

DEC 04 1985

8001408

40-012

ARGONNE
NATIONAL
LABORATORY

INTRA-LABORATORY MEMO

November 27, 1985

TO: E. Huberman

FROM: R. A. Schlenker RAS

SUBJECT: Freedom of Information Act Request

We have been unable to locate the memo from Rowland to Schultz dated December 21, 1972 which you requested about 5:15 p.m. yesterday following the receipt of a letter from D. T. Goldman to A. Schriesheim concerning this matter. As today is the last business day before the deadline, December 2, further search is not possible without missing the deadline. Locating this memo is complicated by the fact that Rowland retired about two years ago and Schultz is dead.

Other intra-laboratory memos on the 18 plutonium research subjects referred to in the Goldman letter, mention them by name and give personal information about them. The release of such documents would be a violation of the patients' privacy and the right-to-privacy is protected by law. It would also constitute a violation of normal ethical practice in the handling of patient medical records.

The subjects referred to have been studied by several organizations since the mid 1940s. Non-personal information can be found in the scientific literature. A good review and guide to the literature up to the time of its publication can be found in Patricia W. Durbin, "Plutonium in Man: A New Look at the Old Data," pp.469-530, Radiobiology of Plutonium, Edited by Betsy J. Stover and Webster S.S. Jee, Published by the J. W. Press, Department of Anatomy, University of Utah, Salt Lake City, 1972.

lw

DEC 04 1985

8001409

40-012

PRIVACY ACT MATERIAL REMOVED

CENTER FOR HUMAN RADIOBIOLOGY

Operated for the U.S. Department of Energy by Argonne National Laboratory

September 10, 1984

Mr. Joseph Dehring, Staff Assistant
Research Projects, Bureau of Vital Records
Corning Tower, Rockefeller Empire State Plaza
Albany, New York 12237

RE: Project 80-194

Dear Mr. Dehring:

In conjunction with our ongoing radium study, we are again requesting a copy of your original vital records. May we please have a copy of the death certificate for the participant listed below?

74 75 76 77 78 79 80 81 82 83 84 Thru May

NAME:	
DATE OF DEATH:	Search 1974 to present
SPOUSE:	
BORN:	about
LAST RESIDENCE:	
PLACE OF DEATH:	University of Rochester Medical Center (??) Rochester New York

We are enclosing our check for $6.00, the initial fee for this service; please bill us for your search efforts. All records received at the Center are used for scientific research. We are enclosing a self-addressed, pre-paid envelope for your reply. Thank you for your cooperation.

Sincerely,

Gail L. Knasko, ART, CTR
Supervisor, Records

RECEIVED
SEP 14 1984
BUREAU OF VITAL RECORDS
NYS DEPT. OF HEALTH

MICROFILMED

/glk
Enc. Check #058630

OCT 25 1984 RECEIVED CHR

CHR RECORDS OCT 2 1984

RECORDS ROOM

PRIVACY ACT MATERIAL REMOVED

8001410

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne, Illinois 60439 Telephone 312/972-4

STATE OF NEW YORK
DEPARTMENT OF HEALTH OFFICE OF PUBLIC HEALTH

CORNING TOWER • THE GOVERNOR NELSON A. ROCKEFELLER EMPIRE STATE PLAZA • ALBANY, N.Y. 12237

DAVID AXELROD, M.D.
Commissioner

WILLIAM F. LEAVY
Executive Deputy Director

argonne National Laboratory
9700 South Cass avenue
argonne, Illinois
60439

proj. # 80-194

We have completed your research project.

1 Uncertified copy/copies enclosed.

____ Request(s) not filled - no record(s) on file for name(s) submitted.

____ Additional Information and Comments:

The Public Health Law requires a fee of $5.00 per hour or fractional part thereof for a search of each name submitted, and a fee of $1.00 per uncertified copy provided.

$ 6.00 Total fee

$ 6.00 Will be retained from your advance fee
Receipt # 1215890
Amount $ 6.00

$_____ Balance due

$_____ Refund in process from our fiscal office

If a balance is due, please send us your check or money order, payable to the New York State Department of Health, as soon as possible so that we may credit your account. Return this letter with your payment.

Thank you.

Sincerely,

Joseph Dehring

Joseph Dehring
Staff Assistant
Research Projects
Bureau of Vital Records
9-26-84

RECEIVED
OCT 25 1984
CHR RECORDS

JD/jes
Enc.

RECEIVED CHR
OCT 2 1984
RECORDS ROOM

(0883)

8001411

40-012

PRIVACY ACT MATERIAL REMOVED

Date _____

TO: Gail L. Knasko
CHR Records Room
203-J160

TRY FOR D[illegible]
SEARCH

FROM: GAIL K

OCT 25 1984
CHR RECEIVED

Death Certificates to be Ordered from States or Provinces

CHR #	Name	Last Residence	Date of Death	Place of Death (include town, county, state)
			SEARCH - 1974 to present	NY STATE REGISTER

SS#:

DOB: about

~~Father's name:~~ Spouse

? Vaginal [illegible]

40-012

PRIVACY ACT MATERIAL REMOVED

8001412

40-012

ARGONNE
NATIONAL
LABORATORY

INTRA-LABORATORY MEMO

PRIVACY ACT MATERIAL REMOVED

July 6, 1984

TO: File

FROM: E. E. Adams

SUBJECT: (40-012)

7/5/84 EEA

(40-012) We were referred to Medical Records, Strong Memorial Hospital, for information about this man. However, they require us to write to them and will give out nothing over the phone.

EEA/md

cc: A. F. Stehney

PRIVACY ACT MATERIAL REMOVED

8001413

ARGONNE
NATIONAL
LABORATORY

40-012

INTRA-LABORATORY MEMO

June 8, 1981

TO: CHR Records Room

FROM: Nancy A. Leventry

SUBJECT: Location of Dr. Christine Waterhouse

Christine Waterhouse, M.D., once physician to 40-009 and 40-012, has left Rochester, NY. The 1979-1980 Directoryof Medical Specialists lists her birthplace as Kennebunk, ME. Directory assistance for Maine (207) lists the office of a Christine Waterhouse, MD, in Biddeford, ME (about 10 miles from Kennebunk), as 207/283-0255.

md

40-012

ARGONNE
NATIONAL
LABORATORY

INTRA-LABORATORY MEMO

PRIVACY ACT MATERIAL REMOVED

June 5, 1981

TO: CHR Records Room

FROM: J. Rundo

SUBJECT: Current status of ^{239}Pu injection case 40-009

1. Mrs. Leventry obtained the current telephone number (207/283-0255, via FTS operator 833-3131) of Dr. Christine Waterhouse, who is now living in Maine.

2. I called Dr. Waterhouse on June 3 and asked if she knew if the two patients ( ) were still alive and if so, in whose care. I told her of the negative response to Dr. Adams' letter of April 3, 1981, to Dr. Robert Heinig, and she replied that the patients were in the care of Dr. Hornick, Chairman of the Department of Medicine at the University of Rochester. She said she would make enquiries and would call me back.

3. Dr. Waterhouse called me on June 5; is alive and is in a nursing home in Canandaigua, NY (about 30 miles from Rochester) in the care of Dr. Joseph Guattery (335 Parrish Street, Canandaigua, NY 14424) who knows about her background. The University of Rochester is paying the nursing home and Dr. Guattery.

4. Dr. Waterhouse thought that we stand a good chance of eventually getting some material for examination. is almost certainly not able to will her body. An eventual autopsy might be permitted by the son and his wife, whom Dr. Waterhouse knows well.

5. Dr. Waterhouse is still trying to find out the status of _____ 40-012.

md

cc: R. E. Rowland
A. F. Stehney
E. E. Adams
B. C. Patten
R. A. Schlenker
R. P. Larsen

MICROFILMED

JUN 15 1981

CHR RECORDS

PRIVACY ACT MATERIAL REMOVED

RECEIVED CHR

JUN 9 1981

RECORDS ROOM

8001415

No: 40-009
+ 40-012

CENTER FOR HUMAN RADIOBIOLOGY

Operated for the U.S. Department of Energy by Argonne National Laboratory

April 7, 1981

American Medical Association
Membership Information
535 N. Dearborn
Chicago, Illinois 60600

Dear Sirs:

In order to follow up subjects in our radium research project, I am anxious to contact Dr. Christine Waterhouse who was formerly at the University of Rochester Hospitals.

I would appreciate your help in obtaining a current address (and if possible, a phone number) for her.

Sincerely,

Evelyn E. Adams, M.D.
Medical Director

EEA/llw

8001416

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne Illinois 60439 Telephone 312/972-4153

~~70-007~~
40-012

CENTER FOR HUMAN RADIOBIOLOGY

Operated for the U.S. Department of Energy by Argonne National Laboratory

PRIVACY ACT MATERIAL REMOVED

April 3, 1981

Robert E. Heinig, M.D.
Department of Medicine
Strong Memorial Hospital
Rochester, New York 14620

Dear Dr. Heinig:

Some years ago we collaborated with Dr. Christine Waterhouse in a study of two patients of hers:

/ born and 40-009

born 40-012

and for the sake of completeness of our records we should like to know if they are still alive, or, if dead, what the causes of death were. I understand that since Dr. Waterhouse left Rochester, most of her patients are now in your care. Does this apply to these two and if so, are you able to give us any information about their present status? We should be most grateful.

Sincerely,

Evelyn E Adams MD

PRIVACY ACT MATERIAL REMOVED

Evelyn E. Adams, M.D.
Medical Director

3/7/81 12:30 p.m.
Dr. Rundo -
Dr. Heinig's sec. called to say they have no information regarding the above cases.
L.W.

EEA/md

bcc: J. Rundo
R. E. Rowland
A. F. Stehney
CHR RR

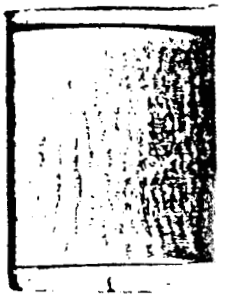
MICROFILMED

RECEIVED CHR
APR 8 1981
RECORDS ROOM

8001417

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne Illinois 60439 Telephone 312/972-4153

PRIVACY ACT MATERIAL REMOVED



ARGONNE NATIONAL LABORATORY 1/31/80

Gail:

Dr. Rowland was in here this morning and was looking at the charts listed below:

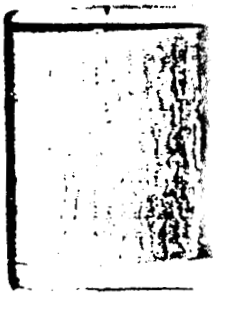
40-003
40-009
40-012

They are the only Pu cases which do not have a code in SAC to indicate whether they are living or dead, except for CHI/3 Unknown which was lost and which we can forget.

(We lost track of person--we have the file.)

He would like to have you code in the following for these people:

40-003	L78 (Brues memo)
40-009	L75 (Her signature)
40-012	L74 (His signature)



PRIVACY ACT MATERIAL REMOVED

ANL-352 (11-77)

8001418

Center for Human Radiobiology
Peripheral Leucocyte Chromosome Analysis

Case # 40-012 Sample date Feb. 14, 1973

A sample of peripheral blood was drawn from the patient into a sterile heparinized tube at Strong Memorial Hospital, Rochester, New York. Leucocytes were cultured, using standard culture techniques including PHA stimulation. The cultures were terminated after 50-53 hours. Slides were examined following standard Giemsa staining. Slides were scored on 3/14/73 and a sample of 100 cells was obtained. The sample consisted of sufficiently well spread cells with 46 or more centromeres. A copy of the cytogenetic unit's score sheet is attached.

PRIVACY ACT MATERIAL REMOVED

Results were as follows:

	Number
Cells with 46 centromeres	92
Cells with >46 centromeres	8
% hyperdiploid cells	8
Rings + dicentrics (and associated fragments)	0
Chromosome minutes	0
Acentric fragments	0
Total chromosome aberrations per cell	0
Chromatid deletions	1
Gaps	1
Total chromatid aberrations per cell	.02
Total aberrations per cell	.02

PRIVACY ACT MATERIAL REMOVED

Date of report 7/1/72 Submitted by L. F. Hoffman

8001420

MICROFILMED

CENTER FOR HUMAN RADIOBIOLOGY

CHROMOSOME STUDY CASE SUMMARY SHEET

CASE NO. 40-012 Ra NO. 292

SLIDE NO.	STAIN	SCORED BY	NO. CELLS SCORED	CHROMOSOME ABERRATIONS												
				DICENTRICS	POLYCENTRICS	ASSOCIATED FRAGMENTS	CENTRIC RINGS	ACENTRIC RINGS	ASSOCIATED FRAGMENTS	MINUTES	TRANSLOCATIONS	INVERSIONS	TOTAL TWO HIT	FRAGMENTS	CHROMATID DELETIONS	GAPS
1-1		J.G.	11/3	0	0	0	0	0	0	0	1	—	0	0	0	0
2-1 1	Giemsa	"	6/0	0	0	0	0	0	0	0	—	—	0	0	0	0
1		J.S.	11/0	0	0	0	0	0	0	0	—	—	0	0	0	0
2		"	2/1	0	0	0	0	0	0	0	—	—	0	0	0	0
2		S.F.H	6/1	0	0	0	0	0	0	0	—	—	0	0	0	0
3-1 1		I.G.	2/0	0	0	0	0	0	0	0	—	—	0	0	0	0
1		S.F.H	13/2	0	0	0	0	0	0	0	—	—	0	0	0	0
2		"	17/0	0	0	0	0	0	0	0	—	—	0	0	0	0
3		"	2/0	0	0	0	0	0	0	0	—	—	0	0	0	0
4-1		J.S	7/1	0	0	0	0	0	0	0	—	—	0	0	0	0
5-1		I.G.	7/0	0	0	0	0	0	0	0	—	—	0	0	0	1
		S.F.H	6/0	0	0	0	0	0	0	0	—	—	0	0	0	0
6-1		J.S.	2/0	0	0	0	0	0	0	0	—	—	0	0	1	0
Total			92/8	0	0	0	0	0	0	0	—	—	0	0	1	1
			(100)													
chromosome		#47	6													
		4X	1													
		84	1													

Fragments, Gaithersburg

RER-41 (10-72)

8001421

TABLE 5

PLUTONIUM CONTENT OF BLOOD SAMPLES* FOLLOWING INTRAVENOUS INJECTION OF APPROXIMATELY 5 μg OF PLUTONIUM AS Pu^{+4} - CITRATE

DAYS AFTER INJECTION	PATIENT CODE AND PERCENT OF INJECTED DOSE IN TOTAL BLOOD VOLUME*											AVERAGE
	Hp-1	Hp-2	Hp-3	Hp-4	Hp-5	Hp-6	Hp-7	Hp-8	Hp-9	Hp-10	Hp-12	
1/6	46.02	-	28.32	83.31	31.51	36.70	32.57	37.64	40.83	51.57	5.34	~~86.7~~
1	21.83	19.35		-	6.23	10.97	16.40	14.51	12.39	24.66		15.7
2	-	8.38	11.56	-	-	-	-	-	-	-	-	9.97
3	-	10.03	-	16.64	1.16	2.94	6.97	4.94	6.22	20.06		8.62
4	-	-	4.22	-	-	-	-	-	-	-	-	4.9
5	-	-	-	-	0.66	-	-	-	-	-	-	-
6	3.30	4.25	2.17	6.14	-	1.00	2.96	2.07	3.91	4.91	-	3.4
8	-	2.32	1.42	-	-	-	-	-	-	-	-	1.9
9	-	-	-	4.60	-	-	-	-	-	-	-	-
10	1.42	-	-	-	0.39	0.38	1.13	1.37	2.21	1.72	-	1.2
13	-	-	0.61	2.34	-	-	-	-	-	-	-	1.5
15	-	-	-	-	0.11	0.26	0.66	0.71	1.42	1.02	-	.70
17	-	-	0.51	1.45	-	-	-	-	-	-	-	1.0
22	-	0.70	-	-	0.18	0.25	-	-	-	-	-	.38
23	-	-	0.25	0.72	-	-	-	-	-	-	-	.48
29	-	-	-	-	-	-	0.37	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	0.36	-	-
31	-	-	-	-	-	-	-	-	-	-	0.51	-
36	-	-	-	-	-	-	-	-	0.42	-	-	-
42	-	-	-	-	-	-	-	0.17	-	-	-	-
46	-	-	-	-	-	-	-	-	-	-	0.45	-

*Total Weight of Blood Taken as 7.71% of Total Body Weight.

C. Excretion of Plutonium

1. Urinary Excretion

The urinary excretion of plutonium was studied in eleven of the subjects following the intravenous injection of approximately 5 μg of plutonium as Pu^{+4} in 0.4 per cent solution of sodium citrate · $2H_2O$. With the exception of the first day, urine from all subjects was collected in 24 hour samples through 22 days post injection. After 22 days the collection of 24 hour urine samples was continued as long as the patients were available for study. It was not possible to retain the subjects as long as was desired and the major weakness in these results is the short time interval over which the studies were continued. Two subjects were followed 22 days, one for 23 days, one for 27, and the remainder for 30 days or longer after injection. The Chicago cases (13) were followed for 16, 140, and 186 days and the California case (14) was followed for a period of 341 days. Because of the great importance of measurements at longer time intervals, the Chicago and California data have been incorporated with

Plasma

HP-6

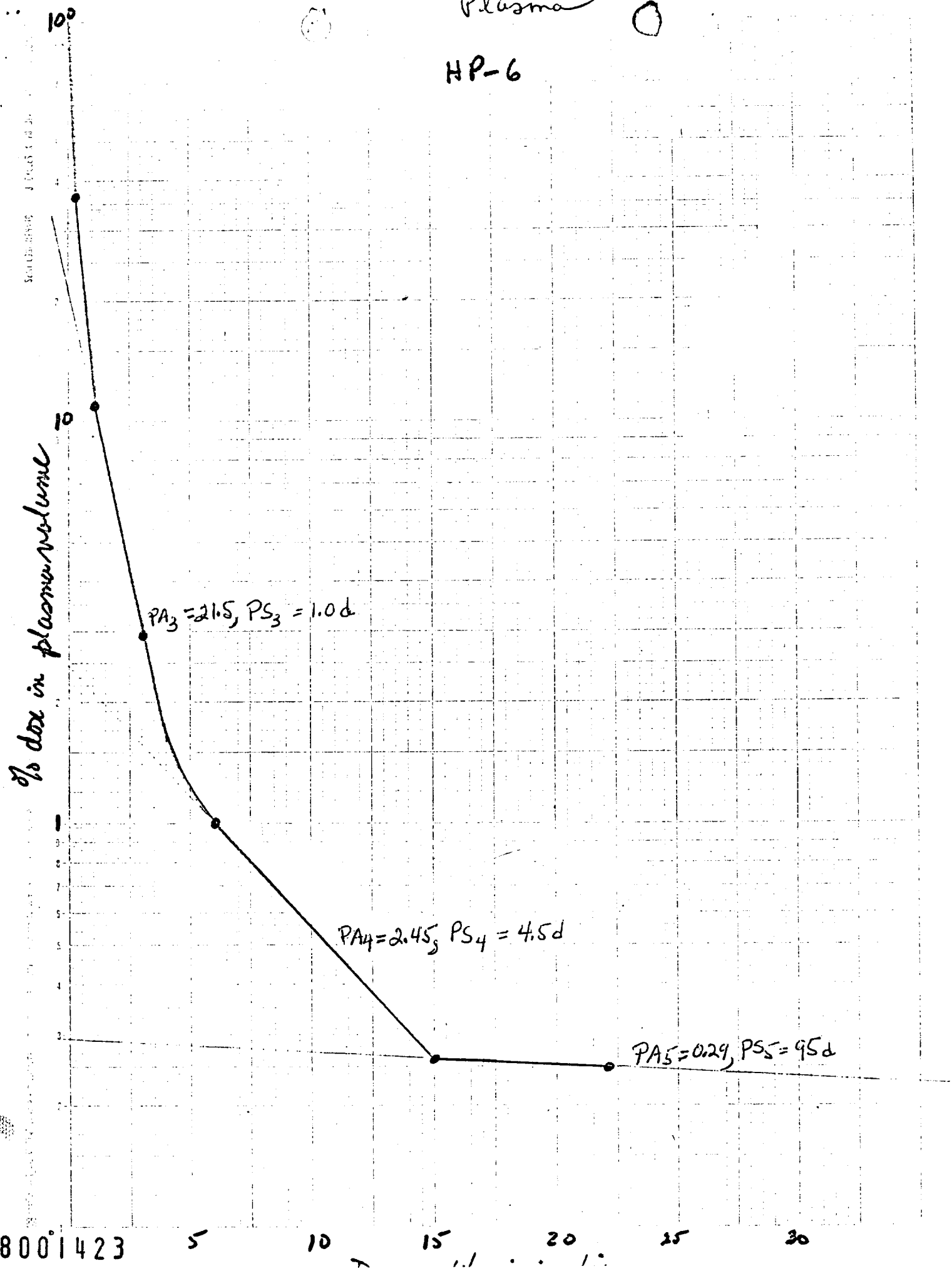

100
10
1
% dox in plasma vs time
PA3 = 21.5, PS3 = 1.0 d
PA4 = 2.45, PS4 = 4.5 d
PA5 = 0.29, PS5 = 95 d
5
10
15
20
25
30

TABLE 6

INDIVIDUAL URINARY EXCRETION VALUES OF PLUTONIUM FOLLOWING INTRAVENOUS ADMINISTRATION[1] TO HUMAN SUBJECTS (EXPRESSED AS PER CENT OF DOSE EXCRETED PER DAY)

DAYS POST INJECTION	PER CENT OF INJECTED DOSE EXCRETED PER DAY														
	Hp-1	Hp-2	Hp-3	Hp-4	Hp-5	Hp-6	Hp-7	Hp-8	Hp-9	Hp-10	Hp-12	Chi-1[2]	Chi-3[2]	Chi-11[2]	Cal.-1[3]
1	.181	.472	.569	.440	.296	-	.217	.377	.160	.414	.101	.857	2.531*	.152	.480
2	.146	.294	.289	.236	.166	.216	.212	.232	.085	.330	.103	.182	.153	.167	.150
3	.114	.174	.112	.221	.077	.127	.137	.128	.069	.218	.088	.063	.184	.067	.120
4	.094	.123	.107	.132	.052	.111	.096	.140	.066	.170	.078	.077	.133	.033	.031
5	.069	.116	.078	.116	.030	.076	.069	.083	.047	.089	.068	.026	.032	.042	.037
6	.066	.061	.043	.119*	.020	.057	.059	.078	.052	.060	.044	.0256	.029	.042	-
7	.062	.062	.043	.077	.033	.044	.045	.066	.050	.079	.069	.0234	.024	.024	-
8	.055	.048	.049	.081	.026	.043	.037	.057	.032	.065	.080	.0227	.023	.025	.016
9	.051	.046	.022	.095*	.027	.032	.033	.047	.032	.051	.043	-	.027	.019	.069
10	.045	.038	.027	.081*	.022	.031	.023	.050	.035	.044	.038	.0082*	.034	.030	.026
11	.040	.048	.027	.075*	.021	-	.018	.044	.026	.041	.038	.0097	.047	.019	.036
12	.038	.039	.015	.072*	.026	.024	.019	.023	.030	.038	.027	.0095	.047	.014	.029
13	.034	.045	.020	.067*	.023	.023	.019	.037	.027	.029	.030	.0256	.018	.034	-
14	.035	.036	.020	.058*	.018	.020	.013	.035	.030	.029	.039	.007	.034	.009	-
15	.034	.039	.028	.050	.015	.022	.012	.035	.030	.025	.029	.0059	.026	.016	.013
16	.026	.024	.024	.033	.020	.017	.012	.036	.049*	.021	.023	.0109	.012	.004	.016
17	.027	.027	.021	.032	.020	.013	.011	.032	.038	.023	.029	-	.028	-	.0056
18	.026	.020	.017	.037	.020	.015	.011	.029	.027	.021	.026	-	.026	-	.010
19	.025	.019	.018	.032	.018	.015	.010	.031	.029	.017	.029	.0022	.015	-	.006
20	.017	.021	.012	.025	.021	.013	.008	.032	.029	.018	.032	.0093	.038	-	.0048
21	.017	.017	.019	.029	.020	.012	.010	.029	.032	.022	.025	.0076	.032	-	.0017
22	.016	.015	.014	.035	.018	.012	.013	.021	.032	.016	.025	.0145	.027	-	.0050
23	.025	.018	.014	.014	-	-	.008	.021	.032	.019	.039	.0151	.029	-	.0091
24	.021	.014	-	-	-	-	.008	.025	.032	.016	.023	.0128	.020	-	.0076
25	.013	.014	-	.011	-	-	.008	.023	.029	.016	.021	.0128	.148*	-	.011
26	-	.017	-	.011	-	-	.007	.022	.032	.016	.023	.0175	.024	-	.0022
27	-	.008	-	.008	-	-	.008	.028	.032	.014	.017	.0151	.043*	-	.0044
28	-	.009	-	-	-	-	.008	.023	.024	.013	.024	.0197	.034	-	.0074
29	-	.009	-	-	-	-	.008	.019	.025	.014	.023	.0138	.022	-	.0043
30	-	.008	-	-	-	-	.006	.021	.023	.014	.021	.0151	.024	-	.0069
31	-	.007	-	-	-	-	.005	.017	.025	-	.021	.010	.027	-	.0077
32	-	.007	-	-	-	-	.007	.010	.024	-	.012	.010	.020	-	.0063
33	-	.009	-	-	-	-	.006	.015	.022	-	.037*	.017	.011	-	.0073
34	-	.009	-	-	-	-	.006	.015	.020	-	.020	.0139	.008	-	.0084
35	-	-	-	-	-	-	.006	-	.022	-	.026	.0127	.009	-	.0069
36	-	-	-	-	-	-	.006	.015	.022	-	.018	.0165	.015	-	.0079
37	-	-	-	-	-	-	.006	.011	-	-	.022*	.0111	.011	-	.0063
38	-	-	-	-	-	-	-	.016	-	-	.018	.0174	.009	-	.0085
39	-	-	-	-	-	-	-	.012	-	-	.021	.0112	.009	-	.0064
40	-	-	-	-	-	-	-	.017	-	-	.019	.0072	.009	-	.0072
41	-	-	-	-	-	-	-	.019	-	-	.013	.0092	.011	-	.0080
42	-	-	-	-	-	-	-	.014	-	-	.013	.0127	-	-	.0081
43	-	-	-	-	-	-	-	.016	-	-	.015	.0095	.017	-	.0076
44	-	-	-	-	-	-	-	.014	-	-	.015	.0031	-	-	.0055
45	-	-	-	-	-	-	-	.013	-	-	.017	.013	.018	-	.0063
46	-	-	-	-	-	-	-	.015	-	-	-	.012	-	-	.0073
47	-	-	-	-	-	-	-	.014	-	-	.015	-	.020	-	.0059
48	-	-	-	-	-	-	-	.014	-	-	.017	.0064	-	-	.0059
49	-	-	-	-	-	-	-	.018	-	-	.015	.0063	-	-	.0063
50	-	-	-	-	-	-	-	.014	-	-	-	.0054	.018	-	.0078
51	-	-	-	-	-	-	-	.013	-	-	-	.007	-	-	.0082
52	-	-	-	-	-	-	-	-	-	-	.035	.0073	-	-	.0098
53	-	-	-	-	-	-	-	.013	-	-	.019	.0023	-	-	.0074
54	-	-	-	-	-	-	-	.013	-	-	.043	-	-	-	.0077
55	-	-	-	-	-	-	-	.015	-	-	.043*	.0073	.014	-	.0096
56	-	-	-	-	-	-	-	.013	-	-	.026	.003	-	-	.0064
57	-	-	-	-	-	-	-	.012	-	-	.018	.0075	-	-	.0050
58	-	-	-	-	-	-	-	.013	-	-	.026	.0004	-	-	.0058
59	-	-	-	-	-	-	-	.012	-	-	-	.011	-	-	.0068
60	-	-	-	-	-	-	-	.011	-	-	-	.0063	.022	-	.0067
61	-	-	-	-	-	-	-	.012	-	-	-	.0068	-	-	.0066
62	-	-	-	-	-	-	-	.010	-	-	-	.0052	-	-	.0058
63	-	-	-	-	-	-	-	.009	-	-	-	.0094	-	-	.0077
64	-	-	-	-	-	-	-	.012	-	-	-	.0071	-	-	.0042
65	-	-	-	-	-	-	-	.011	-	-	-	.0099	.024	-	.0042
66	-	-	-	-	-	-	-	-	-	-	-	.014	-	-	.0047
67	-	-	-	-	-	-	-	-	-	-	-	.014	-	-	.0064
68	-	-	-	-	-	-	-	-	-	-	-	.011	-	-	.0063
69	-	-	-	-	-	-	-	-	-	-	-	.011	-	-	.0070
70	-	-	-	-	-	-	-	-	-	-	-	.014	-	-	.0100
71	-	-	-	-	-	-	-	-	-	-	-	.0098	-	-	.0072
72	-	-	-	-	-	-	-	-	-	-	-	.0039	.014	-	.0062
73	-	-	-	-	-	-	-	-	-	-	-	.0083	-	-	.0039

CH-3007 CH-3559

Dennis W. Murphy - ADC - BN DATE 6/7/76

TABLE 9

INDIVIDUAL FECAL EXCRETION VALUES OF PLUTONIUM FOLLOWING INTRAVENOUS ADMINISTRATION[1] TO HUMAN SUBJECTS (EXPRESSED AS PER CENT OF DOSE EXCRETED PER DAY)

DAYS POST INJECTION	PER CENT OF INJECTED DOSE EXCRETED PER DAY											
	Hp-1	Hp-2	Hp-3	Hp-4	Hp-5	Hp-6	Hp-7	Hp-8	Hp-9	Hp-10	Hp-12	Chi-1[2]
1	.052*	.204	.018*	.134	.004*	.085	.147	.178	.333	.087	.370	.250
2	.221	.204	.157	.274	.311	.085	.120	.266	.389	.087	.370	.465
3	.241	.204	.157	.274	.311	.179	.087	.210	.389	.087	.297	.284
4	.050	.317	.095	.306	.185	.179	.080	.080	.131	.110	.297	.330
5	.105	.317	.099	.306	.110	.179	.055	.080	.131	.110	.163	.223
6	.046	-	.070	.126	.110	.179	.055	.080	.131	.110	.183	.116
7	.021	-	.070	.126	.110	.037	.055	.080	.131	.110	.020	.083
8	.021	.120	.070	.126	.064	.037	.055	.070	.131	.034	.020	.112
9	.021	.120	.070	.126	.051	.037	.032	.070	.131	.034	.020	-
10	.021	.084	.027	.117	.051	.037	.032	.070	.131	.034	.020	.021
11	.046	.084	.027	.117	.052	.023	.032	.070	.118	.034	.020	-
12	.046	.084	.027	.117	.052	.023	.032	.045	.118	.034	.020	.083
13	.046	.084	.027	.117	.032	.023	.023	.045	.118	.034	.020	.045
14	.046	.062	.023	.085	.032	.023	.023	.045	.118*	.022	.020	.044
15	.035	.062	.023	.085	.032	.015	.023	.045	.118*	.022	.023	.042
16	.035	.062	.023	.040	.017	.015	.023	.032	.414*	.022	.023	.034
17	.035	.062	.023	.040	.017	.015	.016	.032	.157*	.022	.023	-
18	.035	.055	.016	.040	.017	.015	.016	.025	.157*	.022	.023	.031
19	.015	.055	.016	.028	.017	.015	.016	.025	.055	.012	.053	.027
20	.015	.055	.016	.028	.020	.015	.016	.025	.055	.012	.053	.019
21	.015	.055	.016	.028	.020	.010	.008	.025	.055	.012	.053	.019
22	.015	.022	.006	.028	.020	.010	.008	.045	.055	.012	.053	.018
23	.017	.022	.006	.026	-	-	.008	.045	.052	.012	.026	.010
24	.017	.022	-	-	-	-	.008	.009	.052*	.012	.026	.023
25	-	.022	-	-	-	-	.011	.009	.052*	.006	.026	.013
26	-	.021	-	-	-	-	.011	.009	.052*	.006	.026	.023
27	-	.021	-	-	-	-	.011	.009	.043*	.006	.016	.0083
28	-	-	-	-	-	-	.011	.009	.043*	.006	.016	.0069
29	-	-	-	-	-	-	-	.009	.043	.006	.016	.0158
30	-	-	-	-	-	-	-	.018	.043	.006	.016	.0063
31	-	-	-	-	-	-	-	.018	.035	-	.016	.0074
32	-	-	-	-	-	-	-	.018	.035	-	.016	.0062
33	-	-	-	-	-	-	-	.018	.035	-	.016	.0079
34	-	-	-	-	-	-	-	.018	.035	-	.016	.0079
35	-	-	-	-	-	-	-	.018	.035	-	.022	.0054
36	-	-	-	-	-	-	-	.018	-	-	.022	.0054
37	-	-	-	-	-	-	-	.028	-	-	.022	.0050
38	-	-	-	-	-	-	-	.028	-	-	.022	.0042
39	-	-	-	-	-	-	-	.011	-	-	-	.0047
40	-	-	-	-	-	-	-	.011	-	-	-	.0066
41	-	-	-	-	-	-	-	.011	-	-	-	.0064
42	-	-	-	-	-	-	-	.011	-	-	-	.0053
43	-	-	-	-	-	-	-	.011	-	-	.008	.0047
44	-	-	-	-	-	-	-	.011	-	-	.008	.0032
45	-	-	-	-	-	-	-	.014	-	-	.008	.0042
46	-	-	-	-	-	-	-	.014	-	-	.008	.0063
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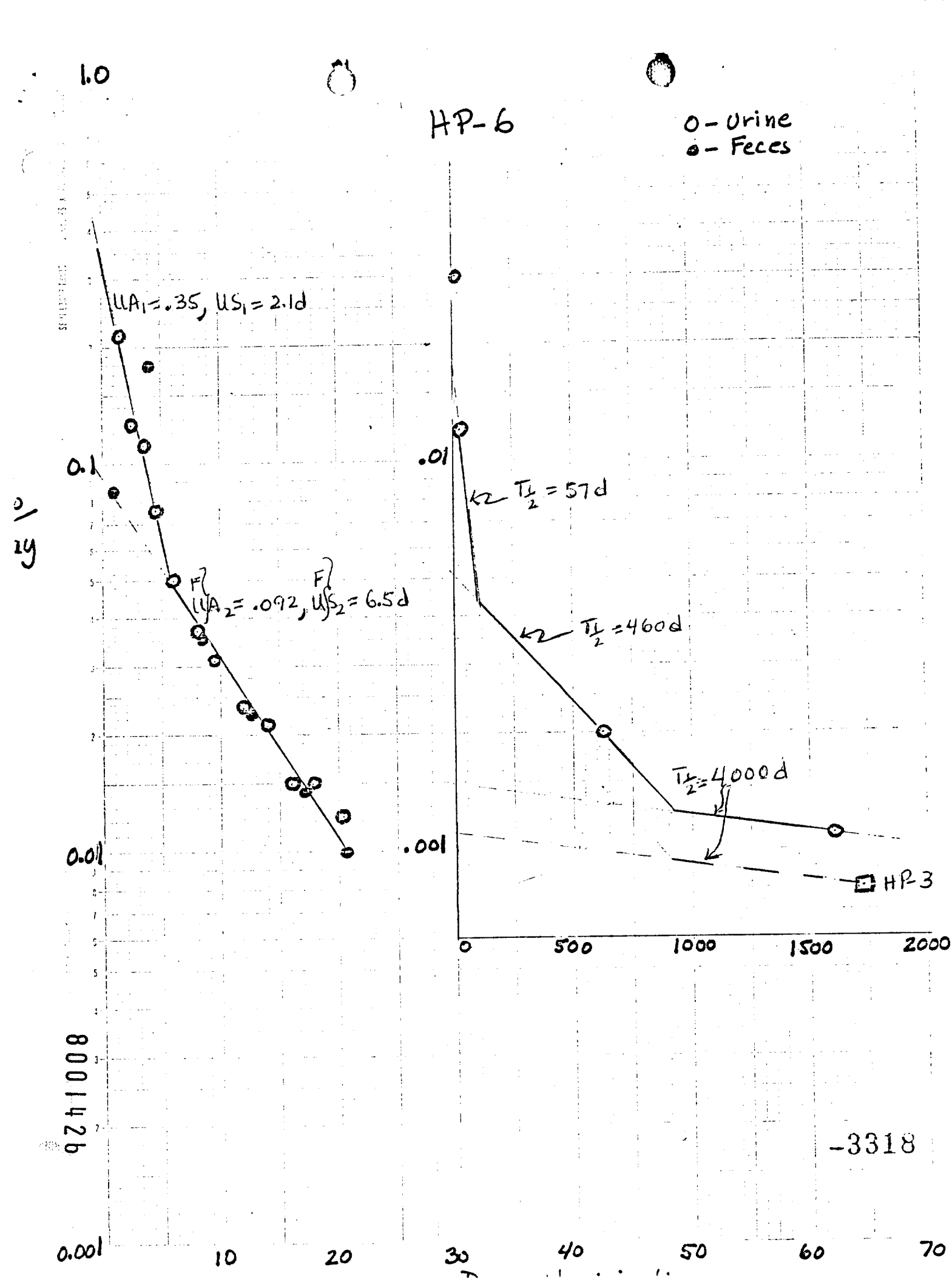
HP-6
O - Urine
● - Feces
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0.01
.01
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F
$UA_2 = .092$, F $US_2 = 6.5d$
$T_{\frac{1}{2}} = 57d$
$T_{\frac{1}{2}} = 460d$
$T_{\frac{1}{2}} = 4000d$
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10
20
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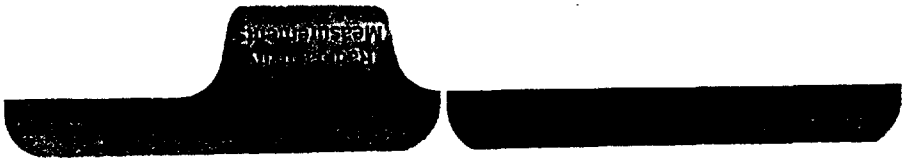
70

-3318



40-012

RADIOCHEMISTRY

RECORDS FILED 10/3/84

SAMPLE ANALYSIS FOR THIS CASE IS IN PROGRESS

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

Name _____ Case No. 40.012 Sample No. .07

Event EXCRETION Time, Date 0800 6/22 – 0800 6/23/73 Mean Time, Date _____

Sample Description FRESH URINE

Collected at UNIV. OF ROCHESTER Other Information _____

Sample Size (Unit) 1.00 (DAYS) Chem Lab. No. 1146

Analyses Requested for: ^{239}Pu by: Initials/Date RPL / 8-15-73

SUMMARY OF RESULTS (at time of event)

Nuclide, Element or Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date: Entered	Checked	To CHR File
^{239}Pu	Pu 1	pCi	4.62 ± 0.2	4.62 ± 0.2		RC-2B-PS	RPL 11-30-73	RPL 12-3-73	gp 12/21/73

Additional Comments:

CHR Form 11/7/73

8001429

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

Name _____ Case No. 40.012 Sample No. .08

Event EXCRETION Time, Date 0800 6/23 - 0800 6/24/73 Mean Time, Date _____

Sample Description FRESH URINE

Collected at UNIV. OF ROCHESTER Other Information _____

Sample Size (Unit) 1.00 (DAYS) Chem Lab. No. 1147

Analyses Requested for: ^{239}Pu by: Initials/Date RPL / 8-15-73

SUMMARY OF RESULTS (at time of event)

Nuclide, Element or Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date: Entered	Checked	To CHR File
^{239}Pu	Pu 1	pCi	3.94 ± 0.3	3.94 ± 0.3		RC-2B-PS	RPL 11-30-73	RPL 12-3-73	gp 12/21/73

Additional Comments:

CHR Form 11/7/73

8001430

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

Name _____ Case No. 40,012 Sample No. 109

Event EXCRETION Time, Date 0800 6/24 - 0800 6/25/73 Mean Time, Date _____

Sample Description FRESH URINE

Collected at UNIV. OF ROCHESTER Other Information _____

Sample Size (Unit) 1.00 (DAYS) Chem Lab. No. 1148

Analyses Requested for: ^{239}Pu by: Initials/Date RPL / 8-15-73

SUMMARY OF RESULTS (at time of event)

Nuclide, Element or Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date		
							Entered	Checked	To CHR File
^{239}Pu	PU1	pCi	3.56 ± 0.3	3.56 ± 0.3		RC-28-PS	RPL 11-30-73	RPL 12-3-73	gp 12/21/73

Additional Comments:

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

PRIVACY ACT MATERIAL REMOVED

Name _____ Case No. 40,012 Sample No. ,10

Event EXCRETION Time, Date 0800 6/25 - 0800 6/26/73 Mean Time, Date _____

Sample Description FRESH URINE

Collected at UNIV. OF ROCHESTER Other Information _____

Sample Size (Unit) 1.00 (DAYS) Chem Lab. No. 1149

Analyses Requested for: 239 Pu by: Initials/Date RPL / 8-15-73

SUMMARY OF RESULTS (at time of event)

Nuclide, Element or Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date		
							Entered	Checked	To CHR File
^{239}Pu	PU1	pCi	5.33 ± 0.3	5.33 ± 0.3		RC-28-PS	RPL 11-30-73	RPL 12-3-73	gp 12/21/73

Additional Comments:

RECEIVED
DEC 21 73
CHR RECORDS

PRIVACY ACT MATERIAL REMOVED

CHR Form 11/7/73

8001432

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

PRIVACY ACT MATERIAL REMOVED

Name _____ Case No. 40.012 Sample No. 11

Event EXCRETION Time, Date 0800 6/26 – 0800 6/27/73 Mean Time, Date _____

Sample Description FRESH URINE

Collected at UNIV. OF ROCHESTER Other Information _____

Sample Size (Unit) 1.00 (DAYS) Chem Lab. No. 1150

Analyses Requested for: ^{239}Pu by: Initials/Date RPL / 8-15-73

SUMMARY OF RESULTS (at time of event)

Nuclide, Element or Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date		
							Entered	Checked	To CHR File
^{239}Pu	Pu I	pCi	4.42 ± 0.3	4.42 ± 0.3		RC-28-PS	RPL 11-30-73	RPL 12-3-73	gp 12/21/73

Additional Comments:

RECEIVED
DEC 21 '73
CHR RECORDS

PRIVACY ACT MATERIAL REMOVED

CHR Form 11/7/72

8001432

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

Name _____ Case No. 40.012 Sample No. .12

Event EXCRETION Time, Date 0800 6/27 - 0800 6/28/73 Mean Time, Date _____

Sample Description FRESH URINE

Collected at UNIV. OF ROCHESTER Other Information _____

Sample Size (Unit) 1.00 (DAYS) Chem Lab. No. 1151

Analyses Requested for: 239 Pu by: Initials/Date RPL / 8-15-73

SUMMARY OF RESULTS (at time of event)

Nuclide, Element or Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date: Entered	Checked	To CHR File
239 Pu	Pu I	pCi	4.90 ± 0.3	4.90 ± 0.3		RC-28-PS	RPL 11-30-73	RPL 12-3-73	JP 12/21/73

Additional Comments:

HR Form 11/7/73

8001434

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

PRIVACY ACT MATERIAL REMOVED

Name _____ Case No. 40.012 Sample No. .08

Event EXCRETION Time, Date 0800 6/23 - 0800 6/24/73 Mean Time, Date _____

Sample Description FRESH URINE

Collected at UNIV. OF ROCHESTER Other Information _____

Sample Size (Unit) 1.00 (DAYS) Chem Lab. No. 1147

Analyses Requested for: ^{239}Pu by: Initials/Date RPL / 8-15-73

SUMMARY OF RESULTS (at time of event)

Nuclide, Element or Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date: Entered	Checked	To CHR File
^{239}Pu	Pu I	pCi	3.94 ± 0.3	3.94 ± 0.3		RC-2B-PS	RPL 11-30-73	RPL 12-3-73	gp 12/21/73

Additional Comments:

RECEIVED DEC 21 '73 CHR RECORDS

PRIVACY ACT MATERIAL REMOVED

8001435

DETAILED RESULTS: 40-012 090 CASTB (NEW) 750529

PRIVACY ACT MATERIAL REMOVED

CALCIUM
*****

NAME: *CASE NO.: 40-012 *SAMPLE NO.: 090

EVENT: COLLECTN *DATE OF EVENT: 730624 *LAB NO.: 1148

TYPE: U *SAMPLE DESCRIPTION: URINE -

ITEM	UNIT	ANALYSIS NUMBER 1	ANALYSIS NUMBER 2
1. SAMPLE SUB-NUMBER		090D	090D
2. METHOD		CHA	CHA
3. DATE REQUESTED		730815	730815
4. DATE ANALYZED		741022	741210
5. SAMPLE SIZE	DAY	1.000	1.000
6. ALIQUOT FRACTION		0.762	0.762
7. VOL. OF ALIQUOT	ML	100.000	100.000
8. VOL. MEASURED	ML	0.050	0.050
9. ALIQUOT FACTOR		3.812E-04	3.812E-04
10. SAMPLE SIZE MEASURED	DAY	3.812E-04	3.812E-04
11. CA IN ALIQUOT	UG	36.400	36.200
12. STD. ERROR(SYS) - 2%	UG	0.728	0.724
13. CA CONCN OR RATE	MG/DAY	95.475	94.951
14. REFERENCES-CHR DOCS.		RC30	RC30

RECEIVED

JAN 7 '76

CHR RECORDS

****
* RESULTS *
****

1. CA CONCENTRATION OR RATE(WTD. MEAN)	95.212	MG/DAY	
2. STD.ERROR(EXTERNAL)	0.262	MG/DAY	
3. STD. ERROR(INTERNAL)	1.347	MG/DAY	
4. VARIANCE RATIO,F	0.038		
5. FRACTIONAL STD. ERROR	0.014		

****

CA (MEAN) IN ALIQ #1 : 36.299 ± 0.513 UG

CA CONCENTRATION OR RATE: 95.212 ± 1.347 MG/DAY

ANALYZED BY: JS CHECKED: _____ REVIEWED BY/DATE: RBH DEC 1 '75

COMMENTS AND REFERENCES:

TO (BY/DATE): CHR FILE: 90 15/76 SR FORM:_____SA CARD:_____CHEM FILE:_____

CHR FORM 3/7/75

PRIVACY ACT MATERIAL REMOVED

8001436

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

ame _____ Case No. 40.012 Sample No. .13

vent EXCRETION Time, Date 0800 6/28 - 0800 6/21/73 Mean Time, Date _____

mple Description FRESH URINE

ollected at UNIV. OF ROCHESTER Other Information _____

mple Size (Unit) 1.00 (DAYS) Chem Lab. No. 1152

alyses Requested for: ^{239}Pu by: Initials/Date RPL/8-15-73

SUMMARY OF RESULTS (at time of event)

uclide, ement Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date		
							Entered	Checked	To CHR File
^{239}Pu	Pu I	pCi	5.35 ± 0.3	5.35 ± 0.3		RC-28-PS	RPL 11-30-73	RPL 12-3-73	GJP 12/21/73

Additional Comments:

8001437

PRIVACY ACT MATERIAL REMOVED

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

ame _____ Case No. 40.012 Sample No. .14

vent EXCRETION Time, Date 0800 6/29 - 0800 6/30/73 Mean Time, Date _____

ample Description FRESH URINE

ollected at UNIV. OF ROCHESTER Other Information _____

ample Size (Unit) 1.00 (DAYS) Chem Lab. No. 1153

nalyses Requested for: ^{239}Pu by: Initials/Date RPL/8-15-73

SUMMARY OF RESULTS (at time of event)

uclide, ement Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date		
							Entered	Checked	To CHR File
^{239}Pu	Pu I	pCi	4.46 ± 0.3	4.46 ± 0.3		RC-2B-P5	RPL 11-30-73	RPL 12-3-73	GP 12/21/73

dditional Comments:

RECEIVED
DEC 21 '73
CHR RECORDS

HR Form 11/7/73 8001438

PRIVACY ACT MATERIAL REMOVED

40-012

010	BL	PU239	7.70000E+00	8.00000E-01	780901	KGW	———
020	BL	PU239	4.08000E+01	2.60000E+00	780901	KGW	———
070	U	CASTB	8.50624E-02	1.20301E-03	770200	DAY	
		PU239	4.62000E+00	2.50000E-01	780901	DAY	———
080	U	AM241	3.50000E-02	4.00000E-03	780901	DAY	———
		PU239	3.94000E+00	2.80000E-01	780901	DAY	
090	U	CASTB	9.52116E-02	1.34650E-03	770200	DAY	
		PU239	4.56000E+00	2.60000E-01	780901	DAY	———
100	U	AM241	3.70000E-02	5.00000E-03	780901	DAY	———
		PU239	5.33000E+00	2.60000E-01	780901	DAY	
110	U	AM241	4.00000E-02	4.00000E-03	780901	DAY	———
		PU239	4.42000E+00	3.20000E-01	780901	DAY	
120	U	PU239	4.90000E+00	2.80000E-01	780901	DAY	
130	U	AM241	4.10000E-02	4.00000E-03	780901	DAY	———
		PU239	5.35000E+00	3.40000E-01	780901	DAY	
140	U	CASTB	7.91227E-02	1.25989E-03	770200	DAY	
		PU239	4.46000E+00	2.50000E-01	780901	DAY	
150	F	PU239	1.28000E+01	6.00000E-01	780901	KGW	———
160	F	PU239	1.63000E+00	6.00000E-02	780901	DAY	———
170	F	PU239	2.40000E+00	8.00000E-02	780901	DAY	———
180	F	PU239	1.48000E+00	6.00000E-02	780901	DAY	———
190	F	PU239	1.66000E+00	1.00000E-01	780901	DAY	———

8901439

——— = missing

No detailed reports available for Pu239, Am241

10/8/84
GA/HFL

There are summary sheets for Pu239 (V's)

ARGONNE
NATIONAL
LABORATORY

40-012

INTRA-LABORATORY MEMO

October 30, 1978

TO: Records

FROM: Robert Oldham

SUBJECT: Sample Analyses Without Detailed Result Forms

The following analyses on the samples indicated do not have Detailed Result Forms. Results were entered directly into CHEM FILE from notebooks containing the calculations using the CHEM Coding Form, CHR-ANL-12/19/73.

Nuclide Analyzed	Sample ID	LAB NO
^{239}Pu	40-009.310	958
^{239}Pu	40-009.320	959
^{239}Pu	40-012.010	960
^{239}Pu	40-012.020	961

cc: J. Plondke
R. Oldham

RO/ns

8001440

-26 (11-68)

40-012

ARGONNE NATIONAL LABORATORY

INTRA-LABORATORY MEMO

October 4, 1978

TO: Records

FROM: Robert Oldham R. Oldham

SUBJECT: Sample Analyses Without Detailed Result Forms

The following analyses on the samples indicated do not have Detailed Result Forms. Results were entered directly into CHEM FILE from notebooks containing the calculations using the CHEM coding Form, CHR-ANL-12/19/73.

NUCLIDE ANALYZED	SAMPLE ID	LAB NO
AM241	40-004.010	2980
"	40-004.E1C2	2986
"	40-009.19	946
"	40-009.20	947
"	40-009.22 to 40-009.27	949 to 954
"	40-010.B51	1824
"	40-010.E14	1877
"	40-012.08	1147
"	40-012.10	1149
"	40-012.11	1150
"	40-012.13	1152
PU239	40-009.01 to 40-009.28	930 to 955
"	40-012.07 to 40-012.23	1146 to 1162
PU238	40-001.BY1	3006
"	40-003.04	1130
"	40-003.11	1137
"	40-003.12	1138

cc: J. Plondke
R. Oldham

RO/ns

8001441

200	F	PU239	2.04000E+00	8.00000E-02	780901	DAY
210	F	PU239	8.60000E-01	3.00000E-02	780901	DAY
220	F	PU239	1.50000E+00	5.00000E-02	780901	DAY
230	F	PU239	1.83000E+00	8.00000E-02	780901	DAY

No detailed reports available
10/18/84
GA/HFL

DETAILED RESULTS: [redacted] 40-[redacted] 070 CASTB (NEW) 750529

PRIVACY ACT MATERIAL REMOVED

CALCIUM
****

NAME: *CASE NO.: 40-012 *SAMPLE NO.: 070

EVENT: COLLECTN *DATE OF EVENT: 730622 *LAB NO.: 1146

TYPE: U *SAMPLE DESCRIPTION: URINE -

ITEM	UNIT	ANALYSIS NUMBER 1	ANALYSIS NUMBER 2
1. SAMPLE SUB-NUMBER		070D	070D
2. METHOD		CHA	CHA
3. DATE REQUESTED		730815	730815
4. DATE ANALYZED		741022	741210
5. SAMPLE SIZE	DAY	1.000	1.000
6. ALIQUOT FRACTION		0.818	0.818
7. VOL. OF ALIQUOT	ML	100.000	100.000
8. VOL. MEASURED	ML	0.050	0.050
9. ALIQUOT FACTOR		4.090E-04	4.090E-04
10. SAMPLE SIZE MEASURED	DAY	4.091E-04	4.091E-04
11. CA IN ALIQUOT	UG	35.100	34.500
12. STD. ERROR(SYS) - 2%	UG	0.702	0.690
13. CA CONCN OR RATE	MG/DAY	85.808	84.342
14. REFERENCES-CHR DOCS.		RC30	RC30

RECEIVED

JAN 7 '76

CHR RECORDS

****
* RESULTS *
****

1. CA CONCENTRATION OR RATE(WTD. MEAN)	85.062	MG/DAY
2. STD.ERROR(EXTERNAL)	0.733	MG/DAY
3. STD. ERROR(INTERNAL)	1.203	MG/DAY
4. VARIANCE RATIO,F	0.372	
5. FRACTIONAL STD. ERROR	0.014	

****

CA (MEAN) IN ALIQ #1 : 34.795 ± 0.492 UG

CA CONCENTRATION OR RATE: 85.062 ± 1.203 MG/DAY

ANALYZED BY: JS CHECKED: [redacted] REVIEWED BY/DATE: RBH DEC 1- '75

COMMENTS AND REFERENCES:

TO (BY/DATE): CHR FILE: 12/5/76 SR FORM:_____SA CARD:_____CHEM FILE:_____

CHR FORM 3/7/75

PRIVACY ACT MATERIAL REMOVED

8001443

PRIVACY ACT MATERIAL REMOVED

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

Name _____ Case No. 40.012 Sample No. 109

Event EXCRETION Time, Date 0800 6/24 - 0800 6/25/73 Mean Time, Date _____

Sample Description FRESH URINE

Collected at UNIV. OF ROCHESTER Other Information _____

Sample Size (Unit) 1.00 (DAYS) Chem Lab. No. 1148

Analyses Requested for: ^{239}Pu by: Initials/Date RPL / 8-15-73

SUMMARY OF RESULTS (at time of event)

Nuclide, Element or Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date		
							Entered	Checked	To CHR File
^{239}Pu	PU1	pCi	3.56 ± 0.3	3.56 ± 0.3		RC-28-PS	RPL 11-30-73	RPL 12-3-73	9P 12/21/73

Additional Comments:

RECEIVED DEC 21 '73 CHR RECORDS

PRIVACY ACT MATERIAL REMOVED

8001444

PRIVACY ACT MATERIAL REMOVED

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

Name _____ Case No. 40,012 Sample No. ,10

Event EXCRETION Time, Date 0800 6/25 - 0800 6/26/73 Mean Time, Date _____

Sample Description FRESH URINE

Collected at UNIV. OF ROCHESTER Other Information _____

Sample Size (Unit) 1.00 (DAYS) Chem Lab. No. 1149

Analyses Requested for: ^{239}Pu by: Initials/Date RPL / 8-15-73

SUMMARY OF RESULTS (at time of event)

Nuclide, Element or Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date		
							Entered	Checked	To CHR File
^{239}Pu	Pu I	pCi	5.33 ± 0.3	5.33 ± 0.3		RC-2B-PS	RPL 11-30-73	RPL 12-3-73	gp 12/21/73

Additional Comments:

RECEIVED DEC 21 '73 CHR RECORDS

8001445

PRIVACY ACT MATERIAL REMOVED

PRIVACY ACT MATERIAL REMOVED

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

Name _____ Case No. 40.012 Sample No. 11

Event EXCRETION Time, Date 0800 6/26 - 0800 6/27/73 Mean Time, Date _____

Sample Description FRESH URINE

Collected at UNIV. OF ROCHESTER Other Information _____

Sample Size (Unit) 1.00 (DAYS) Chem Lab. No. 1150

Analyses Requested for: ^{239}Pu by: Initials/Date RPL / 8-15-73

SUMMARY OF RESULTS (at time of event)

Nuclide, Element or Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date: Entered	Checked	To CHR File
^{239}Pu	Pu I	pCi	4.4 ± 0.3	4.4 ± 0.3		RC-28-PS	KPL 11-30-73	RPL 12-3-73	gp 12/21/73

Additional Comments:

RECEIVED DEC 21 '73 CHR RECORDS

8001446

PRIVACY ACT MATERIAL REMOVED

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

Name _____ Case No. 40.012 Sample No. .12

Event EXCRETION Time, Date 0800 6/27 - 0800 6/28/73 Mean Time, Date _____

Sample Description FRESH URINE

Collected at UNIV. OF ROCHESTER Other Information _____

Sample Size (Unit) 1.00 (DAYS) Chem Lab. No. 1151

Analyses Requested for: ^{239}Pu by: Initials/Date RPL / 8-15-73

SUMMARY OF RESULTS (at time of event)

Nuclide, Element or Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date		
							Entered	Checked	To CHR File
^{239}Pu	Pu I	pCi	4.90 ± 0.3	4.90 ± 0.3		RC-28-PS	RPL 11-30-73	RPL 12-3-73	JP 12/21/73

Additional Comments:

8001447

PRIVACY ACT MATERIAL REMOVED

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

Name _____ Case No. 40.012 Sample No. .13

Event EXCRETION Time, Date 0800 6/28 - 0800 6/29/73 Mean Time, Date _____

Sample Description FRESH URINE

Collected at UNIV. OF ROCHESTER Other Information _____

Sample Size (Unit) 1.00 (DAYS) Chem Lab. No. 1152

Analyses Requested for: ^{239}Pu by: Initials/Date RPL/8-15-73

SUMMARY OF RESULTS (at time of event)

Nuclide, Element or Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date: Entered	Checked	To CHR File
^{239}Pu	Pu 1	pCi	5.35 ± 0.3	5.35 ± 0.3		RC-28-PS	RPL 11-30-73	RPL 12-3-73	GP 12/21/73

Additional Comments:

PRIVACY ACT MATERIAL REMOVED

8001448

RECEIVED DEC 21 '73 R RECORDS

DETAILED RESULTS: 40-012 140 CASTB (NEW) 750529

PRIVACY ACT MATERIAL REMOVED

CALCIUM
****

NAME: *CASE NO.: 40-012 *SAMPLE NO.: 140

EVENT: COLLECTN *DATE OF EVENT: 730629 *LAB NO.: 1153

TYPE: U *SAMPLE DESCRIPTION: URINE -

ITEM	UNIT	ANALYSIS NUMBER 1	ANALYSIS NUMBER 2
1. SAMPLE SUB-NUMBER		140C	140C
2. METHOD		CHA	CHA
3. DATE REQUESTED		730815	730815
4. DATE ANALYZED		741022	741210
5. SAMPLE SIZE	DAY	1.000	1.000
6. ALIQUOT FRACTION		0.793	0.793
7. VOL. OF ALIQUOT	ML	100.000	100.000
8. VOL. MEASURED	ML	0.050	0.050
9. ALIQUOT FACTOR		3.966E-04	3.966E-04
10. SAMPLE SIZE MEASURED	DAY	3.967E-04	3.967E-04
11. CA IN ALIQUOT	UG	31.900	30.900
12. STD. ERROR(SYS) - 2%	UG	0.638	0.618
13. CA CONCN OR RATE	MG/DAY	80.423	77.902
14. REFERENCES-CHR DOCS.		RC30	RC30

RECEIVED
JAN [illegible]
CHR RECORDS

****
* RESULTS *
****

1. CA CONCENTRATION OR RATE(WTD. MEAN)	79.123	MG/DAY	
2. STD.ERROR(EXTERNAL)	1.260	MG/DAY	
3. STD. ERROR(INTERNAL)	1.119	MG/DAY	
4. VARIANCE RATIO,F	1.267		
5. FRACTIONAL STD. ERROR	0.016		

****

CA (MEAN) IN ALIQ #1 : 31.384 ± 0.500 UG

CA CONCENTRATION OR RATE: 79.123 ± 1.260 MG/DAY

ANALYZED BY: JS CHECKED: _____ REVIEWED BY/DATE: BH DEC 1 [illegible]

COMMENTS AND REFERENCES:

TO (BY/DATE): CHR FILE: BH 1/5/76 SR FORM: _____ SA CARD: _____ CHEM FILE: _____
CHR FORM 3/7/75

PRIVACY ACT MATERIAL REMOVED

8001449

PRIVACY ACT MATERIAL REMOVED

SUMMARY REPORT - CHEMICAL ANALYSES
Center for Human Radiobiology

Name _____ Case No. 40.012 Sample No. .14

Event EXCRETION Time, Date 0800 6/29 - 0600 6/30/73 Mean Time, Date _____

Sample Description FRESH URINE

Collected at UNIV. OF ROCHESTER Other Information _____

Sample Size (Unit) 1.00 (DAYS) Chem Lab. No. 1153

Analyses Requested for: ^{239}Pu by: Initials/Date RPL/8-15-73

SUMMARY OF RESULTS (at time of event)

Nuclide, Element or Ratio	Method of Analysis	Unit	Amount in Whole Sample ± SE	Concentration or Rate ± SE Unit/	Comments and Assumptions	Laboratory Documents	Initials and Date: Entered	Checked	To CHR File
^{239}Pu	Pu I	pCi	4.46 ± 0.3	4.46 ± 0.3		RC-28-PS	RPL 11-30-73	RPL 12-3-73	gp 12/21/73

Additional Comments:

PRIVACY ACT MATERIAL REMOVED

RECEIVED
DEC 21 '73
RECORDS

8001450

Outside
Medical

THE UNIVERSITY OF ROCHESTER
MEDICAL CENTER
SCHOOL OF MEDICINE AND DENTISTRY · SCHOOL OF NURSING
STRONG MEMORIAL HOSPITAL

601 ELMWOOD AVENUE
ROCHESTER, NEW YORK 14642
AREA CODE 716

PRIVACY ACT MATERIAL REMOVED

Unit # ? 239322

Gail L. Knasli, ART
Argonne National Laboratory
9700 S. Cass Ave.
Argonne, Ill 60439

Date: 8/3/84

Re:
SMH Unit Number: 27-26-05

Dear Sir:

This is in reply to your request of 7/5/84 concerning the above named patient.

We regret that we are unable to provide you with the information requested as this patient's medical record is unavailable at this time. Every effort is being made to locate this patient's record.

We will contact you again, in the near future, as to the status of your request.

Sincerely,

Gertrude Kirchner

Correspondence Secretary
Medical Records Department
Strong Memorial Hospital

716/ 275-5954

RECEIVED
OCT 25 1984
CHR RECORDS

Called 9/5/84 —
Records still coming,
once letter on file,
they will check again in
two weeks.

MRD-23C
8/24/78

PRIVACY ACT MATERIAL REMOVED

called 9/10/84
held new unit #:
23 93 22

RECEIVED CHR
AUG 7 1984
RECORDS ROOM

DC obtained 10/2/84 No further Contact to be
this Facility

8001452

PRIVACY ACT MATERIAL REMOVED

40-01c

CENTER FOR HUMAN RADIOBIOLOGY

Operated for the U.S. Department of Energy by Argonne National Laboratory

July 5, 1984

Medical Record Department
Strong Memorial Hospital of the
University of Rochester
601 Elmwood Avenue
Rochester, New York 14642

Attention: Correspondence Secretary

RE:
Unit#: 27 26 05 –
DOB:

Dear Reader:

The Center for Human Radiobiology at Argonne National Laboratory is engaged in an ongoing medical and scientific study of persons who have been exposed to the internal deposition of radium and/or other radioisotopes.

We are writing to request the most recent discharge date for the patient listed above, . has been a participant in this study for many years.

Thank you in advance for your cooperation. Enclosed is a self-addressed pre-paid envelope for your reply.

Sincerely,

Gail L. Knasko, ART, CTR
Supervisor, Records

GLK
Enc.

PRIVACY ACT MATERIAL REMOVED

RECEIVED

OCT 25 1984

CHR RECORDS

8001453

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue

CENSUS TRACT | SUB-DIVISION

RECORDED DISTRICT 2700
REGISTER NUMBER 002265

NEW YORK STATE DEPARTMENT OF HEALTH
CERTIFICATE OF DEATH

0 0 0 0 0 3 2

PRIVACY ACT MATERIAL REMOVED 40-012

STATISTICAL DISTRICT
REC. 2769
RES. 2769

C 0

STATUS VERIFIED UNCLASSIFIED 33 DATE 5/16/84
AUTHORIZED DERIVATIVE CLASSIFIER
USUAL RESIDENCE OF DECEDENT

00

0

431

RECEIVED
OCT 2 1984
RECORDS ROOM

CHS

COD

DECEDENT

1 NAME FIRST — MIDDLE — LAST

2 SEX: MALE [X] 1 FEMALE [ ] 2

3A DATE OF DEATH: MONTH 5 DAY 6 YEAR 84

3B HOUR 6 30 A

4 AGE: 82 YEARS — IF UNDER 1 YEAR: MONTHS, DAYS — IF UNDER 1 DAY: HOURS, MINUTES

5 DECEDENT BORN: MONTH, DAY, YEAR

6 VETERAN OF U.S. ARMED FORCES? NO [X] YES [ ] IF YES, SPECIFY WAR OR DATES OF SERVICE

7 SOCIAL SECURITY NUMBER

8A COUNTY OF DEATH: Monroe

8B LOCALITY (CHECK ONE AND SPECIFY): [ ] CITY OF [ ] TOWN OF [X] VILLAGE OF East Rochester

8C HOSPITAL OR OTHER INSTITUTION (IF NEITHER, GIVE ADDRESS): 145 W. Ivy St.

8D IF IN HOSPITAL OR INSTITUTION (CHECK ONE): 1 [ ] D.O.A. 2 [ ] EMERGENCY ROOM 3 [ ] OUTPATIENT 4 [ ] INPATIENT

8E IF INPATIENT ADMISSION DA: MONTH, DAY, YR

9 STATE OF BIRTH (COUNTRY IF NOT USA): New York

10 CITIZEN OF WHAT COUNTRY? U.S.A.

11 MARITAL STATUS (CHECK ONE): 1 [ ] NEVER MARRIED 2 [ ] MARRIED OR SEPARATED 3 [X] WIDOWED 4 [ ] DIVORCED

12 SURVIVING SPOUSE (IF WIFE GIVE MAIDEN NAME)

13 RACE WHITE, BLACK, AMERICAN INDIAN, OTHER (SPECIFY): white

14 OF SPANISH ORIGIN? IF YES CHECK ONE: 1 [ ] MEXICAN 2 [ ] PUERTO RICAN 3 [ ] CUBAN 4 [ ] CENTRAL OR SOUTH AMERICAN — [ ] YES 0 [X] NO 9 [ ] OTHER SPANISH ORIGIN (SPECIFY)

15 EDUCATION INDICATE HIGHEST GRADE COMPLETED ONLY: ELEMENTARY 0 1 2 3 4 5 6 7 8 (00 01 02 03 04 05 06 07 08) — HIGH SCHOOL 1 2 3 4 (09 10 11 12) — COLLEGE 1 2 3 4 5+ (13 14 15 16 17)

16A USUAL OCCUPATION (DO NOT ENTER RETIRED): custodian

16B KIND OF BUSINESS OR INDUSTRY: municipality

16C NAME AND LOCALITY OF FIRM OR COMPANY

RESIDENCE

17A STATE: New York

17B COUNTY: Monroe

17C LOCALITY (CHECK ONE AND SPECIFY): [ ] CITY OF [ ] TOWN OF [X] VILLAGE OF East Rochester

17E IF CITY OR VILLAGE, IS RESIDENCE WITHIN CITY OR VILLAGE LIMITS? YES [X] NO [ ] IF NO, SPECIFY TOWN

17D STREET AND NUMBER OF RESIDENCE (INCLUDE ZIP CODE)

18A NAME OF FATHER: FIRST — MIDDLE — LAST

18B MAIDEN NAME OF MOTHER: FIRST — MIDDLE — LAST

19A NAME OF INFORMANT

19B MAILING ADDRESS (INCLUDE ZIP CODE)

DISPOSITION

20A BURIAL, CREMATION, REMOVAL OR OTHER DISPOSITION (SPECIFY): Burial — MONTH 5 DAY 09 YEAR 84

20B PLACE OF BURIAL, CREMATION, REMOVAL OR OTHER DISPOSITION

20C LOCATION (CITY OR TOWN, STATE): Perinton, N.Y.

21A NAME AND ADDRESS OF FUNERAL HOME

21B REGISTRATION NO: 01075

22A NAME OF FUNERAL DIRECTOR

22B SIGNATURE OF FUNERAL DIRECTOR

22C REGISTRATION NO: 02270

CERTIFIER

23A SIGNATURE OF REGISTRAR: Elizabeth N. Riley D.P. — 23B DATE FILED: MONTH 5 DAY 8 YEAR 84

24A BURIAL OR REMOVAL PERMIT ISSUED: Sharon Beeymer — 24B: MONTH 5 DAY 8 YE 8

TO BE COMPLETED BY CERTIFYING PHYSICIAN ONLY

25 A TO THE BEST OF MY KNOWLEDGE, DEATH OCCURRED AT THE TIME, DATE AND PLACE AND DUE TO THE CAUSES STATED — MONTH 5 DAY 6 YEAR 84

SIGNATURE ▶ John Kiaer MD

B THE PHYSICIAN ATTENDED THE DECEASED: FROM 1940 TO 5 6 84 — C LAST SEEN ALIVE: 5 5 84

D NAME OF ATTENDING PHYSICIAN, IF OTHER THAN CERTIFIER

—OR—

TO BE COMPLETED BY CORONER OR MEDICAL EXAMINER ONLY

25 A ON THE BASIS OF EXAMINATION AND/OR INVESTIGATION, IN MY OPINION DEATH OCCURRED AT THE TIME, DATE AND PLACE AND DUE TO THE CAUSES STATED — [ ] CORONER [ ] CORONER PHYSICIAN [ ] MEDICAL EXAMINER

SIGNATURE AND TITLE ▶

B PRONOUNCED DEAD ON — C HOUR — D DATE SIGNED: MONTH, DAY, YEAR

E SIGNATURE OF CORONER OR CORONER'S PHYSICIAN, IF OTHER THAN CERTIFIER ▶

COPY
CONFIDENTIAL

26 NAME AND ADDRESS OF CERTIFIER (PHYSICIAN, CORONER, MEDICAL EXAMINER, CORONER'S PHYSICIAN, MEDICAL DIRECTOR): John Kiaer MD 54 S. Main Fairport NY 14450

CAUSE

27 DEATH WAS CAUSED BY — ENTER ONLY ONE CAUSE PER LINE FOR (A), (B), AND (C) — APPROXIMATE INTERVAL BETWEEN ONSET AND DEATH

PART I IMMEDIATE CAUSE
(A) Cerebral hemorrhage - massive — 36 hr

DUE TO, OR AS A CONSEQUENCE OF
(B) cerebral arterio sclerosis — 10+ yrs

DUE TO, OR AS A CONSEQUENCE OF
(C) generalized arterio sclerosis — 20 yrs

CONDITIONS, IF ANY, WHICH GAVE RISE TO IMMEDIATE CAUSE (A) STATING THE UNDERLYING CAUSE LAST

PART II OTHER SIGNIFICANT CONDITIONS CONDITIONS CONTRIBUTING TO DEATH BUT NOT RELATED TO CAUSE GIVEN IN PART I (A): diabetes mellitus - senile dementia

28A AUTOPSY? YES [ ] 1 NO [ ] 2

28B IF YES WERE FINDINGS CONSIDERED IN DETERMINING THE CAUSE OF DEATH? 1 [ ] YES 2 [ ] NO

29 WAS CASE REFERRED TO CORONER OR MEDICAL EXAMINER? 1 [ ] YES 2 [X] N

30A SPECIFY IF ACCIDENT, HOMICIDE, SUICIDE, UNDETERMINED, PENDING INVESTIGATION

30B DATE OF INJURY: MONTH, DAY, YEAR

30C HOUR OF INJURY

30D DESCRIBE HOW INJURY OCCURRED

30E INJURY AT WORK? YES [ ] NO [ ]

30F PLACE OF INJURY HOME, FACTORY OFFICE BLDG., ETC.

30G LOCATION (STREET & NO., CITY OR VILLAGE, TOWN, COUNTY, STATE)

SUP ORDER

PRIVACY ACT MATERIAL REMOVED

MAY 7 1985

8001455

PRIVACY ACT MATERIAL REMOVED

Offer of Medical Care

I hereby acknowledge that Dr. Wakeham has advised me that the Atomic Energy Commission has offered to me at government expense a program of regular medical surveillance and care. I understand that the above program incurs no obligation whatsoever on my part including further research studies. I have decided to accept (~~reject~~) this offer.

Date 12/30/74 Patient's Signature _____

Witnessed by: _____

PRIVACY ACT MATERIAL REMOVED

PRIVACY ACT MATERIAL REMOVED

Acknowledgement of Disclosure

I do hereby acknowledge that I have been informed by Dr. Wolbarst on Aug 28, 1974 of my participation in a biological experiment undertaken by the Manhattan Engineer District between 1945 and 1947 to determine how plutonium, a man-made radioactive material, is deposited and excreted in the human body. More specifically, I have been informed that I was injected with soluble plutonium on _____, 1945 while I was a patient at Strong Memorial Hospital, Rochester (City), N.Y. (State).

Date _____ Patient's Signature _____

Witnessed by: _____

PRIVACY ACT MATERIAL REMOVED

THE UNIVERSITY OF ROCHESTER
SCHOOL OF MEDICINE AND DENTISTRY
AND
STRONG MEMORIAL HOSPITAL
260 CRITTENDEN BOULEVARD
ROCHESTER, NEW YORK 14620

PRIVACY ACT MATERIAL REMOVED

July 13, 1973

Argonne National Laboratory
9700 S. Cass Avenue
Argonne, Illinois 60439

Billing for hospitalization of
Research Patient

June 21 to July 1, 1973

10 days at $132.29	$1,322.90

Billing for hospitalization of
Research Patient

June 13, to June 26, 1973

13 days at $132.29	1,719.77
Shipping charges for frozen specimens relating to these patients	71.58
	$3,114.25

Your Purchase Order #762107 dated 1-11-73

Send check to the attention of
Mr. David J. Fanning

PRIVACY ACT MATERIAL REMOVED

8001460

filename = SNOP
file type = PDS

Page 1 of 1

Description		Case #		A,T								
Addison's disease	@M,	40-012,	@A,T,	9300,	M,	0000,	E,	0000,	F,	4639,	D,	4550J,
infected lesions - eyelids	@M,	↓,	@A,T,	XX81,	M,	4000,	E,	↓,	F,	0000,	D,	↓,
--toes	@M,	↓,	@A,T,	Y930,	M,	4000,	E,	↓,	F,	0000,	D,	↓,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,
	@M,	,	@A,T,	,	M,	,	E,	,	F,	,	D,	,

8001461