USTUR - 0487-17

United States Transuranium and Uranium Registries

Annual Report

April 1, 2016 - March 31, 2017

College of Pharmacy
WASHINGTON STATE UNIVERSITY

USTUR - 0487-17

United States Transuranium and Uranium Registries

Annual Report

April 1, 2016 - March 31, 2017

Compiled and Edited

Stacey L. McComish and Sergei Y. Tolmachev

September 2017

Acknowledgment: This material is based upon work supported by the U.S. Department of Energy, Office of Domestic and International Health Studies (AU-13) under Award Number DE-HS0000073.

USTUR

A unique resource since 1968

Learning from Plutonium and Uranium Workers

United States Transuranium and Uranium Registries
College of Pharmacy, Washington State University
1845 Terminal Drive, Suite 201, Richland, WA 99354
800-375-9317 Toll Free
509-946-6870 Direct
509-946-7972 FAX
www.ustur.wsu.edu

Table of Contents

Faculty and Staff

Faculty

Sergei Y. Tolmachev	Director
Stacey L. McComish	Associate in Research
Maia Avtandilashvili	Research Associate
George Tabatadze	Research Associate
Sara Dumit	PhD Candidate

Adjunct Faculty and Emeritus

Alan Birchall	Adjunct Professor
Ronald L. Kathren	Professor, Emeritus

Classified Staff

Margo D. Bedell	Fiscal Specialist I
Elizabeth M. Thomas	Laboratory Technician II

Part-time Employees

Warnick Kernan	Laboratory Assistant I
Florencio T. Martinez	Medical Technologist

Consultants

Eric Kiesel	Forensic Pathologist
Minh Pham	IT Support
Mariya Tolmachova	Technical Editor

Student Employees

Elizabeth Gage	Laboratory Assistant I

Advisory Committee

Committee Chair

Richard E. Toohey	Health Physics, Radiobiology

Committee Members

Heather J. Hoffman	Epidemiology
Timothy J. Ledbetter	Ethics
Roger O. McClellan	Toxicology
Thomas L. Rucker	Radiochemistry
Arthur W. Stange	Occupational Health
Robert W. Bistline	Occupational Health (*retired*)
Herman J. Gibb	Epidemiology (*retired*)

Contact Information

Address

U.S. Transuranium and Uranium Registries
College of Pharmacy
Washington State University
1845 Terminal Drive, Suite 201
Richland, WA 99354-4959

Phone: 509-946-6870
Toll-Free: 800-375-9317
Fax: 509-946-7972
www.ustur.wsu.edu

E-mail

Sergei Y. Tolmachev	stolmachev@wsu.edu
Stacey L. McComish	s.mccomish@wsu.edu
Maia Avtandilashvili	m.avtandilashvili@wsu.edu
George Tabatadze	george.tabatadze@wsu.edu
Elizabeth M. Thomas	elizabeth.thomas@wsu.edu
Margo D. Bedell	margo.bedell@wsu.edu
Sara Dumit	sara.dumit@wsu.edu

Executive Summary

Sergei Y. Tolmachev, *USTUR Director*

This report summarizes organization, activities, and scientific accomplishments for the U.S. Transuranium and Uranium Registries (USTUR) and the associated National Human Radiobiology Tissue Repository (NHRTR) for the period of April 1, 2016 – March 31, 2017. This is the fifth fiscal year (FY) of the USTUR's 5-year grant proposal (April 1, 2012 – March 31, 2017).

50-year Anniversary Events

On July 19, 2016, the USTUR conducted a one-day special session on the USTUR's research, "USTUR: Five Decade Follow-up of Plutonium and Uranium Workers," at the 61st Annual Meeting of the Health Physics Society (HPS), Spokane, WA. The special session concluded with a roundtable discussion on 50 years of USTUR history. A two-day information booth exposition was displayed during the meeting.

Scientific Advisory Committee

The annual Scientific Advisory Committee (SAC) meeting was held July 20, 2016 in conjunction with the HPS meeting. The committee reviewed the USTUR's progress since the previous meeting (September 2015) and made recommendations for the upcoming year. Two SAC members retired this year: epidemiology representative Herman Gibb and occupational health representative Robert Bistline. Both members had served for three 3-y terms. Dr. Bistline was involved in the inception of the Registries in 1966. Drs. Bistline and Gibb will be greatly missed.

U.S. AEC meeting on plutonium contamination in man (Rocky Flats, July 1966)

Dr. Heather J. Hoffman (George Washington University) and Dr. Arthur W. Stange (Oak Ridge Associated Universities) were appointed as epidemiology and occupational health representatives, respectively.

Funding Increase

A 5-year grant renewal proposal to manage and operate the United States Transuranium and Uranium Registries and the associated National Human Radiobiology Tissue Repository (NHRTR), during FY2018-22 (April 1, 2017 – March 31, 2022), was submitted to the Department of Energy (DOE) Associate Under Secretary for the Office of Environment, Health, Safety and Security (AU-13). The approved 5-y budget amounted to $5,500,000. This is the first USTUR funding increase since 2009, when the USTUR operated on a $900,000 annual budget.

Graduate Student Research Involvement

Sara Dumit, defended her dissertation proposal "Plutonium Biokinetics in the Human Body under Decorporation Treatment" and became a candidate for the degree of Doctor of Philosophy in Pharmaceutical Sciences at the College of Pharmacy, Washington State University. Ms. Dumit will continue her research at the USTUR under Dr. Tolmachev's supervision.

Organization and Personnel

The organizational structure of the USTUR Research Center as of March 31, 2017 is provided in Appendix A. A total of 6.1 full-time equivalent (FTE), including graduate student at 0.3 FTE, was supported in FY2017 by the available funding.

Registrant Donations

Two partial-body donations were received by the USTUR in FY2017: Case 0410 (Rocky Flats) and Case 0421 (Rocky Flats). As of March 31, 2017, USTUR received 43 whole- and 304 partial-body donations.

NHRTR Inventory

Inventory of tissue samples from FY2017 donations was completed. As of March 31, 2017, 8,908 tissue samples from 42 whole- and 108 partial-body donations were inventoried. These Registrants passed away between 1982 and 2017.

Radiochemistry Operation

Significant progress was made by the Radiochemistry Group on tissue analyses. A total of 406 tissue samples from 8 whole-body and 10 partial-body donations were analyzed for plutonium and americium isotopes using α-spectrometry. Radiochemical survey analyses of 3 whole-body cases and full analyses of 9 partial-body cases were completed. Overall, 1,604 tissue samples from 26 whole- and 29 partial-body donors, and one living Registrant were analyzed at the USTUR during FY2013–FY2017.

Health Physics Database

Standardization of exposure records and bioassay data for 11 living Registrants, including 7 whole- and 4 partial-body donors, and 19 deceased partial-body donors was completed. As of March 31, 2017, the database holds a total of 105,000 data records from 203 deceased donors (43 whole-body and 160 partial-body), 15 living Registrants (7 whole-body and 8 partial-body), and one special study case.

Research Results

The USTUR faculty authored one and co-authored two papers published in a special issue of Radiation Protection Dosimetry journal on Mayak Worker Dosimetry System - 2013 (MWDS-2013). The USTUR adjunct faculty, Dr. Alan Birchall, authored four and co-authored eight peer-reviewed articles in the MWDS-2013 special issue. In addition, Dr. Birchall co-authored a paper on a case-control study of lung cancer and leukemia among European nuclear workers. During FY2017, two invited, six podium, and one poster presentations at national and international conferences were given by USTUR faculty and a graduate student.

Administrative

The annual Institutional Review Board (IRB) review was completed and the program was approved without changes for another year. The annual USTUR Newsletter was sent to the Registrants and/or their next-of-kin.

Financial and Administrative Report

Margo D. Bedell, *Fiscal Specialist I*

On April 1, 2016, the USTUR began the fifth grant year of the USTUR's 5-year grant proposal (April 1, 2012 – March 31, 2017).

Fiscal year (FY) 2017 (April 1, 2016 – March 31, 2017) funding sources were:

Federal Resources

Grant

U.S. Department of Energy Office of Health, Safety and Security, Office of Domestic and International Health Studies (DOE/AU-13):

Manage and Operate the United States Transuranium and Uranium Registries

DE-HS0000073

Amount awarded: $900,000

Period: April 1, 2016 – March 31, 2017

Total funding granted by DOE/AU-13 to WSU/COP/USTUR from April 1, 2012 until March 31, 2017 (FY2013 – FY2017) was $4,500,000.

Operating budget

With $33,036 negative carry-over from FY2016, the USTUR net operating budget for FY2017 was $866,964. Total operating expenses for FY2017 were $903,567,442 resulting in a negative balance of $36,603.

50th Anniversary Funding

U.S. Department of Energy Office of Health and Safety (DOE/AU-10):

USTUR: Five Decade Follow-up of Plutonium and Uranium Workers

Amount awarded: $30,000

Period: October 1, 2016 – September 30, 2018

Available in FY2017: $30,000.

Grant Administration

Five-year Grant Renewal Proposal

On January 17, 2017, a 5-year grant renewal proposal to manage and operate the United States Transuranium and Uranium Registries and the associated National Human Radiobiology Tissue Repository (NHRTR), during FY2018-22 (April 1, 2017 – March 31, 2022), was submitted to the DOE/AU-13 through the WSU's Office of Research Support and Operations (ORSO). The requested FY2018-22 budget was $5,500,000.

Human Subject Protocol

WSU's Institutional Review Board (IRB) reviews the USTUR's human subject protocol annually. This year, the USTUR protocol underwent expedited IRB revision, and approval was granted for another year (until August 22, 2017). The USTUR also provided information on its current research project to DOE's Human Subject Database. This is required annually for projects funded by DOE that involve human subjects.

Reporting Requirements Met

Four quarterly progress reports for the federally funded grant (DE-HS0000073) were distributed on a timely basis to sponsoring agencies and the university during the period April 1, 2016 – March 31, 2017. The FY2016 annual report (USTUR-0403-16) for the DE-HS0000073 grant was published and electronically distributed.

USTUR: Celebrating 50 Years

Stacey L. McComish, *Associate in Research*

The year 2018 will mark 50 years of actinide research at the USTUR. In honor of this upcoming milestone, and the Registries' continued impact in the field of radiation protection, the USTUR has organized several special activities, which will increase the USTUR's visibility in the scientific community:

1. Conduct a one-day special session on the USTUR's research, "USTUR: Five Decade Follow-up of Plutonium and Uranium Workers," at the 61st Annual Meeting of the Health Physics Society (HPS), Spokane, WA. (2016)

2. Host a USTUR booth at the HPS's annual meeting. (2016)

3. Publish a special issue of the *Health Physics* journal. (2017)

4. Publish an extension of the previous book of USTUR publications, which spanned the years 1968-1996. (2018)

Special Session

On July 19, the 61st Annual Meeting of the Health Physics Society featured a one-day special session, "USTUR: Five-Decade Follow-Up of Plutonium and Uranium Workers." The special session program is available as Appendix B. The session was opened by Dr. Patricia Worthington, Director of the Office of Health and Safety (DOE/AU-10), followed by keynote presentations

Keynote presentation by Ronald L. Kathren

by Ronald Kathren (WSU) and Eugene Carbaugh (Dade Moeller at NV5). The morning session focused on internal research projects conducted by the USTUR. Presenters were: Sergei Tolmachev (USTUR), Maia Avtandilashvili (USTUR), Sara Dumit (USTUR), George Tabatadze (USTUR), and Joey Zhou (DOE/AU-13). The afternoon session covered research carried out through external collaborations. Presenters were: Richard Toohey (M. H. Chew and Associates), Roan Goans (REAC/TS), Maria Lopez (EURADOS), and Bastian Breustedt (KIT).

The special session concluded with a roundtable discussion on "50 years of USTUR history." It was led by a panel of former directors and scientists who were involved with the Registries when its predecessor organizations were established:

- Margery Swint, USTR/USUR director (1982–1989)
- Ronald Kathren, USTUR director (1989–1999)
- Ronald Filipy, USTUR director (1999–2005)

Roundtable panel (left to right): Robert Bistline, Roger McClellan, James McInroy, Margery Swint, Ronald Kathren, and Ronald Filipy; roundtable chair: Richard Toohey

- Jim McInroy, in charge of USTUR radio-chemistry work at Los Alamos (1975–1992)
- Roger McClellan, SAC member (2010-present)
- Robert Bistline, SAC member (2007-2016).

The roundtable discussion was moderated by Richard Toohey (SAC Chair, and USTUR Associate Director 1992–1993).

Panel members discussed various aspects of the USTUR. Topics included: (i) receiving the first whole body donation (Margery Swint); (ii) moving the Registries from Hanford to WSU (Ronald Kathren); (iii) USTUR collaboration with the Russian Radiobiological Human Tissue Repository (Ronald Filipy); (iv) autopsy studies at Los Alamos (Jim McInroy); (v) early days of the Registry from a personal perspective (Roger McClellan); (vi) early days of the Registry at Rocky Flats (Robert Bistline). Conference attendees were then invited to ask questions of the roundtable panel members.

The special session was publicized through a series of three articles in *Health Physics News* prior to the meeting. These included articles by Richard Toohey(1) (March 2016), Joey Zhou and Sergei Tolmachev(2) (May 2016), and Ronald Kathren(3) (July 2016).

Informational Booth

The USTUR hosted a two-day informational booth at HPS 2016 vendor exhibition hall. USTUR staff answered questions about the Registries, and handed out informational brochures. The booth's purpose was to maintain the visibility of the USTUR among HPS members, and to introduce the USTUR's research and personnel to those who were not familiar with the Registries.

Special Issue of *Health Physics*

Papers presented at the 2016 Health Physics Society Meeting are being compiled for publication as a special issue of the *Health Physics* journal. The following articles will be submitted to *Health Physics* as they are completed, so that they can be published electronically ahead of print:

- Kathren RL, Tolmachev SY. The United States Transuranium and Uranium Registries: Five Decade Follow-up of Plutonium and Uranium Workers.
- Cargaugh E. The Atomic Man: Case Study of the Largest Recorded ^{241}Am Deposition in a Human.
- Avtandilashvili M, Tolmachev SY. Improving ICRP Skeleton Weight vs. Body Height Equation.
- Birchall A, Puncher M, Hodgson A, Tolmachev SY. The Importance and Quantification of Plutonium Binding in Human Lungs.

- Breustedt B, Avtandilashvili M, McComish SL, Tolmachev SY. USTUR Case 0846: Modeling Americium Biokinetics Following Intensive Decorporation Therapy.
- Goans RE, Toohey RE, Iddins CJ, Dainiak N, McComish SL, Tolmachev SY. The Pseudo Pelger-Huet Cell as a Retrospective Dosimeter: Analysis of a Radium Dial Painter Cohort.
- Lopez MA, Nogueira P, Vrba T, Tanner R, Ruhm W, Tolmachev SY. EURADOS-USTUR Collaboration: Measurements of ^{241}Am and Monte Carlo Simulations in 3 Skull Phantoms.
- Tabatadze G, Miller B, Tolmachev SY. Mapping ^{241}Am Spatial Distribution Within Anatomical Bone Structures Using Digital Autoradiography.
- Tolmachev SY, Kathren RL. Estimation of Actinide Skeletal Content from Patella Bone Analysis.
- Zhou JY, Tolmachev SY. Reanalysis of Radiation and Mesothelioma in the U.S. Transuranium and Uranium Registries.

Publications Book

In 1993, all known USTUR journal articles, conference proceedings, annual reports, book chapters, and other publications were compiled and published in a three-volume series, “Publications of the United States Transuranium and Uranium Registries.” In 1997, scientific papers and reports from July 1993 through December 1996 were published as two additional volumes. Collectively, the five volumes were assigned USTUR publication number, USTUR-0004-93. In 2018, the USTUR will update this series with two additional volumes, which will include journal articles and various publications from January 1997 through December 2017.

References

1. Toohey RE. Special Session: Learning From Plutonium and Uranium Workers. *Health Physics News.* 44(3): 18-19; 2016.
2. Zhou J and Tolmachev S. USTUR Special Session: Five-Decade Follow-Up of Plutonium and Uranium Workers. *Health Physics News.* 44(5): 2-3; 2016.
3. Kathren R. A Little More on the Special USTUR Session. *Health Physics News*. 44(7): 8-9; 2016.

Presenters and chairs of the USTUR's special session at the Health Physics Society meeting, "USTUR: Five Decade Follow-up of Plutonium and Uranium Workers"

Registrant Statistics

Stacey L. McComish, *Associate in Research*

As of March 31, 2017, the Registries had 879 Registrants in all categories (Table 1). Of that number, 49 were living and 353 were deceased. The 49 living Registrants included 8 individuals who were registered for eventual whole-body donation, 36 for partial-body donation, and 5 for 'Special Studies,' i.e., a bioassay study with no permission for autopsy. There were also 477 Registrants in an inactive category, which includes those lost to follow-up and those whose voluntary agreements were not renewed.

Table 1. Registrant Statistics as of March 31, 2017

Total Living and Deceased Registrants:	402
Living Registrants:	49
Potential Partial-body Donors:	36
Potential Whole-body Donors:	8
Special Studies:	5
Deceased Registrants:	353
Partial-body Donations:	304
Whole-body Donations:	43
Special Studies:	6
Inactive Registrants:	477
Total Number of Registrants:	879

Registrant Renewals

The USTUR renews agreements with active Registrants every five years, to ensure that they still wish to participate in the program. The renewal process, along with the annual Registrant newsletter (Appendix C), also serves to maintain contact between the USTUR and living Registrants.

During this fiscal year, three Registrants renewed, one was placed in an inactive category, and one living Registrant changed from a future partial-body donor to a whole-body donor.

Registrant Deaths

The USTUR was notified of two Registrant deaths. Both were registered for partial-body donation. These autopsies were performed near the municipality where the Registrants passed away, and tissues were sent to the USTUR laboratory for radiochemical analysis.

Case 0410: This partial-body donor worked with plutonium, americium, and uranium at various points during his 29-year career. He was involved in five potential inhalation incidents, including a fire. The worksite estimated that he had a 4 nCi systemic burden of plutonium.

Case 0421: This partial-body donor worked with plutonium, americium, and uranium over the course of 38 years. He was involved in several contamination and wound incidents, and the worksite estimated that he had a 5.7 nCi systemic burden of plutonium.

Registrant Status

The average age of living whole- and partial-body Registrants was 81 years and 82 years, respectively. The average age at death for the USTUR's 347 deceased Registrants was 69 years.

The number of donations by calendar year, as well as the average age of donors by year, is shown in Figure 3.

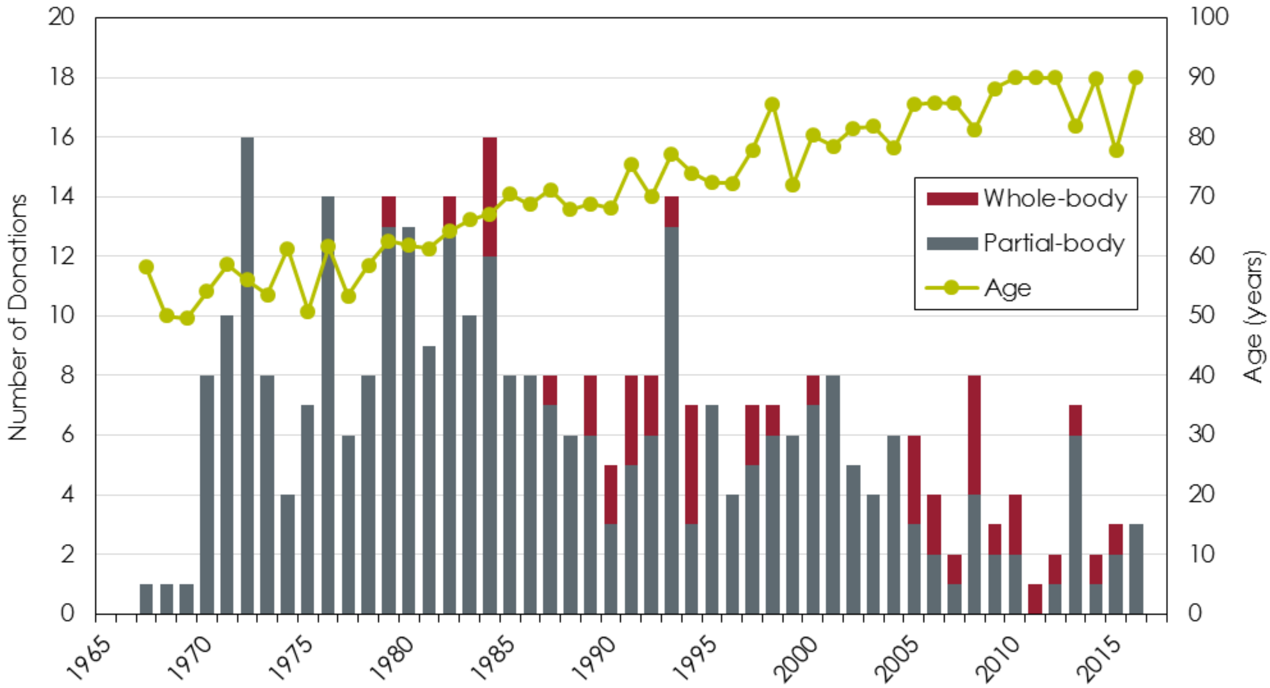


Fig. 3. Number of donations by calendar year and average age.

Health Physics Database

Maia Avtandilashvili, *Research Associate*

The USTUR Internal Health Physics Database is designed to standardize extensive sets of health physics data for USTUR donors and provide access to detailed incident, contamination, *in vitro* and *in vivo* bioassay, air monitoring, work site assessment, external dosimetry, and treatment information for scientists who are interested in studying the distribution and dosimetry of actinides in the human body.

FY2017 Data Entry

The USTUR currently holds documents containing health physics and bioassay records for 43 whole-body and 304 partial-body tissue donors, as well as 44 living Registrants.

The initial effort was focused on standardization of data from deceased Registrants. In 2012, the USTUR adopted the following strategy for populating the health physics database:

- Latest donation was given the highest priority and was completed immediately
- Existing donation cases were completed based on specific worksites with higher priority given to whole-body cases than to partial-body donations
- In special circumstances, priority was given to specific case(s) of particular scientific interest.

In 2016, the decision was made to complete population of health physics database for living Registrants before resuming data entry for remaining donation cases. Experience showed that the availability of standardized exposure information in the database (e.g. route of intake(s), location of contaminated wound(s), material characteristics etc.) for a recently deceased Registrant is essential for determining if additional samples, such as wound site samples, need to be collected at autopsy.

As of March 31, 2017, standardization of health physics records and bioassay data was completed for 203 deceased donors (43 whole-body and 160 partial-body), 15 living potential donors (7 whole-body and 8 partial-body), and one special study case. In total, 105,000 health physics records from deceased and living Registrants have been entered into the database. Figure 4 shows the FY2013–FY2017 overall progress in population of the health physics database for deceased and living Registrants.

The summary statistics of all completed cases, categorized based on the type of intake, primary radionuclide of exposure, and material type (solubility class), are presented in Figure 5.

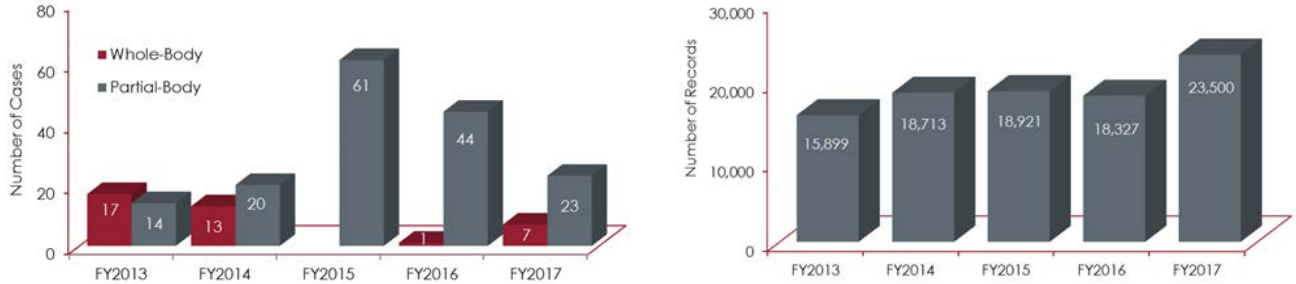


Fig. 4. FY2013-FY2017 progress of the USTUR health physics database for living and deceased Registrants by number of cases (left) and number of records (right).

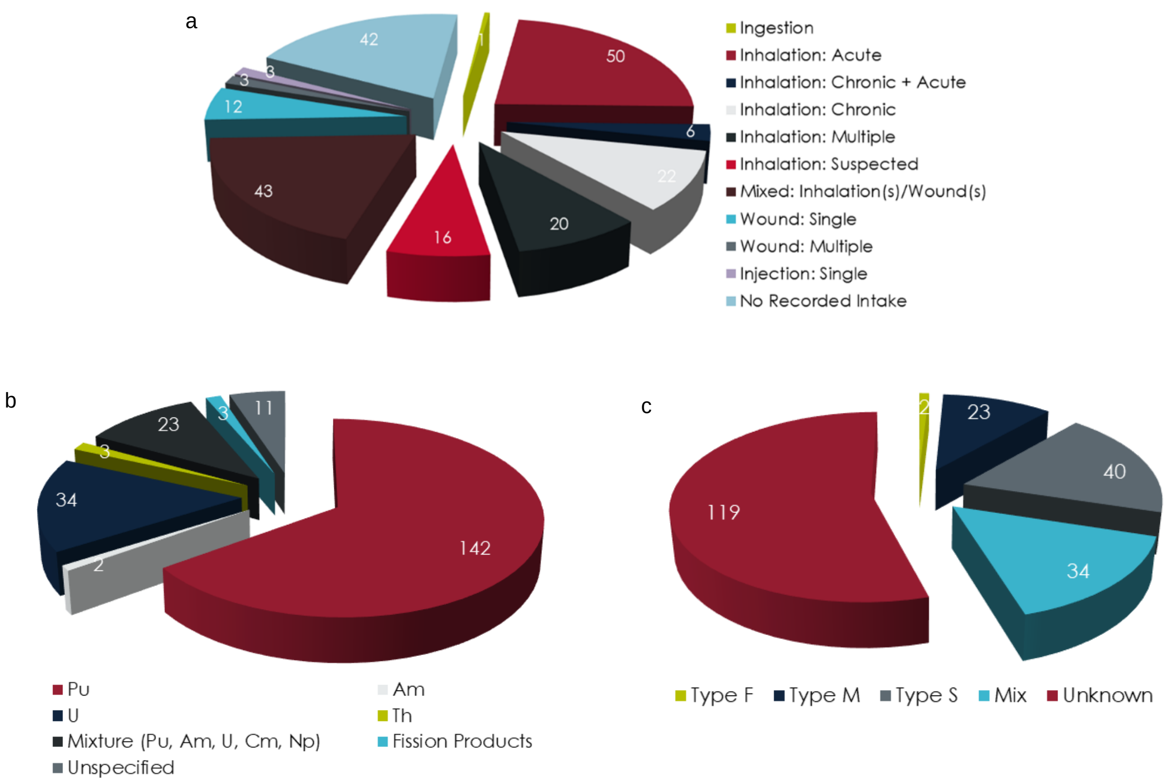


Fig. 5. Summary statistics of the health physics database: completed Registrant cases by intake (a); primary radionuclide (b); material type (c).

Five-year Database Progress

Figure 6 shows the progress toward population of the health physics database for deceased Registrants since its inception in 2008. By the end of FY2012 (March 31, 2012), health physics records and bioassay data were standardized for 19 deceased Registrants, including 12 whole-body and 7 partial-body donors. This was 6% of all donation cases received by the USTUR at that time.

Significant progress has been made during FY2013 - FY2017. As of March 31, 2017, population of the database was completed for 59% of all donation cases. These include all whole-body donations and 53% of partial-body donations.

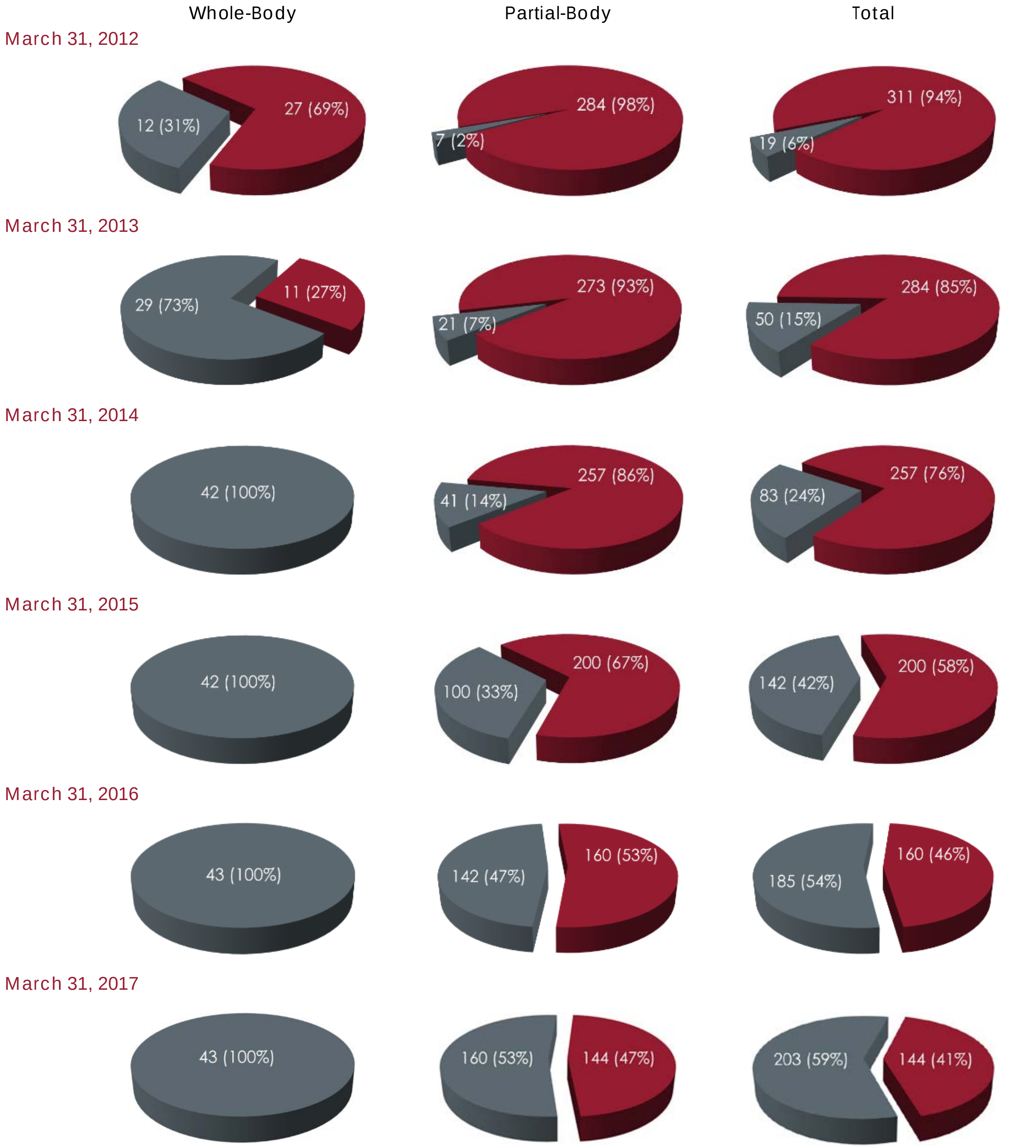


Fig. 6. Health physics database progress for deceased Registrants: ■ complete cases; ■ incomplete cases.

NHRTR: National Human Radiobiology Tissue Repository

Stacey L. McComish, *Associate in Research*

The National Human Radiobiology Tissue Repository (NHRTR) houses several collections of tissues, and related materials, from individuals with intakes of actinide elements and radium. These collections include tissues from USTUR donations, acid dissolved tissues from the Los Alamos Scientific Laboratory's (LASL) population studies, and tissues from the terminated radium worker and plutonium injection studies, which were received from Argonne National Laboratory (ANL).

Three primary activities, related to USTUR tissue donations, were carried out at the NHRTR: autopsies, dissection of donated tissues, and radiochemical analysis of tissues. Each of these activities generated specific samples, which were either stored for future use, or consumed during the radiochemical process. Table 2 summarizes these laboratory activities and the fate of the resulting USTUR samples.

During FY2017, NHRTR activities focused on the dissection and hygienic packaging of USTUR tissues, and inventory of (i) USTUR acid solution aliquots, (iI) LASL acid solutions, and (iii) USTUR and ANL histopathological slides. Sample inventory was carried out using The Management Information System (THEMIS). Due to limited funding, no further progress was made toward inventorying USTUR planchets or ANL tissues.

Table 2. USTUR samples generated at the NHRTR facility

Laboratory Operation	NHRTR samples generated	THEMIS Inventory	Storage
Autopsy	Paraffin-embedded tissue blocks	no	yes
	Histopathology slides	yes	yes
Dissection	Frozen and/or formalin-fixed tissues	yes	yes
Radiochemical Analysis of Tissues			
Drying/Ashing	Ashed tissues	no	no†
Digestion/Dissolution	Acid solutions	yes	yes
Actinide separation	Acid solution aliquots	yes	no†
Alpha Spectrometry	α-counting sources (planchets)	yes	yes

† Sample is consumed during radiochemical analysis.

Tissue Dissection

During FY2017, Florencio Martinez completed the dissection of two partial-body donations (0410 and 0421). Mr. Warnick Kernan assisted Mr. Martinez, and carried out vacuum packaging of the tissue samples.

THEMIS Inventory

As of March 31, 2017, 21,901 parent samples and 6,779 subsamples had been inventoried using the THEMIS database (Table 3). Parent samples best represent the number of unique tissues available at the USTUR; therefore, the following discussions about tissues and acid solutions exclude subsamples.

Table 3. Inventoried samples as of March 31, 2017

Tissue Type	Samples		
	Parent	Sub-	Total
USTUR donations			
Soft tissue samples	4,589	513	5,102
Bone samples	4,319	90	4,409
Histology slides	1,394	2,096	3,490
Acid solutions	6,015	2,618	8,633
Planchets	313	766	1,079
ANL tissues	1,449	427	1,876
LASL solutions	3,173	12	3,185
Blank and QC samples	358	200	558
Miscellaneous	291	57	348
Total	21,901	6,779	28,680

USTUR Tissue Samples

Information on 137 parent samples was entered into THEMIS during FY2017. This placed the total number of inventoried USTUR tissues at 8,908 samples from 42 whole- and 108 partial-body cases, and a surgical specimen from 1 living case. The six most common types of USTUR tissues are skeletal, muscle/skin/fat, alimentary, circulatory, glands, and respiratory/tracheobronchial. Tissues are typically stored in a frozen state, and skeletal samples are most common due to the large number of bones in the human body, as well as the dissection protocol. On average, whole-body cases had 147 ± 97 tissue samples per case and partial-body cases had 25 ± 20 tissue samples per case.

USTUR Acid Solutions

In addition to frozen and formalin-fixed tissues, the NHRTR holds thousands of acid-digested tissue samples (acid solutions) that were previously analyzed for actinides. Staff finished inventorying USTUR acid solutions during FY2016. Since that time, no parent acid solution samples have been inventoried; however, subsamples have been created as aliquots were taken for radiochemical analysis. During FY2017, information on 520 acid solution aliquots from 23 cases, along with 61 analytical blanks, was entered into THEMIS.

USTUR Histology Slides

The USTUR holds thousands of paraffin-embedded tissue blocks and microscope slides that were provided by pathologists following USTUR Registrant autopsies. Inventory of microscope slides was completed during FY2016. Since that time, slides have been inventoried as they are received/generated. In March 2017, 35 slides were cut from case 0785 tissue blocks: brain (7), kidney (10), liver (8), and tumor (10). Sixteen of these slides were sent to Radiation Emergency Assistance Center/ Training Site (REAC/TS) in Oak Ridge, TN for collaborative research, leaving 19 slides in the NHRTR inventory.

Argonne National Laboratory Samples

The NHRTR houses an existing collection of tissue materials obtained from the terminated radium worker study at Argonne National Laboratory (ANL) and the historical plutonium injection studies. The ANL collection consists of frozen and dried tissues, histological slides, and plastic and paraffin-embedded tissue blocks. This collection was acquired by the NHRTR/USTUR in the 1990s under Ronald L. Kathren's directorship.

Twenty blood smears were inventoried and sent to REAC/TS for biodosimetric research. No further progress was made toward inventorying ANL tissues due to lack of personnel.

Los Alamos Scientific Laboratory Solutions

NHRTR staff organized and inventoried acid solutions from population studies carried out by Los Alamos Scientific Laboratory. Bottles were grouped by case number, tested to determine whether they contained nitric (corrosive and oxidizer agent) or hydrochloric (corrosive) acid, paraffin-sealed, and inventoried. During FY2017, 2,242 LASL acid solutions were inventoried. This brought the total number of inventoried LASL acid solutions to 3,173 from 908 autopsies. Commonly inventoried (acid-digested) tissues included liver, lung(s), spleen, kidney(s), bone, thyroid, and lymph nodes.

THEMIS Inventory Status

As of March 31, 2017, laboratory staff had completed the inventory of all existing USTUR frozen/formalin-fixed tissues, histopathology slides, and acid solutions. These three projects are in a "maintenance" phase, where samples are inventoried as they are received and/or generated. Laboratory staff continue to inventory four additional types of samples, as personnel resources allow: USTUR planchets, frozen ANL tissues, ANL histopathology slides, and LASL acid solutions. These projects are in an "active" phase. Table 4 summarizes the inventory status of various NHRTR materials.

Table 4. NHRTR materials THEMIS inventory status

NHRTR samples	Collection		
	USTUR	ANL	LASL
Frozen and/or formalin-fixed tissues	Maintenance	Active	--
Histology slides	Maintenance	Active	--
Acid solutions	Maintenance	--	Active
Planchets	Active	--	--

Five-year Inventory Progress

Figure 7 shows the number of inventoried parent samples at the end of each of the past five calendar years (2012–2016). Changes from year to year represent net changes. Thus, the relatively constant number of USTUR tissues from 2014 to 2016 indicates that new frozen tissues were acquired and inventoried at approximately the same rate that previously-inventoried frozen tissues were analyzed for actinides, and therefore changed to 'acid solutions' in the THEMIS database. From 2012 through 2014, laboratory personnel primarily focused on inventorying USTUR tissues and acid solutions. As these projects were completed, effort was shifted to inventorying ANL samples, USTUR planchets, and LASL acid solutions.

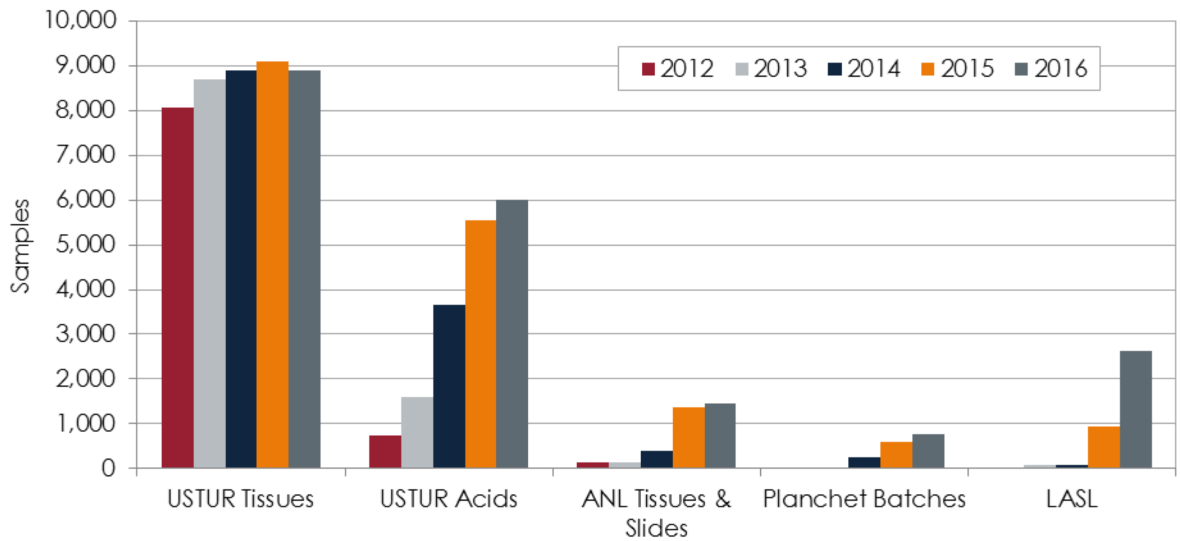


Fig. 7. NHRTR samples inventory progress during 2012–2016.

Radiochemistry Operation

George Tabatadze, *Research Associate*
Sergei Y. Tolmachev, *Director/Principal Radiochemist*

This section describes specific activities and achievements of the Radiochemistry Group during FY2017.

Personnel

As of April 1, 2016, operation of the radiochemistry laboratory was supervised by Dr. Tolmachev (Principal Radiochemist) with two full-time personnel – Dr. George Tabatadze (Research Associate) and Ms. Elizabeth Thomas (Laboratory Technician II).

FY2017 Tissue Sample Analysis

Tissue sample analysis is a multi-step process. During the analysis, a tissue undergoes five different analytical steps: (i) drying and ashing, (ii) digestion and dissolution, (iii) radiochemical actinide separation, (iv) preparation of an α-counting source (planchet), and (iv) measurement of individual actinides – plutonium (^{238}Pu and $^{239+240}$Pu), americium (^{241}Am), uranium (^{234}U, ^{235}U, and ^{238}U), and thorium (^{232}Th).

During FY2017, 406 tissue samples, including 93 bone and 313 soft tissues from 18 donations, were analyzed for ^{238}Pu, $^{239+240}$Pu, and ^{241}Am using α-spectrometry.

Whole-body Donations

In FY2017, analysis of 116 tissue samples from three whole-body donations, received between 2006 and 2015, has been completed. Analyzed cases included: 0303 (43 samples), 0391 (32), and 0806 (41). A total of 23 bone samples and 93 soft tissues were analyzed. All samples were analyzed for ^{238}Pu, $^{239+240}$Pu, and ^{241}Am.

Twenty miscellaneous tissue samples, including 17 bone samples and two soft tissues from eight whole-body donations, were analyzed. Analyzed cases included: 0193 (1), 0259 (1), 0407 (2), 0503 (2), and 0846 (13).

Partial-body Donations

In FY2017, analysis of 266 tissue samples from eight partial-body donations, received between 2006 and 2016, was completed. Analyzed cases included: 0385 (32), 0443 (24), 0521 (37), 0658 (28), 0771 (44), 0800 (29), 0845 (32), and 0958 (40). A total of 53 bone samples and 213 soft tissues were analyzed for ^{238}Pu, $^{239+240}$Pu, and ^{241}Am.

Five miscellaneous soft tissue samples, from two partial-body donations, were analyzed. Analyzed cases included: 0737 (2), and 0785 (3).

Analysis of 172 tissue samples, including 54 bone and 118 soft tissues from six partial-body donations were submitted for analysis: Case 0371 (17), Case 0410 (41), Case 0421 (39), Case 0695 (10), Case 0702 (37) and Case 0817 (28).

One miscellaneous soft tissue sample from Case 0333 was submitted for radiochemical analysis.

FY2017 Radiochemistry Case Analysis

As of March 31, 2017, the USTUR had received 43 whole- and 304 partial-body donations, including two partial-body donations accepted during FY2017.

In FY2017, survey radiochemical analysis for three whole-body donors was completed (Table 5). A survey analysis is an analysis of selected tissue samples that provides key scientific information to determine the level of exposure, and can be sufficiently used for biokinetic modeling.

Table 5. FY2017 whole-body case analysis progress

Case No	Year of Donation	Radiochemistry Status	
		FY2016	FY2017
0303	2008	Incomplete	Incomplete†
0391	2006	Incomplete	Incomplete†
0806	2015	Incomplete	Incomplete†

† - Survey analysis complete

Full analyses of eight partial-body cases were completed and analyses for four donations are in progress. Analysis status for Case 0579 was administratively changed from 'Incomplete' to 'Complete'. Table 6 summarizes partial-body case analysis progress.

Cases are categorized as 'Intact,' 'Incomplete,' or 'Complete'. 'Intact' means that no tissue samples have been analyzed. 'Incomplete' typically denotes that a selected sub-set of tissues was analyzed (surveyed) or case analysis is in progress, and 'Complete' denotes that a full selection of tissue samples was analyzed and results were reported.

Table 6. FY2017 partial-body case analysis progress

Case No	Year of Donation	Radiochemistry Status	
		FY2016	FY2017
0385	2010	Intact	Complete
0410	2016	Intact	Incomplete
0421	2016	Intact	Incomplete
0443	2006	Intact	Complete
0521	2010	Intact	Complete
0579	1993	Incomplete	Complete
0658	2007	Incomplete	Complete
0695	2008	Intact	Incomplete
0702	2006	Intact	Incomplete
0771	2008	Intact	Complete
0800	2009	Incomplete	Complete
0845	2016	Intact	Complete
0958	2009	Incomplete	Complete

Five-year Radiochemistry Progress

During FY2013–FY2017, 1,604 samples were analyzed, including 547 bone samples, 1,057 soft tissues, and one surgically removed soft tissue sample from a living Registrant (Figure 8).

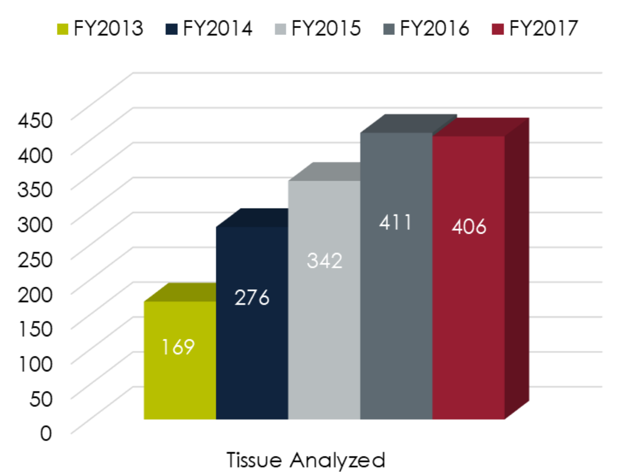


Fig. 8. USTUR tissue analysis progress in FY2013–FY2017.

Tissue samples from 26 whole-body, 29 partial-body, and one living Registrant have been analyzed during FY2013–FY2017 (Figure 9).

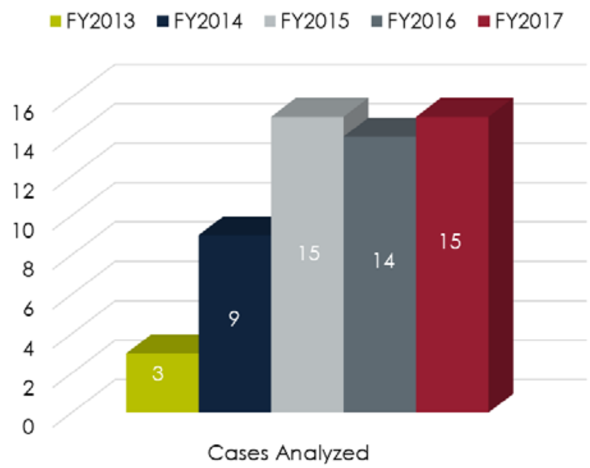


Fig. 9. USTUR case analysis progress in FY2013–FY2017.

From FY2013 to FY2017, the USTUR received four new whole-body donations, cases: 0757 (FY2013), 0804 (FY2014), 0343 (FY2014), and 0806 (FY2016), and thirteen new partial-body donations, cases: 0636 (FY2013), 0272 (FY2013), 0803 (FY2013), 0691 (FY2014), 0743 (FY2014), 0861 (FY2014), 0814 (FY2014), 0377 (FY2015), 0805 (FY2015) , 0787 (FY2016), 0845 (FY2016), 0410 (FY2017), and 0421 (FY2017), resulting in a total of 43 whole- and 304 partial-body donations.

The overall status of case analyses from FY2013 to FY2017 is shown in Figure 10.

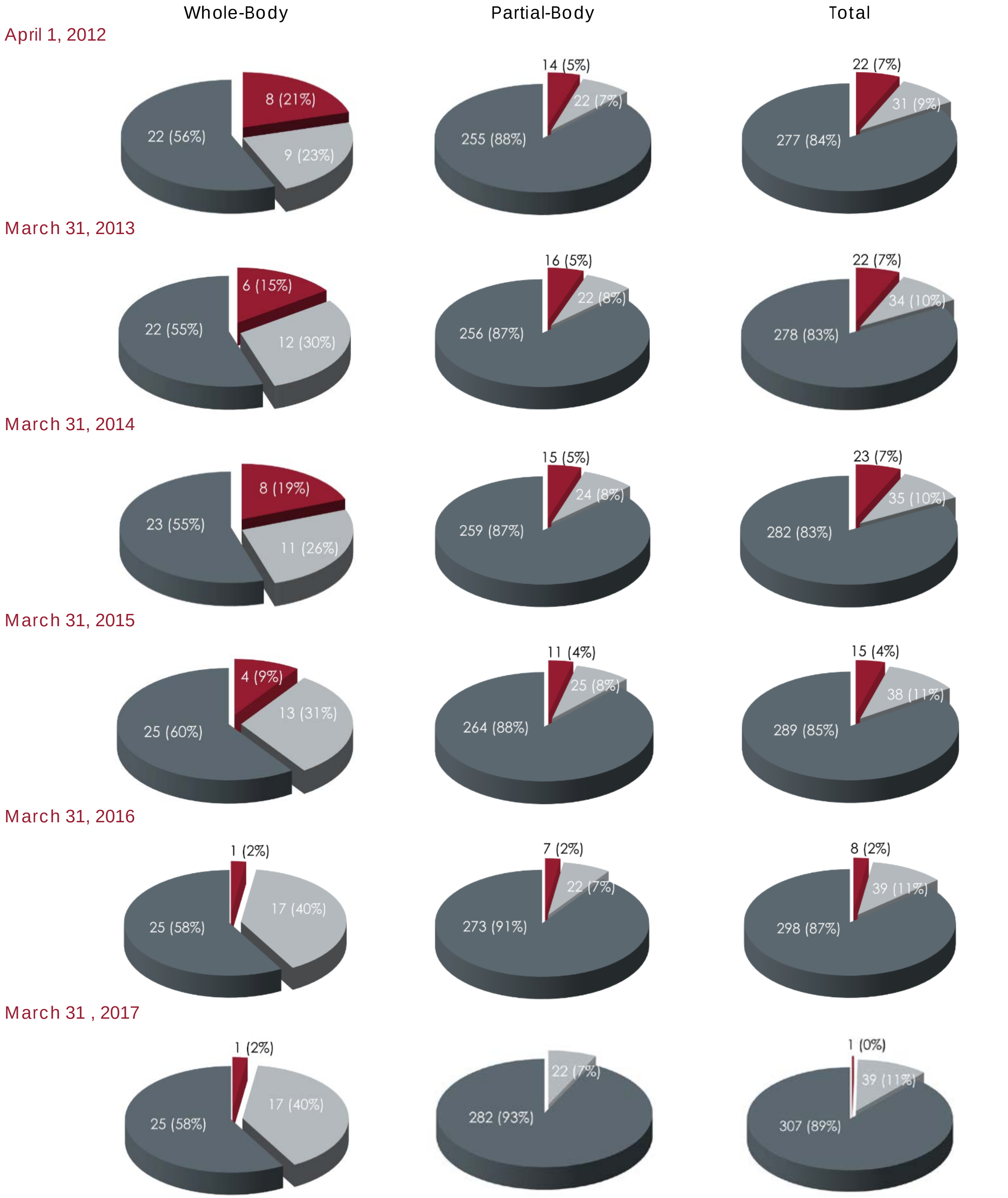


Fig. 10. Radiochemistry analysis status: ■ intact cases; ■ incomplete cases; ■ complete cases.

Tissue Sample Backlog

As of April 1, 2017, analysis of thirty eight whole- and partial-body cases remain 'Incomplete'. This includes 16 whole-body cases for which the survey analysis was previously completed, and 22 partial-body cases for which the analysis status is 'Incomplete'. Case and tissue sample backlog at the end of FY2017 is shown in Figure 11.

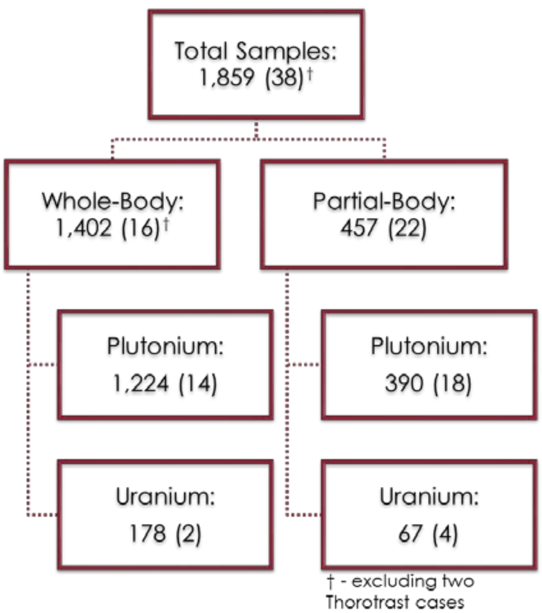


Fig. 11. USTUR tissue sample backlog at the end of FY2017. † excluding two Thorotrast cases.

Sample Backlog Reduction

Figure 12 summarizes tissue backlog reduction plan for FY2018–2022. It accounts for elimination of the 1,859 tissues accumulated prior to FY2018, as well as additional samples from an anticipated single whole-body donation each year. Partial-body donations will be analyzed as received, and no tissue backlog will be generated from these cases. By the end of FY2022, the tissue backlog will consist of 575 samples from five whole body donations, which the USTUR anticipates receiving during the FY2018–2022 grant period.

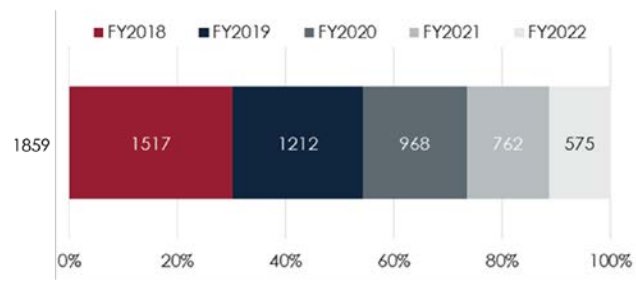


Fig. 12. Remaining tissue sample backlog at the end of each fiscal year.

Graduate Research

Sara Dumit, *PhD Candidate*
Sergei Y. Tolmachev, *Associate Research Professor*

On July 21, 2016, Graduate Committee for Sara Dumit's PhD project had its first in-person meeting. This meeting was held on the WSU Spokane campus. Attendees were: Dr. Sayed Daoud (Committee Chair), Dr. Kathryn E Meier, Dr. Jeannie Padowski, Dr. Daniel J Strom, and Dr. Sergei Y Tolmachev (Advisor). The committee discussed the project's general directions and COP/WSU requirements on the timeline.

Graduate Preliminary Examination

On November 18, 2016, USTUR/College of Pharmacy PhD student, Sara Dumit, presented her dissertation proposal "Plutonium Biokinetics in the Human Body under Decorporation Treatment" at a COP graduate research seminar and successfully passed her PhD preliminary examination.

On November 21, 2016, Ms. Dumit was officially notified by WSU's Graduate School Program that she became a candidate for the degree of Doctor of Philosophy in Pharmaceutical Sciences. The program is subject to completion no later than fall 2019.

Student Awards

Ms. Dumit was awarded a student scholarship of $1,000 from the Columbia Chapter of the Health Physics Society.

She received five travel grants:

- Health Physics Society Student Travel Grant ($350)
- WSU/COP Erwin & Jeannie Foisy Scholarship ($500)
- Associated Students of Washington State University Spokane Travel Grant ($500)
- European Radiation Dosimetry Group Travel Grant (€450)
- Brazilian Graduate Student Conference Travel Grant ($100).

Conference Presentations

Invited Talk

Ms. Dumit was invited to speak at the Columbia Chapter of Health Physics Society monthly meeting at the Dade Moeller, an NV5 Company, facility (Richland) on January 26, 2017. Upon request from the chapter, she gave podium presentations on her doctoral research. This event was covered in the March 2017 issue of Health Physics News.

DTPA meeting (Left to the right): M. Avtandilashvili (USTUR), S. Dumit (USTUR), W. Klein (KIT), M. Kastl (HMGU). B. Breustedt (KIT), A. Giussani (BfS), E. Blanchardon (IRSN), S. Lamart (CEA)

Podium Presentations

On July 19, 2016, Ms. Dumit participated in the USTUR special session at the 61st Annual Health Physics Society Meeting in Spokane, WA and gave a presentation titled "USTUR Case 0785: Modeling Plutonium Decorporation Following Complex Exposure".

On February 28, 2017, Ms. Dumit gave a podium presentation titled "Plutonium Biokinetics in the Human Body under Decorporation Treatment" at the European Radiation Dosimetry Group (EURADOS) Annual Meeting (Karlsruhe, Germany). She also participated in the satellite meeting on the development of a new DTPA therapy model organized by Karlsruhe Institute of Technology on March 3, 2017.

Poster Presentation

On March 11, 2017, Ms. Dumit presented a poster at the Brazilian Graduate Student Conference (BRASCON) held on the University of Southern California Campus (Los Angeles, CA). BRASCON promotes activities to enable integration, communication, and professional development for Brazilian graduate students (professional or academic masters, doctoral, and postdoctoral) in the United States within the research fields of Science, Technology, Engineering, and Mathematics (STEM). http://www.brasconference.org/

Peer-reviewed publications

One peer-reviewed abstract was published: S. Dumit, M. Avtandilashvili, B. Breustedt, S. Y. Tolmachev. USTUR Case 0785: Modeling Pu Decorporation Following Complex Exposure. Health Physics 2016; 111 (1 Suppl): S41.

Plutonium Excretion Following Decorporation Treatment

Sara Dumit, *PhD Candidate*
Maia Avtandilashvili, *Research Associate*
Sergei Y. Tolmachev, *Associate Research Professor*

Individuals with significant internal deposition of plutonium are likely to be treated with intravenous injections of chelating agents such as calcium or zinc salts of ethylene diamine tetraacetic acid (EDTA) and diethylene triamine pentaacetic acid (DTPA). Chelation with Ca-DTPA is known to enhance urinary excretion of plutonium by up to a factor of 100. The enhancement factor (EF) may be higher for soluble plutonium compounds and varies significantly among individuals. Knowing the EF is critical for interpretation of bioassay data collected during chelation therapy. The EF is an important parameter for the estimation of radionuclide intake and radiation dose assessment using standard biokinetic models. In current practice, and in the absence of individual-specific data, a value of 50 is recommended.

USTUR Case 0785

Plutonium EFs for delayed treatment were estimated using data from USTUR Case 0785, who was exposed to plutonium due to an explosion at nuclear facility. This individual was initially treated with Ca-EDTA followed by a delayed treatment with Ca-EDTA 9 months after intake and Ca-DTPA 7.2 years after intake. Delayed treatments consisted of 4 g of Ca-EDTA daily for 5 days, and of 1 g of Ca-DTPA weekly for 11 weeks. A total of 478 urine samples were collected over 44 years post-accident (1957–2001) and analyzed for plutonium Figure 13 summarizes measured plutonium urinary excretion rates (*U*).

Pu-EDTA excretion

To evaluate plutonium elimination from the human body following initial EDTA treatment, the Pu-EDTA complex removal half-time (τ) was calculated. An average plutonium excretion rate of 6.5±3.3 Bq d^{-1} was calculated for five consecutive injections during the last week of treatment (days 24–28). Plutonium excretion rates on days 29–35 normalized to 6.5 Bq d^{-1} were fitted with the exponential function of $\hat{U}_t = 0.33 \exp(-0.693\, t / 1.6)$ (Fig. 14).

A strong correlation ($r^2 = 0.893$) was found between Pu-EDTA excretion and the time elapsed since the last EDTA injection. From the regression analysis, τ was estimated to be 1.6 days. For comparison, Schadilov *et al.* estimated that τ = 3.2 d for the Pu-DTPA complex in a group of Mayak PA Workers(1).

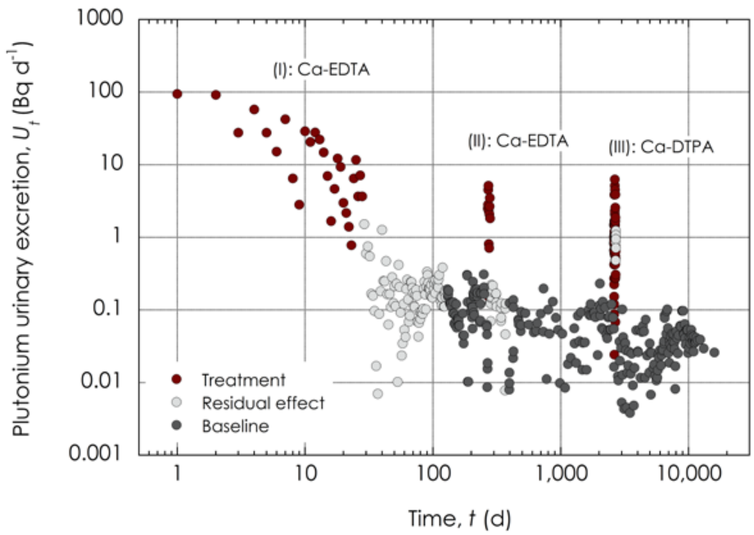


Fig. 13. Measured plutonium urinary excretion rates and treatment schedules for USTUR Case 0785.

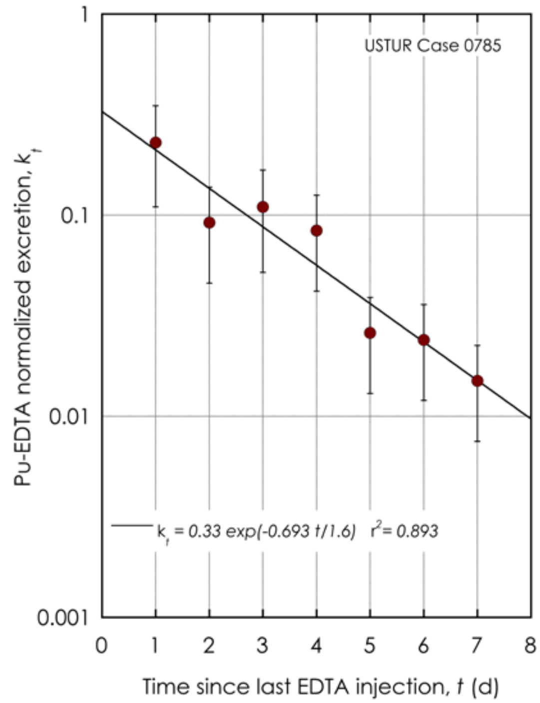


Fig. 14. Urinary excretion of Pu-EDTA complex.

Enhancement factor

To estimate plutonium urinary excretion enhancement factors for delayed treatments, the activities excreted after injections were divided by the 'baseline' excretion rate on the day before each treatment started. In the case of the EDTA treatment, the Pu EF_{EDTA} ranged from 71 to 159, with a geometric mean of 101. For DTPA, the Pu EF_{DTPA} ranged from 8 to 192, with a geometric mean of 33. Results were within the range of published values(2). The finding that EF_{DTPA} was lower than the EF_{EDTA} was likely due to a decrease of systemic plutonium available for complexation over time.

References

1. Schadilov AY, Khokhryakov VF, Kudryavtseva TI, Vostrotin VV. Ca-DTPA Effects on Plutonium Excretion from the Human Organism. Buluten' Sibirskoi Medeciny (in Russian) 2: 128 - 132; 2005.
2. Sokolova AB, Efimov AV, Suslova KG. Specification of the Pu Urinary Excretion Enhancement Factor Due to Pentacinum to Interpret Results of Internal Exposure Control in Terms of Chronic Inhalation Intake of Industrial Plutonium Compounds. Voprosy Radiacionnoi Bezopasnosti (in Russian) 2: 60-66; 2015.

Plutonium in Tissues of Occupationally Exposed Individuals

Sergei Y. Tolmachev, *Associate Research Professor*
Maia Avtandilashvili, *Research Associate*

Tissue analysis provides data on actinide distribution, retention, and radiation dose estimation from internally deposited radionuclides. The respiratory tract, liver, and skeleton are primary deposition sites for plutonium. In 1994, the USTUR published results of $^{239+240}$Pu and ^{241}Am activity concentration measurements in tissues from 82 donations(1). As of March 31, 2017, the USTUR has analysis results for $^{239+240}$Pu and ^{241}Am in tissue samples from 295 voluntary donors. The activity concentrations of $^{239+240}$Pu were measured in 291 lung tissues, 268 thoracic lymph nodes (LNTH), 290 liver samples, and 840 bone samples from 256 cases. The number of analyzed bone samples for individual cases varied from as low as 2 samples for a partial-body donation to over 150 samples for a whole-body donation. An average $^{239+240}$Pu concentration in skeleton was calculated. The $^{239+240}$Pu activity concentrations in the lungs ranged from 0.55 mBq kg^{-1} to 7.23 kBq kg^{-1} (median: 1.28 Bq kg^{-1}); in LNTH from 1.79 mBq kg^{-1} to 68.4 kBq kg^{-1} (median: 18.8 Bq kg^{-1}); in the liver from 0.45 mBq kg^{-1} to 0.92 kBq kg^{-1} (median: 1.15 Bq kg^{-1}), and in the skeleton from 3.55 mBq kg^{-1} to 0.21 kBq kg^{-1} (median: 0.35 Bq kg^{-1}). The LNTH-to-lung activity concentration ratios were calculated for 258 cases. The ratios ranged from 0.01 to 561, with a median of 17. This indicates that the majority of the USTUR donors was exposed to insoluble plutonium material. Total activities in the liver and the skeleton were estimated using ICRP Reference Man organ weights. Liver-to-skeleton activity ratios were calculated for 238 cases with a median of 0.71, resulting in 1:1.4 plutonium systemic distribution between the liver and the skeleton. This is inconsistent with the ICRP assumption that plutonium is equally distributed between the liver and the skeleton.

The brain is not considered to be a depository site for plutonium; however, $^{239+240}$Pu activity was measured in brain samples from 66 donors. Plutonium is one of the radionuclides that provide a high-LET dose to the brain. This is of a particular interest to National Aeronautics and Space Administration in their studies of behavioral and cognitive impairments due to effects of space irradiation on the central nervous system(2). The $^{239+240}$Pu activity concentrations in the brain ranged from 0.2 mBq kg^{-1} to 4.42 Bq kg^{-1} (median: 26.2 mBq kg^{-1}).

Figure 15 summarizes $^{239+240}$Pu activity concentrations measured in tissue samples from USTUR donors.

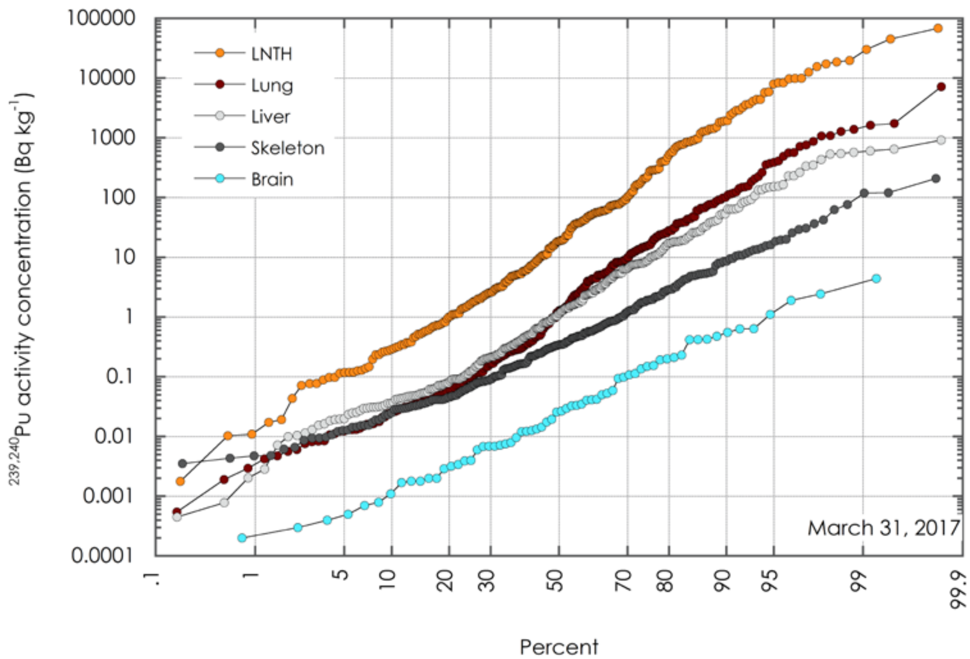


Fig. 15. $^{239+240}$**Pu activity concentrations in tissue samples from USTUR donors.**

References

1. Filipy RE, Kathren RL, McInroy JF, Short RA. Soft Tissue Concentrations of Plutonium and Americium in Occupationally-Exposed Humans. Health Physics 67: 477-85; 1994.

2. Boice JD, Jr. Space: The Final Frontier-Research Relevant to Mars. Health Physics 112: 392-397; 2017.

2016 Advisory Committee Meeting Summary

Richard E. Toohey, *SAC Chair*
Stacey L. McComish, *Associate in Research*

The 2016 Scientific Advisory Committee (SAC) meeting was coordinated with the 61st Annual Health Physics Society (HPS) meeting in Spokane, WA. The one-day SAC meeting was held July 20 at the College of Pharmacy on the WSU Spokane campus. It focused on operational aspects of the Registries, because USTUR research had been presented the previous day at the USTUR's special session of the HPS meeting. The meeting agenda is available as Appendix D.

2016 Meeting Attendees

The Scientific Advisory Committee, DOE representatives, colleagues from the WSU College of Pharmacy, USTUR faculty/staff, a next-of-kin representative, and several invited guests attended the 2016 meeting. All participants were invited to attend the morning session; however, the afternoon session was executive in nature, and attended only by SAC members, USTUR staff, and the DOE program manager.

Advisory Committee

- Robert Bistline, *Occupational Health*
- Timothy Ledbetter, *Ethics*
- Roger McClellan, *Toxicology*
- Thomas Rucker, *Radiochemistry*
- Richard Toohey, *Health Physics*
- Unable to attend: Herman Gibb, *Epidemiology*

Incoming SAC Member

- Heather Hoffman, *Epidemiology/Biostatistics*
- Unable to attend: William (Bill) Stange, *Occupational Health*

Department of Energy

- Patricia Worthington, *Director of Health Safety and Security Office (AU-10)*
- Isaf Al-Nabulsi, *Japanese Atomic Bomb Survivor Studies Program Manager (AU-10)*
- Joey Zhou, *USTUR Program Manager (AU-13)*

U.S. Transuranium and Uranium Registries

- Sergei Tolmachev, *Director*
- Stacey McComish, *Associate in Research*
- Maia Avtandilashvili, *Research Associate*
- George Tabatadze, *Research Associate*
- Elizabeth Thomas, *Laboratory Technician II*
- Margo Bedell-Parker, *Fiscal Specialist I*
- Sara Dumit, *WSU/COP PhD student*

Washington State University

- Ronald Kathren, *Professor Emeritus*
- Andrea Lazarus, *Assistant Vice President for Research, Clinical Health Sciences*
- Philip Lazarus, *Pharmaceutical Sciences Chair, College of Pharmacy*
- Kathryn Meier, *Associate Dean for Graduate Education, College of Pharmacy*

Invited Guests

- Bastian Breustedt, *Karlsruhe Institute of Technology,* Germany
- Ronald Goans, *MJW Corporation*
- Nolan Hertel, *Georgia Institute of Technology*
- Carol Iddins, *Radiation Emergency Assistance Center/Training Site*
- Maria Lopez, *Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas,* Spain
- Dunstana Melo, *Mellohill Technology LLC*
- Next-of-Kin, *Family Representative*

Summary

Dr. Tolmachev welcomed the attendees and introduced Dr. Lazarus, assistant Vice-President for Research at WSU, who noted that there were 1,500 students at the Spokane medical campus, and $18M in extramural funding. A new genomics laboratory was available and could possibly be used for USTUR samples. Dr. Worthington, director of the Department of Energy's Office of Worker Health and Safety (AU-10), provided an overview of her Office's activities. The Office remains committed to long-term support of the USTUR, but no programs have line item funding; consequently, the total available research budget is divided up between programs. Although it is difficult to increase funding for the USTUR, the funding is at least holding constant.

SAC members noted that Dr. Toohey's second term on SAC would end September 30, 2017. Dr. Bistline stated it is important to link the former worker program with the USTUR to ensure data gathered in that effort are not lost. However, there seems to be reluctance by some former worker program researchers to "advertise" the USTUR. Perhaps USTUR could distribute information directly to participants. Dr. Worthington offered to discuss the issue; over 100,000 former workers have been screened. The family representative stated that a whole new generation of decontamination and decommissioning (D&D) workers have greater risk of accidents and intakes, but no one is tracking these individuals.

Margo Bedell presented the financial picture: in grant year 4 of 5, the budget was $900,000 plus $20,000 from Pacific Northwest National Laboratory. In FY2016, the budget was overspent by $33,000, due in large part to a doubling of autopsy costs and travel expenses. In FY2017, the operating budget is $887,000; DOE also contributed an extra $30,000 for the 50th anniversary celebration, combined with a special session on the USTUR at the annual Health Physics Society meeting held in Spokane. Dr. Tolmachev noted that an academic exchange with Kyushu University, Fukuoka, Japan, has begun. In the past year, USTUR staff have made twelve oral presentations at scientific meetings, and two posters presentations.

Dr. Tolmachev then reviewed SAC recommendations from the last year and their implementation: all whole-body case data has been entered into the Health Physics database; 51% of partial-body case data has been entered. The laboratory analyzed 432 samples this year (a new record), vs. the goal of 350 – 400. Analyses of 25 whole-body cases were completed.

Publications included six papers, three editorials, and nine abstracts. The total number of USTUR publications is now 198. The average number of citations of a USTUR paper is 14.8, and the total number of citations is about 100 per year by now. The National Human Radiobiology Tissue Repository (NHRTR) contains about 23,000 inventoried samples, including tissues (about 9,000, almost all frozen), acid solutions (about 6,000), electrodeposited planchets (765 batches of up to 8 planchets each), tissues received from Argonne National Laboratory's radium worker study (about 1,400), and acid solutions of samples collected by Los Alamos National Laboratory (about 1,700). Good progress on inventory and database populating, but only half as many were inventoried as last year due to a 50% decrease in student workers available. Planchets can be tracked by element (e.g. plutonium, americium, uranium, and thorium) and activity. Should there be an effort to flag tissue samples for future biological/cytological analysis, so as not to lose that capability by dissolution? Half of a whole-body donation (left side) is archived; similarly half of the samples from a partial-body donation are archived, but it is a more difficult process to meet the needs for radiochemistry while simultaneously archiving tissues, i.e., if only 1 femur is donated, how to divide it best between radiochemistry and archiving?

SAC members questioned the preparation of data quality objectives, which have not yet been established; Dr. Tabatadze stated that the objectives are taken into account for prioritizing sample analysis, but have not yet been formalized.

The SAC then entered into executive session: it is important to emphasize the value of USTUR to WSU and continue to build bridges to WSU and the College of Pharmacy (COP). Participation of the staff in professional organizations is very important, and they should pursue professional certification as a credential to support the WSU-TriCities certificate program. The program needs to consider the longer term - what would happen when only a few living Registrants remain? Also, consider beryllium cases in the Registries and other chemical exposures that may be synergistic with radiation. There will likely be more wound cases arising from D&D that can be used to improve the NCRP wound model. Future disposition of the tissue repository needs to be considered, although DOE has taken ownership of the radioactive materials. The effects of DTPA therapy and refractory plutonium compounds are also important. Collaborative research is the most likely way to generate new scientific data from the Registries. ^{238}Pu production start-up (for space applications) is another issue; neptunium is also an issue in gaseous diffusion plant D&D, but little known. Senior staff need to transition from collecting the data to thinking of ways to use the data. There needs to be a back-up plan for all staff. The USTUR should continue to increase interactions with the COP and the Health Sciences campus in Spokane, as well as with the WSU/TC certificate program. The USTUR should also tie in with the former worker program; a well-constructed, solid database is critical. Consideration of the ultimate disposition and preservation of data and samples should be ongoing. Staff must continue to promote the current and future value of the program to WSU, DOE, collaborators, regulators, and other stakeholders.

Comments

Specific comments include:

1. There has been good progress in populating the databases.
2. The special session at the HPS annual meeting was excellent, and along with the booth greatly improved the visibility of the program.
3. The Ph.D. student in pharmacy is an excellent example of collaboration with the COP.
4. USTUR recognition of donors is a welcome cultural shift.
5. A shift in emphasis from data collection to research is taking hold.

Recommendations

1. Promote the value of USTUR for research:
   a. Consider possible current and future uses of data (hypotheses to be tested.)
   b. Further research is likely to be collaborative; identify target organizations for outreach, e.g. Oak Ridge National Laboratory's Center for Radiation Protection Knowledge. Set a goal for external funding, e.g., $50,000.
   c. Demonstrate the value of the program to COP (student participation, teaching, etc.)
2. Ph.D. staff should be classified as research associate professors; continue to build staff credentials (certification, professional society participation, publications, etc.)
3. Formally document research goals and objectives and produce a modified set of data quality objectives to support research goals, as well as future missions and funding opportunities.
4. Demonstrate the value of the program for current and future DOE needs:
   a. Improving the wound model [currently animal data only]
   b. beryllium and chemical cases, synergistic response with radiation
   c. former worker program
   d. ^{238}Pu production workers
   e. refractory Pu compounds
   f. ^{237}Np cases exposed in gaseous diffusion plant D&D
5. Offer practica for research students, continue practica for nursing students.
6. Consider outreach to scientific collaborators outside traditional radiation-related disciplines, such as toxicology, biokinetics, cellular biology, etc.
7. Consider outreach to workers, union representatives, etc.

SAC Membership

Drs. Robert Bistline and Herman Gibb completed their third and final terms on the SAC. Dr. Bistline's vacancy on the committee was filled by Dr. Arthur "Bill" Stange. Dr. Gibb's vacancy was filled by Dr. Heather Hoffman, who has a background in epidemiology and biostatistics.

Professional Activities and Services

During FY2017, the USTUR staff was actively involved in professional and academic activities nationally and internationally.

Academic Activities

WSU Graduate Certificate Program in Radiation Protection

The USTUR's Director, Dr. Sergei Tolmachev, continued to serve on the advisory committee for the WSU Graduate Certificate Program in Radiation Protection (GCPRP) at the Tri-City Campus.

In May 2016, Dr. Tabatadze was appointed as a GCPRP advisory committee member.

This two-year course of study will educate students on key topics in radiation protection, preparing them to be technicians in health physics and related fields.

Visiting Professor Appointment

Dr. Sergei Tolmachev continued to serve as a Visiting Professor at Kyushu University (Fukuoka, Japan) through the Central Institute of Radioisotope Sciences and Safety (CIRSS). Appointment: April 2015 – March 2017.

Adjunct Professor Appointment

Dr. Sergei Tolmachev continued to serve as an Adjunct Professor in the Department of Chemistry at Laval University (Quebec, Canada) for a 2nd 3-year term (June 2014 – May 2017).

Professional Committees

Herbert M. Parker Foundation

Dr. Sergei Tolmachev continued to serve as a member of the Board of Trustees for the Herbert M. Parker Foundation:

https://tricities.wsu.edu/parkerfoundation/

HPS International Collaboration Committee

Dr. George Tabatadze was appointed to, and has served as a member of, the International Collaboration Committee (ICC) of the Health Physics Society (HPS). Appointment: 2016–2018.

Scientific Meetings

USTUR faculty attended and participated in the following scientific meetings:

- 61st Annual Health Physics Society Meeting in Spokane, WA, July 17–21, 2016
- Meeting of the Georgian National Academy of Sciences' Committee on Nuclear Energy and Radiation Safety, Tbilisi, Republic of Georgia, September 21, 2016
- Conference on Radiation and Health, Waikoloa Village, HI, October 14–15, 2016
- 62nd Radiation Research Society Annual Meeting, Waikoloa Village, HI, October 16–19, 2016
- Columbia Chapter of Health Physics Society monthly meeting, Richland, WA, January 26, 2017

- European Radiation Dosimetry Group WG-7 Annual Meeting, Karlsruhe, Germany, February 27–March 3, 2017
- Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy (Pittcon), Chicago. IL, March 5–9, 2017
- 2017 Annual Meeting of the National Council on Radiation Protection and Measurements (NCRP), Bethesda, MD, March 6-7, 2017
- Brazilian Graduate Student Conference (BRASCON), Los Angeles, CA, March 11–12, 2017
- Conference on Legacies of the Manhattan Project: Reflections on 75 Years of a Nuclear World. Richland, WA, March 15–18, 2017.

Editorial and Ad-hoc Review Services

Japanese Journal of Health Physics

Dr. Sergei Tolmachev continued to serve as a member of the Editorial Board for the Japanese Journal of Health Physics (JJHP) for his 3rd term from August 2013 to July 2017.

Austin Biometrics and Biostatistics

Dr. Maia Avtandilashvili continued to serve as a member of the Editorial Board for the Journal of Austin Biometrics and Biostatistics:

http://austinpublishinggroup.com/biometrics/editorialBoard.php

Journal of Hazardous Materials

Dr. Maia Avtandilashvili was invited to provide scientific expertise as an ad-hoc reviewer for the Journal of Hazardous Materials (impact factor 4.836). One paper was reviewed by Dr. Avtandilashvili.

Journal of Exposure Science and Environmental Epidemiology

Dr. Maia Avtandilashvili was invited to provide scientific expertise as an ad-hoc reviewer for the Journal of Exposure Science and Environmental Epidemiology (impact factor 3.141). Due to a conflicting schedule, Dr. Avtandilashvili was not able to accept the invitation. She provided the editorial board with the name of recommended alternative expert reviewer.

Professional Affiliations

The USTUR personnel are active members of numerous national and international professional organizations:

- Radiation Research Society (USA)
- Health Physics Society (USA)
- Japan Health Physics Society (Japan)
- European Radiation Dosimetry Group (EURADOS), Working Group 7 (WG7) on Internal Dosimetry (EU).

Publications and Presentations

The following manuscripts and presentations were published or presented during the period of April 2016 to March 2017. Previous manuscripts and abstracts are available on the USTUR website at:

ustur.wsu.edu/Publications/index.html

Abstracts of open peer-reviewed published manuscripts and scientific presentations are included in Appendix E of this report.

Published

USTUR-0468-17

Puncher M, Birchall A, Sokolova AB, Suslova KG. The Mayak Worker Dosimetry System (MWDS-2013): Plutonium Dissolution in the Lungs – an Analysis of Mayak Workers. Radiation Protection Dosimetry: Epub ahead of print; doi: 10.1093/rpd/ncw304; 2016.

USTUR-0469-17

Birchall A, Marsh JW. The Mayak Worker Dosimetry System (MWDS-2013): How to Weight the Absorbed Dose to Different Lung Regions in the Calculation of Lung Dose. Radiation Protection Dosimetry: Epub ahead of print; doi: 10.1093/rpd/ncw245; 2016.

USTUR-0359-14

Suslova KG, Sokolova AB, Tolmachev SY, Miller SC. The Mayak Worker Dosimetry System (MDSW-2013): Estimation of Plutonium Skeletal Content from Limited Autopsy Bone Samples from Mayak PA Workers. Radiation Protection Dosimetry: Epub ahead of print; doi:10.1093/rpd/ncw239; 2016.

USTUR-0357-14

Puncher M, Birchall A, Tolmachev SY. The Mayak Worker Dosimetry System (MWDS-2013): A Re-Analysis of USTUR Case 0269 to Determine Whether Plutonium Binds to the Lungs. Radiation Protection Dosimetry: Epub ahead of print; doi:10.1093/rpd/ncw083; 2016.

USTUR-0356-14

Tolmachev SY, Nielsen CE, Avtandilashvili M, Puncher M, Martinez F, Thomas EM, Miller FL, Morgan WF, Birchall A. The Mayak Worker Dosimetry System (MWDS-2013): Soluble Plutonium Retention in the Lungs of an Occupationally Exposed USTUR Case. Radiation Protection Dosimetry: Epub ahead of print; doi:10.1093/rpd/ncw136; 2016.

USTUR-0405-16

Birchall A, Dorrian M-D, Suslova KG, Sokolova AB. The Mayak Worker Dosimetry System (MWDS-2013): A Comparison of Intakes Based on Urine Versus Autopsy Data from Mayak Workers Using the Leggett Systemic Model for Plutonium. Radiation Protection Dosimetry: Epub ahead of print; doi: 10.1093/rpd/ncw111; 2016.

USTUR-0414-16

Birchall A, Puncher M. The Mayak Worker Dosimetry System (MWDS-2013): How to Reduce Hyper-Realisations to Realisations. Radiation Protection Dosimetry: Epub ahead of print; doi: 10.1093/rpd/ncw267; 2016.

USTUR-0416-16

Birchall A, Puncher M, Vostrotin V. The Mayak Worker Dosimetry System (MWDS-2013): Treatment of Uncertainty in Model Parameters. Radiation Protection Dosimetry: Epub ahead of print; doi: 10.1093/rpd/ncw248; 2016.

USTUR-0397-16

Dorrian M-D, Birchall A, Vostrotin V. The Mayak Worker Dosimetry System (MWDS-2013): Phase I - Quality Assurance of Organ Doses and Excretion Rates from Internal Exposures of Plutonium-239 for the Mayak Worker Cohort. Radiation Protection Dosimetry: Epub ahead of print; doi: 10.1093/rpd/ncw137; 2016.

USTUR-0425-16

Puncher M, Birchall A, Sokolova AB, Suslova KG. The Mayak Worker Dosimetry System (MWDS-2013): Plutonium Binding in the Lungs - an Analysis of Mayak Workers. Radiation Protection Dosimetry: Epub ahead of print; doi: 10.1093/rpd/ncw121; 2016.

USTUR-0426-16

Puncher M, Pellow PGD, Hodgson A, Etherington G, Birchall A. The Mayak Worker Dosimetry System (MWDS-2013): A Bayesian Analysis to Quantify Pulmonary Binding of Plutonium in Lungs Using Historic Beagle Dog Data. Radiation Protection Dosimetry: Epub ahead of print; doi: 10.1093/rpd/ncw243; 2016.

USTUR-0411-16

Sokolova AB, Birchall A, Efimov AV, Vostrotin VV, Dorrian MD. The Mayak Worker Dosimetry System (MWDS-2013): Determination of The Individual Scenario of Inhaled Plutonium Intake in the Mayak Workers. Radiation Protection Dosimetry: Epub ahead of print; doi: 10.1093/rpd/ncw190; 2016.

USTUR-0417-16

Vostrotin V, Birchall A, Zhdanov A, Gregoratto D, Suslova K, Marsh J, Efimov A. The Mayak Worker Dosimetry System (MWDS-2013): Uncertainty in the Measurement of Pu Activity in a 24-hour Urine Sample of a Typical Mayak PA Worker. Radiation Protection Dosimetry: Epub ahead of print; doi: 10.1093/rpd/ncw247; 2016.

USTUR-0415-16

Vostrotin V, Birchall A, Zhdanov A, Puncher M, Efimov A, Napier B, Sokolova A, Miller S, Suslova K. The Mayak Worker Dosimetry System (MWDS-2013): Internal Dosimetry Results. Radiation Protection Dosimetry: Epub ahead of print; doi: 10.1093/rpd/ncw268; 2016.

USTUR-0412-16

Zhdanov A, Vostrotin V, Efimov AV, Birchall A, Puncher M. The Mayak Worker Dosimetry System (MWDS-2013): Implementation of the Dose Calculations. Radiation Protection Dosimetry: Epub ahead of print; doi: 10.1093/rpd/ncw148; 2016.

USTUR-0410-16

Bingham D, Berard P, Birchall A, Bull R, Cardis E, Challeton-de Vathaire C, Grellier J, Hurtgen C, Puncher M, Riddell A, Thierry-Chef I. Reconstruction of Internal Doses for the Alpha-Risk Case-Control Study of Lung Cancer and Leukaemia Among European Nuclear Workers. Radiation

Protection Dosimetry: Epub ahead of print; doi: 10.1093/rpd/ncw227; 2016.

USTUR-0388-16A

Breustedt B, Avtandilashvili M, McComish SL, Tolmachev SY. USTUR Case 0846: Modeling Americium Biokinetics after Intensive Decorporation Therapy. *Health Phys*. 111 (1 Suppl): S58-59; 2016.

USTUR-0389-16A

Tabatadze G, Miller BW, Tolmachev SY. Digital Autoradiography of ^{241}Am Spatial Distribution within Trabecular Bone Regions. *Health Phys*. 111 (1 Suppl): S41-42; 2016.

USTUR-0390-16A

Avtandilashvili M, Tolmachev SY. Updating ICRP 70 Skeleton Weight vs. Body Height Equation. *Health Phys*. 111 (1 Suppl): S40; 2016.

USTUR-0391-16A

Dumit S, Avtandilashvili M, Tolmachev SY. USTUR Case 0785: Modeling Pu Decorporation Following Complex Exposure. *Health Phys*. 111 (1 Suppl): S41; 2016.

USTUR-0392-16A

Tolmachev SY, Kathren RL. Estimation of Actinide Skeletal Content from a Single Bone Analysis. *Health Phys*. 111 (1 Suppl): S40; 2016.

USTUR-0393-16A

Toohey RE, Goans RE, Iddins CJ, Dainiak N, McComish SL, Tolmachev SY. Red Marrow Dosimetry for Former Radium Workers. *Health Phys*. 111 (1 Suppl): S56-57; 2016.

USTUR-0394-16A

Zhou J, McComish SL, Tolmachev SY. Reanalysis of Radiation and Mesothelioma in the U.S. Transuranium and Uranium Registries. *Health Phys*. 111 (1 Suppl): S42; 2016.

USTUR-0395-16A

Birchall A, Puncher M, Tolmachev SY. The Importance of Plutonium Binding in Human Lungs. *Health Phys*. 111 (1 Suppl): S58; 2016.

USTUR-0396-16A

Goans RE, Toohey RE, Iddins CJ, Dainiak N, McComish SL, Tolmachev SY. The Pseudo Pelger-Huët Cell as a Retrospective Dosimeter: Analysis of a Radium Dial Painter Cohort. *Health Phys*. 111 (1 Suppl): S57; 2016.

USTUR-0403-16

Tolmachev SY, McComish SL. United States Transuranium and Uranium Registries Annual Report: April 1, 2015 – March 31, 2016. United States Transuranium and Uranium Registries; USTUR-0403-16, Richland, WA, 2016.

Presented

Invited

USTUR-0485-16P

Avtandilashvili M. U.S. Transuranium and Uranium Registries. Georgian National Academy of Sciences' Committee on Nuclear Energy and Radiation Safety, Tbilisi, Republic of Georgia, September 21, 2016.

Dumit S. Plutonium Biokinetics in Human Body. Columbia Chapter of Health Physics Society monthly meeting, Richland, WA January 26, 2017.

Podium

USTUR-0486-16P

Breustedt B, Avtandilashvili M, McComish SL, Tolmachev SY. USTUR Case 0846: Modeling Americium Biokinetics after Intensive Decorporation Therapy. Podium presentation at the 61st Annual Meeting of the Health Physics Society, Spokane, WA, July 17–21, 2016.

USTUR-0389-16A

Tabatadze G, Miller BW, Tolmachev SY. Digital Autoradiography of ^{241}Am Spatial Distribution within Trabecular Bone Regions. Podium presentation at the 61st Annual Meeting of the Health Physics Society, Spokane, WA, July 17–21, 2016.

USTUR-0390-16A

Avtandilashvili M, Tolmachev SY. Updating ICRP 70 Skeleton Weight vs. Body Height Equation. Podium presentation at the 61st Annual Meeting of the Health Physics Society, Spokane, WA, July 17–21, 2016.

USTUR-0391-16A

Dumit S, Avtandilashvili M, Tolmachev SY. USTUR Case 0785: Modeling Pu Decorporation Following Complex Exposure. Podium presentation at the 61st Annual Meeting of the Health Physics Society, Spokane, WA, July 17–21, 2016.

USTUR-0392-16A

Tolmachev SY, Kathren RL. Estimation of Actinide Skeletal Content from a Single Bone Analysis. Podium presentation at the 61st Annual Meeting of the Health Physics Society, Spokane, WA, July 17–21, 2016.

USTUR-0393-16A

Toohey RE, Goans RE, Iddins CJ, Dainiak N, McComish SL, Tolmachev SY. Red Marrow Dosimetry for Former Radium Workers. Podium presentation at the 61st Annual Meeting of the Health Physics Society, Spokane, WA, July 17–21, 2016.

USTUR-0394-16A

Zhou JY, McComish SL, Tolmachev SY. Reanalysis of Radiation and Mesothelioma in the U.S. Transuranium and Uranium Registries. Podium presentation at the 61st Annual Meeting of the Health Physics Society, Spokane, WA, July 17–21, 2016.

USTUR-0396-16A

Goans RE, Toohey RE, Iddins CJ, Dainiak N, McComish SL, Tolmachev SY. The Pseudo Pelger-Huët Cell as a Retrospective Dosimeter: Analysis of a Radium Dial Painter Cohort. Podium presentation at the 61st Annual Meeting of the Health Physics Society, Spokane, WA, July 17–21, 2016.

USTUR-0473-17P

Avtandilashvili M, McComish SL, Tabatadze G, Tolmachev SY. USTUR Research: Land of Opportunity. Podium presentation at the European

Radiation Dosimetry Group WG-7 Annual Meeting, Karlsruhe, Germany, February 27 – March 3, 2017.

USTUR-0474-17P

Dumit S. Plutonium Biokinetics in the Human Body under Decorporation Treatment. Podium presentation at the European Radiation Dosimetry Group WG-7 Annual Meeting, Karlsruhe, Germany, February 27 – March 3, 2017.

Poster

USTUR-0467-17P

Dumit S, Avtandilashvili M, Breustedt S, Tolmachev SY. Chelation Treatment after Occupational Exposure to Plutonium. Poster presentation at the WSU College of Pharmacy Research Day, Spokane, WA, August 12, 2016.

USTUR-0467-17P

Dumit S, Avtandilashvili M, Breustedt S, Tolmachev SY (*previously presented*). Chelation Treatment after Occupational Exposure to Plutonium. Poster presentation the Brazilian Graduate Student Conference (BRASCON), University of Southern California, Los Angeles, CA, March 11 – 12, 2017.

USTUR Bibliographic Metrics

Stacey L. McComish, *Associate in Research*

Since its inception in 1968, the USTUR has published 223 papers in conference proceedings and peer-reviewed journals, 6 books/book sections, 79 abstracts in journals, and 11 miscellaneous journal publications such as letters to the editor. Of these 319 publications, 253 were published after the Registries moved to WSU in 1992 (Figure 16).

USTUR publications have appeared in 40 different journals with impact factors ranging from 0.894 (Radiation Protection Dosimetry) to 8.556 (Cancer Research). Five journals account for 80% of published peer-reviewed papers: Health Physics (impact factor: 1.193), Radiation Protection Dosimetry (0.894), the Journal of Radioanalytical and Nuclear Chemistry (0.983), Radiation Research (3.022), and the International Journal of Radiation Biology (1.779).

The USTUR's peer-reviewed publications profile was tracked on-line through the ResercherID (I-1056-2013) bibliographic service. The ResearcherID citation metrics included only papers that were in the Web of Science between 1980 and 2017. Of the USTUR's 293 peer-reviewed publications, 199 could be found in the Web of Science. These articles have been cited 2,860 times since 1980. This gives the USTUR an h-index of 28. Figure 17 displays the number of times USTUR journal articles were cited in each of the past 20 years. It is clear from these numbers that the USTUR's research continues to have an important impact on our understanding of actinides in humans. To explore the USTUR's publications on ResearcherID, visit:

http://www.researcherid.com/rid/I-1056-2013

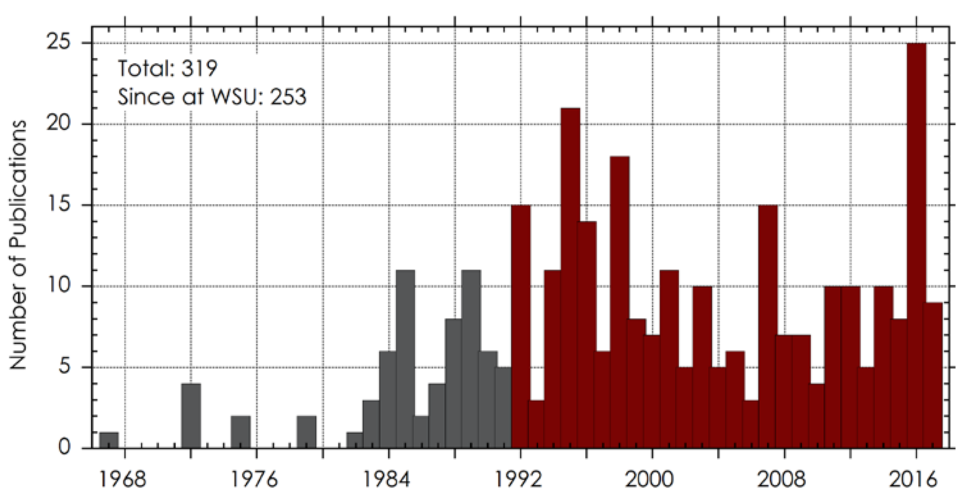


Fig 16. The number of USTUR publications per year.

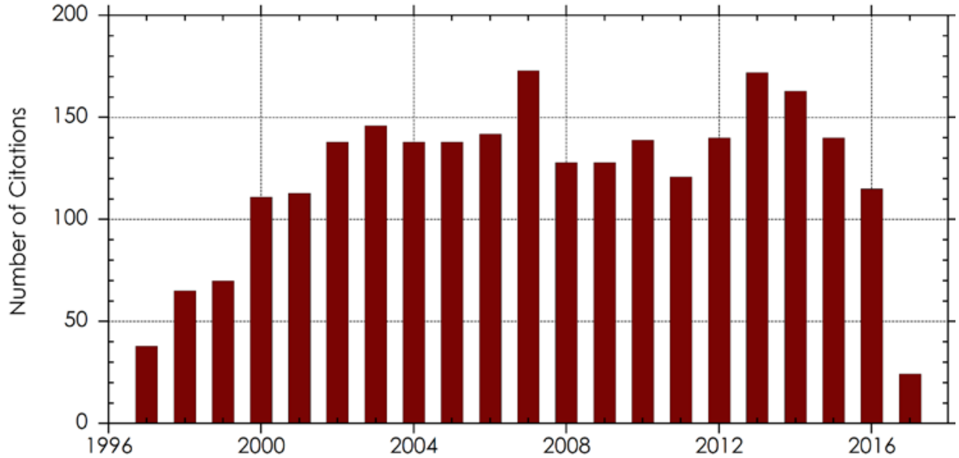
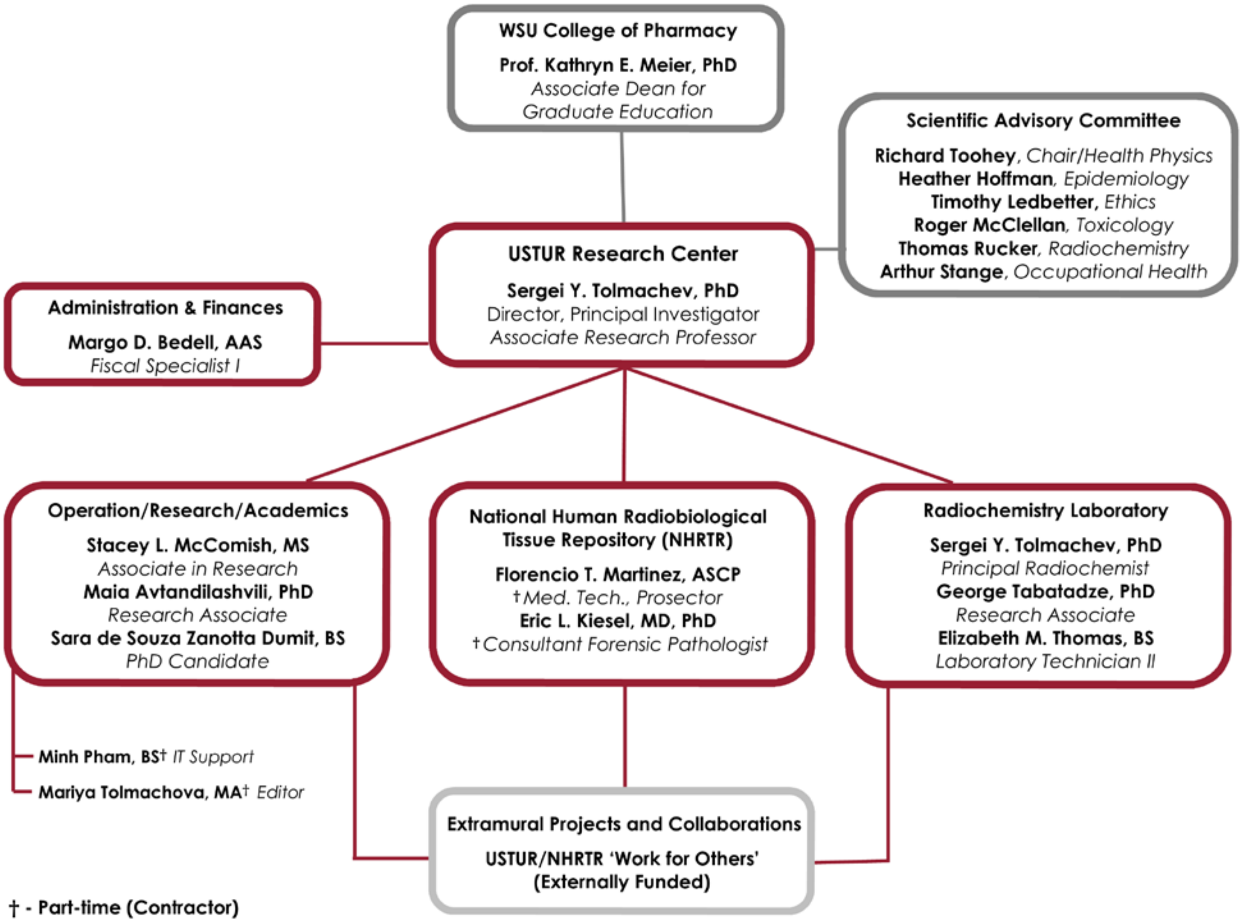


Fig 17. Citation distribution by year.

Appendix A



USTUR Research Center organization structure as of March 31, 2017

Appendix B

July 19, 2016

TAM-A: Special Session: USTUR: Five Decade Follow-up of Plutonium and Uranium Workers
Chair: Patricia R. Worthington, Department of Energy

8:30 AM TAM-A.1

KEYNOTE
The USTUR: Where We Have Been and Where We Are Going
Kathren, R. Washington State University at Tri-cities

9:15 AM TAM-A.2

KEYNOTE
The Atomic Man: Case Study of the Largest Recorded ^{241}Am Deposition in a Human
Carbaugh, E. Dade Moeller

10:00 AM BREAK

TAM-A1: Technical Session I: USTUR Internal Research
Co-Chairs: Carol Iddins, Dunstana Melo

10:30 AM TAM-A1.1

Estimation of Actinide Skeletal Content from a Single Bone Analysis
Tolmachev, S., Kathren, R.
USTUR, Washington State University

10:45 AM TAM-A1.2

Updating ICRP 70 Skeleton Weight vs. Body Height Equation
Avtandilashvili, M., Tolmachev, S.
USTUR, Washington State University

11:00 AM TAM-A1.3

USTUR Case 0785: Modeling Pu Decorporation Following Complex Exposure
Dumit, S., Avtandilashvili, M., Breustedt, B., Tolmachev, S.
USTUR, Washington State University, Karlsruhe Institute of Technology

11:15 AM TAM-A1.4

Digital Autoradiography of ^{241}Am Spatial Distribution within Trabecular Bone Regions
Tabatadze, G., Miller, B., Tolmachev, S.
USTUR, Washington State University, Pacific Northwest National Laboratory, University of Arizona

11:30 AM TAM-A1.5

Reanalysis of Radiation and Mesothelioma in the U.S. Transuranium and Uranium Registries
Zhou, J., McComish, S., Tolmachev, S.
U.S. Department of Energy, USTUR, Washington State University

TPM-A: Technical Session II: USTUR Collaborative Research

Co-chairs: Isaf Al-Nabulsi, Ray Guilmette

2:30 PM TPM-A.1

Red Marrow Dosimetry for Former Radium Workers
Toohey, R., Goans, R., Iddins, C., Dainiak, N., McComish, S., Tolmachev, S.
M.H. Chew & Assoc., MJW Corp., ORISE, USTUR

2:45 PM TPM-A.2

The Pseudo Pelger-Huët Cell as a Retrospective Dosimeter: Analysis of a Radium Dial Painter Cohort
Goans, R., Toohey, R., Iddins, C., Dainiak, N., McComish, S., Tolmachev, S.
MJW Corporation, M.H. Chew and Associates, ORISE, USTUR

3:00 PM TPM-A.3

EURADOS Intercomparison on Measurements of ^{241}Am in Three Skull Phantoms
Lopez, M., Nogueira, P., Vrba, T.
CIEMAT, Spain, HMGU, Germany, CTU-Prague, Czech Rep.

3:15 PM BREAK

3:45 PM TPM-A.4

The Importance of Plutonium Binding in Human Lungs
Birchall, A., Puncher, M., Tolmachev, S.
Global Dosimetry Ltd., UK, Public Health England, UK, USTUR, Washington State University

4:00 PM TPM-A.5

USTUR Case 0846: Modeling Americium Biokinetics after Intensive Decorporation Therapy
Breustedt, B., Avtandilashvili, M., McComish, S., Tolmachev, S.
Karlsruhe Institute of Technology, USTUR, Washington State University

4:15 PM Roundtable Discussion with USTUR Former Directors
4:45 PM Roundtable Open Discussion

Appendix C

USTUR NEWSLETTER

Issue 22 :: USTUR-0413-16 November 2016

Direct from the Director

Last year I promised to keep you updated on events dedicated to the upcoming 50th anniversary of the Registries (in 2018). I am very pleased to tell you that the Department of Energy (DOE) provided $30,000 to support these events.

For the first time, a one-day USTUR special session was organized during the Health Physic Society Meeting. The session's topic was "USTUR: Five Decade Follow-up of Plutonium and Uranium Workers". Dr. Patricia Worthington, Director of the Office of Health and Safety, within the Office of Environment, Health, Safety and Security at DOE, gave the welcome speech. Dr. Worthington emphasized that this event "is dedicated to the Registrants and their Families, who gave an ultimate gift to enhance the understanding of actinide elements in man." She also acknowledged that "it was recognized [by Atomic Energy Commission] from the beginning that the Registry [Plutonium at that time] is a long-term project" and today DOE, as AEC's successor, has a full commitment to the Registries. In addition to eleven scientific talks and a roundtable discussion, an informational booth was hosted by the USTUR. I am pleased to say that the USTUR session was successful given that more than 100 scientists attended the event.

We will publish all scientific presentations from the meeting as a special issue of the *Health Physics* journal (HPJ). This will be the fifth special issue of *Health Physics* dedicated to USTUR research. The first USTUR special issue was published in 1983, followed by publications in 1985, 1992, and 1995. You will find more information about the special session and the informational booth in this newsletter, and I am sure I will have more to tell you about the Registries' 50th anniversary next year.

Sergei Y. Tolmachev

Maia Avtandilashvili, Margo Bedell, Sara Dumit, Sergei Tolmachev, Stacey McComish, George Tabatadze, Elizabeth Thomas

In This Issue

Margo Bedell talks to visitors at the USTUR's informational booth.

50th Anniversary of the USTUR

The year 2018 will mark 50 years of research at the USTUR. In honor of this upcoming milestone, and the Registries' continued impact in the field of radiation protection, the USTUR is organizing several special activities, which will highlight the importance of USTUR research and increase the USTUR's visibility in the scientific community.

During the 2015 Scientific Advisory Committee (SAC) Meeting, the USTUR proposed the following activities:

1. Conduct a one-day special session on the USTUR's research, "USTUR: Five Decade Follow-up of Plutonium and Uranium Workers," at the 61st Annual Meeting of the Health Physics Society (HPS), Spokane, WA. (2016)
2. Host a USTUR booth at the HPS annual meeting. (2016)
3. Publish a special issue of the Health Physics journal. (2017)
4. Publish an extension of the previous book of USTUR publications, which spanned the years 1968-1996. (2018)

The SAC members strongly supported these activities, and the USTUR proposed to the Department of Energy (DOE) that these events be carried out during 2016 to 2018. In response, the DOE awarded the USTUR an additional $30,000 to sponsor the series of commemorative events.

The one-day special session and the informational booth were completed in July as a part of the 2016 Health Physics Society meeting.

Informational Booth

The USTUR hosted a 2-day informational booth at the 2016 Health Physics Society meeting. USTUR staff answered questions about the Registries, and handed out informational brochures. The booth's purpose was to maintain visibility of the USTUR among HPS members, and to introduce ourselves to those who were not familiar with the Registries.

Special Session

The USTUR held a one-day special session at the 2016 Health Physics Society meeting. The session, "USTUR: Five Decade Follow-up of Plutonium Workers," featured eleven presentations and a roundtable discussion (see page 4). Two keynote presentations summarized the largest recorded ^{241}Am deposition in a human, and explored "where we have been and where we are going." The remaining nine presentations showcased current research that is being carried out by USTUR faculty members, as well as by national and international external collaborators. Topics included the use of chelating agents, such as DTPA, to remove plutonium from the human body, and the importance of plutonium binding in the lungs.

Welcome New SAC Members!

We would like to welcome Arthur "Bill" Stange and Heather Hoffman to the USTUR's Scientific Advisory Committee (SAC).

Dr. Stange is the Manager of Health Studies for Oak Ridge Associated Universities, and is responsible for health studies data collection, epidemiologic analyses, and publication of findings for the National Supplemental Screening Program (NSSP), a U.S. Department of Energy (DOE) Former Worker Medical Screening Program.

Dr. Hoffman is an associate professor in the Department of Epidemiology and Biostatistics at the George Washington University, Milken Institute School of Public Health, Washington, DC.

The SAC has been an important part of the USTUR for decades. At annual advisory committee meetings, the SAC makes recommendations on how the USTUR can reach its full potential during the upcoming year.

Graduate Research

WSU pharmaceutical sciences student, Sara Dumit, is studying the removal of plutonium from the human body during treatment with chelating agents such as Ca-EDTA and CA/Zn-DTPA. These chelating agents bind to plutonium in the blood, and enhance its excretion from the body. They also reduce the amount of plutonium in the liver. Ms. Dumit earned a BS degree in pharmacy from Universidade Estácio de Sá (UNESA), Rio de Janeiro, Brazil. In 2014, she was awarded a Science without Borders Scholarship sponsored by the Brazilian Federal Government (CAPES) to pursue a PhD degree at the College of Pharmacy, WSU.

Former Worker Medical Screening Program

You may be eligible for medical screening through the Department of Energy's (DOE) Former Worker Medical Screening Program (FWP). The FWP provides ongoing medical screening examinations, at no cost, to all interested former DOE Federal, contractor, and subcontractor workers from all DOE sites, as well as former workers from its predecessor Agencies (the Manhattan Engineer District, the Atomic Energy Commission, and the Energy Research and Development Administration). Established in 1996, the FWP is designed to detect diseases or conditions at an early stage, often before symptoms develop. FWP does not provide follow-up care, so Individuals with suspicious findings are referred to their personal physicians for further care.

For more information, visit the FWP website at http://energy.gov/ehss/services/worker-health-and-safety/former-worker-medical-screening-program or call the DOE FWP Program Manager, Mary Fields, at (301) 903-1613.

A brochure with detailed information about the FWP is available on the web at:
http://energy.gov/sites/prod/files/2014/12/f19/fwp_brochure.pdf

Introducing the Roundtable Participants

Margery Swint

USTR/USUR director (1982-1989)

Topic: receiving the first whole body donation.

Ronald Kathren

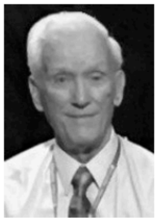
USTUR director (1989-1999)

Topic: moving the Registries from Hanford to WSU.

Ronald Filipy

USTUR director (1999-2005)

Topic: USTUR collaboration with the Russian Radiobiological Human Tissue Repository.



James McInroy

Director of radiochemistry at Los Alamos

Topic: autopsy studies at Los Alamos.

Robert Bistline

SAC member (2007-2016)

Topic: early days of the Registry at Rocky Flats.

Roger McClellan

SAC member (2010-present)

Topic: early days of the Registry, a personal perspective.

*Bryce Breitenstein, USTR director (1976-1982), was unable to attend. The roundtable was moderated by Richard Toohey, associate director (1993-1994), SAC chair (2012-present)

U.S. Transuranium and Uranium Registries * 1845 Terminal Dr., Suite 201 * Richland, WA 99354
1(509)946-6870 or Toll Free: 1(800)375-9317 * www.ustur.wsu.edu

Presenters and chairs of the USTUR's special session at the Health Physics Society meeting, "USTUR: Five Decade Follow-up of Plutonium and Uranium Workers"

Appendix D

2016 Scientific Advisory Committee Meeting

UNITED STATES TRANSURANIUM AND URANIUM REGISTRIES

College of Pharmacy, Washington State University
WSU Spokane, SPBS Bldg, Rm 116, July 20, 2016

08:30 – 08:35	Welcome & Introduction	S. Tolmachev, *Director*
08:35 – 08:50	WSU/COP Campus Overview	A. Lazarus, *WSU/COP, Asst. Vice President Res.*
08:50 – 09:00	Updates from DOE. Guidance for FY2017	P. Worthington, *DOE/AU-10, Director*
09:00 – 09:15	Administrative & Financial Developments	M. Bedell, *Fiscal Specialist*
09:15 – 10:00	2015 SAC Recommendations & 2016 Overview	S. Tolmachev, *Director*
10:00 – 10:15	National Human Radiobiology Tissue Repository	S. McComish, *Assoc. in Research*
10:15 – 10:30	Health Physics Database Progress Report	M. Avtandilashvili, *Research Assoc.*
10:30 – 10:45	*Coffee Break*	
10:45-12:00	SAC Q & A	D. Toohey, *SAC Chair*
12:00 – 13:00	Lunch (Catered)	
13:00 – 16:00	SAC Executive Session	D. Toohey, *SAC Chair*
16:00 – 17:00	SAC Debriefing	D. Toohey, *SAC Chair*
18:30 - ??	Dinner hosted by USTUR, no host bar : Scratch Restaurant & Lounge 1007 W Ist Ave, Spokane, WA (509) 456-5656	

Appendix E

USTUR-0356-14

The Mayak Worker Dosimetry System (MWDS-2013): Soluble plutonium retention in the lungs of an occupationally exposed USTUR case

S.Y. Tolmachev[1], C.E. Nielsen[2], M. Avtandilashvili[1], M. Puncher[3], F. Martinez[1], E.M. Thomas[1], F.L. Miller[1], W.F. Morgan[4], A. Birchall[5]

[1]United States Transuranium and Uranium Registries, Washington State University, Richland, WA, USA
[2]Mission Support Alliance, Richland, WA, USA
[3]Department of Toxicology, Centre for Radiation, Chemical and Environmental Hazards, Public Health England, Chilton, Didcot OX11 0RQ, UK
[4]Pacific Northwest National Laboratory, Richland, WA, USA
[5]Global Dosimetry, Didcot, Oxon, UK.

For the first time, plutonium retention in human upper airways was investigated based on the dosimetric structure of the human respiratory tract proposed by the International Commission on Radiological Protection (ICRP). This paper describes analytical work methodology, case selection criteria, and summarizes findings on soluble (ICRP 68 Type M material) plutonium distribution in the lungs of a former nuclear worker occupationally exposed to plutonium nitrate [$^{239}Pu(NO_3)_4$]. Thirty-eight years post-intake, plutonium was found to be uniformly distributed between bronchial (BB), bronchiolar (bb) and alveolar–interstitial (AI) dosimetric compartments as well as between the left and right lungs. $^{239+240}Pu$ and ^{238}Pu total body activity was estimated to be 2333 ± 23 and 42.1 ± 0.7 Bq, respectively. The results of this work provide key information on the extent of plutonium binding in the upper airways of the human respiratory tract.

Radiation Protection Dosimetry 2016, doi:10.1093/rpd/ncw136.

USTUR-0357-14

The Mayak Worker Dosimetry System (MWDS-2013): A re-analysis of USTUR Case 0269 to determine whether plutonium binds to the lungs

M. Puncher[1], A. Birchall[2], S.Y. Tolmachev[3]

[1]Department of Toxicology, Centre for Radiation, Chemical and Environmental Hazards, Public Health England, Chilton, Didcot OX11 0RQ, UK
[2]Global Dosimetry, Didcot, Oxon, UK
[3]United States Transuranium and Uranium Registries, Washington State University, Richland, WA, USA.

Radionuclides in ionic form can become chemically bound in the airways of the lungs following dissolution of inhaled particulates in lung fluid. The presence of long-term binding can greatly increase lung doses

from inhaled plutonium, particularly if it occurs in the bronchial and bronchiolar regions. However, the only published evidence that plutonium binding occurs in humans comes from an analysis of the autopsy and bioassay data of United States Transuranium and Uranium Registries Case 0269, a plutonium worker who experienced a very high (58 kBq) acute inhalation of plutonium nitrate. This analysis suggested a bound fraction of around 8 %, inferred from an unexpectedly low ratio of estimated total thoracic lymph node activity:total lung activity, at the time of death. However, there are some limitations with this study, the most significant being that measurements of the regional distribution of plutonium activity in the lungs, which provide more direct evidence of binding, were not available when the analysis was performed. The present work describes the analysis of new data, which includes measurements of plutonium activity in the alveolar–interstitial (AI) region, bronchial (BB) and bronchiolar (bb) regions, and extra-thoracic (ET) regions, at the time of death. A Bayesian approach is used that accounts for uncertainties in model parameter values, including particle transport clearance, which were not considered in the original analysis. The results indicate that a long-term bound fraction between 0.4 and 0.7 % is required to explain this data, largely because plutonium activity is present in the extra-thoracic (ET2), bronchial and bronchiolar airways at the time of death.

Radiation Protection Dosimetry 2016, doi:10.1093/rpd/ncw083.

USTUR-0359-14

The Mayak Worker Dosimetry System (MDSW-2013): Estimation of plutonium skeletal content from limited autopsy bone samples from Mayak PA workers

K.G. Suslova[1], A.B. Sokolova[1], S.Y. Tolmachev[2], S.C. Miller[3]

[1]*Southern Urals Biophysics Institute (SUBI), Ozyorsk, Chelyabinsk Region, Russia*
[2]*United States Transuranium and Uranium Registries, Washington State University, Richland, WA, USA*
[3]*Division of Radiobiology, Department of Radiology, School of Medicine, University of Utah, Salt Lake City, UT, USA.*

The method to estimate total skeleton plutonium burden of former Mayak Production Association (MPA) workers from limited bone samples obtained at autopsy is described. From two to nine bone samples were obtained at autopsies conducted from the mid-1950s to 2013. Plutonium was measured using alpha-radiometry up to 2000 and later by alpha-spectrometry. The method was validated using data from whole-body donations from the United States Transuranium and Uranium Registries (USTUR). The developed algorithm overestimated the USTUR values from 20 to 40% that is quite acceptable for conservative estimation. Late-in-life liver diseases known to redistribute plutonium between liver and skeleton were not associated with significant differences in plutonium deposition among sampled bones, except for the pelvis. Sources of uncertainties are discussed and future studies will address the reduction of these

uncertainties. This algorithm can be used to obtain data in support of the development of biokinetic, dosimetric and risk models for humans exposed to plutonium.

Radiation Protection Dosimetry 2016, doi:10.1093/rpd/ncw239.

USTUR-0388-16A

USTUR Case 0846: Modeling Americium Biokinetics after Intensive Decorporation Therapy

B. Breustedt[1], M. Avtandilashvili[2], S.L. McComish[2], S.Y. Tolmachev[2]

[1]*Karlsruhe Institute of Technology, Karlsruhe, Germany*
[2]*United States Transuranium and Uranium Registries, Washington State University, Richland, WA, USA.*

One method to avert dose after incorporation of transuranium elements is decorporation therapy with chelating agents such as diethylenetriamine pentaacetate (DTPA). Administration of the therapeutic agent temporally enhances the excretion of the radionuclides. Biokinetic models, which describe the behavior of the radionuclides in the human body, need to be adapted to take into account the effect of the therapy. In this study, biokinetic modeling of decorporation therapy following americium oxide ($^{241}AmO_2$) inhalation was studied using USTUR Case 0846 (voluntary donor). The modeling of this case is a challenge given that the exact date of exposure is unknown. Previously, the case was evaluated using the assumption of chronic inhalation over a 2-year period. However, a possibility of acute intake cannot be dismissed. Initial ^{241}Am whole-body deposition was estimated to be 66,600 Bq. The Registrant was extensively treated with Ca-DTPA over a period of 7 years. A total of 313.5 g DTPA was administered in 342 i.v. injections. At the time of death, 2,740±274 Bq of ^{241}Am was measured in the lungs, 333±33 in the liver, and 19,570±1,957 in the skeleton by external gamma counting. Based on post-mortem radiochemical analysis results, 219.2±1.9 Bq and 29,600±195 Bq of ^{241}Am were retained in the liver and the skeleton, respectively. For this study, a complete set of data including 106 fecal and 1,130 urine measurements was compiled. The CONRAD (Coordinated Network for Radiation Dosimetry) approach was applied to model americium decorporation using the excreta data only. Based on assumptions about the action and distribution of the administered DTPA, different modifications of the model were tested. To solve the compartmental model equations and fit the data, the ModelMaker4 and the SAAMII® software were used. To improve the modeling, tissue radiochemical analysis results were fitted simultaneously with the excretion data. The Bayesian approach was applied to characterize intake scenario and determine initial distribution of americium in the body prior to the therapy. This presentation provides preliminary results on americium biokinetic modeling after intensive decorporation treatment with Ca-DTPA.

(Abstract) *Health Physics* 2016, 111 (1 Suppl): S41.

USTUR-0389-16A

Digital Autoradiography of ^{241}Am Spatial Distribution within Trabecular Bone Regions

G. Tabatadze[1], B. Miller[2], S. Tolmachev[1]

[1]United States Transuranium and Uranium Registries, Washington State University, Richland, WA, USA
[2]Pacific Northwest National Laboratory, Richland, WA; University of Arizona, Tucson, AZ, USA.

The ionizing-radiation Quantum Imaging Detector (iQID) is used at the United States Transuranium and Uranium Registries (USTUR) for imaging α-emitters: ^{241}Am, ^{239}Pu, and ^{226}Ra. The iQID allows visualizing the distribution of α-particle events and differentiating between the surface-seeker (Am, Pu) and bone volume-seeker (Ra) radionuclides and their activity quantification. In this study, spatial distribution of metabolized ^{241}Am within trabecular bone regions was investigated using USTUR Case 0846 (voluntary donor). For this individual, initial ^{241}Am whole-body deposition was estimated to be 66.6 kBq. Post-mortem radiochemical analysis indicated that 29.6 kBq were retained in the skeleton 40 years post exposure. Bone specimens were sampled from humerus proximal end, humerus proximal shaft, and clavicle acromial end. These specimens were embedded in methyl methacrylate plastic and processed to produce multiple 100-µm-thick sections. Bone sections were polished to a fine surface and anatomical structure images were taken with a digital microscope. All bone sections were imaged at 35 µm resolution for at least two weeks. In order to evaluate the radionuclide distribution and corresponding histology precisely, iQID images were co-registered and superimposed with the anatomical structure images. The ^{241}Am activity distributions were visualized and quantified in cortical bone and trabecular spongiosa. These two bone regions are well represented within the humerus proximal end. High activity concentration of ^{241}Am was measured in trabecular bone region. Activity concentration ratio was used to represent radionuclide distribution within different bone regions. The cortical bone-to-trabecular spongiosa activity concentration ratio of 1:0.7 was calculated for the humerus proximal end. This is in agreement with ratios obtained from radiochemical analysis – 1:0.7 and ICRP biokinetic model predictions – 1:0.5. The cortical-to-trabecular bone activity concentration ratio of 1:2.7 was in agreement with that of 1:3 obtained from radiochemical analysis. This quantitative digital autoradiography imaging approach is proven to be an effective method for micro-scale heterogeneous distribution studies, where traditional counting methods do not apply.

(Abstract) *Health Physics* 2016, 111 (1 Suppl): S41-S42.

USTUR-0390-16A

Updating ICRP 70 Skeleton Weight vs. Body Height Equation

M. Avtandilashvili[1], S.Y. Tolmachev[1]

[1]*United States Transuranium and Uranium Registries, Washington State University, Richland, WA, USA.*

A total skeletal activity is one of the fundamental quantities for modeling biokinetics of bone-seeking radionuclides. The uncertainty in the activity estimates depends on the precision of radionuclide bone concentration measurements and the accuracy of the calculated skeleton weights. This is a challenging task, especially if only limited number of bones are collected and analyzed and no prior information on skeleton weight is available. In 1995, the International Commission on Radiological Protection (ICRP) published the skeleton weight vs. body height equation, W(kg) = –10.7 + 0.119 × H(cm), based upon data from 31 male individuals including two US Transuranium and Uranium Registries' (USTUR) whole-body donors. Currently, data are available from additional USTUR whole-body donations that provide a unique opportunity to update the ICRP 70 equation. In this study, the total skeleton weights were estimated for 39 male whole-body donors, including two previously used by ICRP. All skeleton weights were calculated using a standardized approach and corrected for bilateral asymmetry, and possible bone mass losses during dissection. Body heights were based upon autopsy reports (when available) or medical examination records. To update the skeleton weight vs. body height correlation, original ICRP 70 and new USTUR data were combined in a set of 68 data points representing a group of 25 to 90+ year old individuals. For this group, body heights and skeleton weights ranged from 155 to 188 cm and 6.5 to 13.4 kg, respectively. Data were fitted with a linear least-square regression. A significant correlation between two parameters was observed (r = 0.55), and a new skeleton weight vs. body height equation was derived: W(kg) = –6.65 + 0.094 × H(cm). This equation will be used to estimate the skeleton weights and, ultimately, total skeletal actinide activities for biokinetic modeling of the USTUR partial-body donation cases.

(Abstract) *Health Physics* 2016, 111 (1 Suppl): S40.

USTUR-0391-16A

USTUR Case 0785: Modeling Pu decorporation Following Complex Exposure

S. Dumit[1], M. Avtandilashvili[1], S.Y. Tolmachev[1]

[1]*United States Transuranium and Uranium Registries, Washington State University, Richland, WA, USA.*

High levels of exposure to actinides can cause severe health effects. Individuals with significant internal contamination typically undergo treatment with chelating agents to accelerate urinary excretion and thus reduce radiation dose to sensitive tissues. The US Transuranium and Uranium Registries (USTUR) studies actinide biokinetics and tissue dosimetry by following up occupationally exposed workers. These studies are fundamental to improving the reliability of, and confidence in, radiation dose and risk assessment

methods. By linking radiation exposure history, bioassay results, and medical data with post-mortem measurements of actinides in the human body, we aim to develop and parameterize a biokinetic model for plutonium decorporation therapy. USTUR Case 0785 was selected for this study. This individual was exposed to plutonium via inhalation and wounds due to an explosion at the defense nuclear facility, and underwent chelation treatment. Worksite personnel estimated his systemic deposition at 7.4 kBq. The ^{239}Pu whole-body activity at the time of death, estimated from tissue radiochemical analysis, was 2.8 kBq. Of these, 69.7% was deposited in the skeleton, 21.7% in the liver, and 6.5% in the respiratory tract. The results confirmed that internal deposition of plutonium was caused by inhalation and wound intake, and provided additional information on material solubility type. In this preliminary study, IMBA Professional Plus® software was applied to fit post-mortem plutonium activities measured in the lungs, liver and skeleton. The ICRP 130 human respiratory tract model, NCRP 156 wound model, and Leggett plutonium systemic model were used with default assumptions of material type. As small particles are typically generated due to explosion, 1 □m particle size was used instead of ICRP 130's default value of 5 μm. Inhalation and wound intake regimes were fitted simultaneously. Results of calculations were consistent with the ICRP 68 Type S material. The residual fraction of total intake, not removed by chelation treatment, was estimated at approximately 24 kBq with 89% contributed by inhalation. This information will be used for modeling plutonium decorporation therapy.

(Abstract) *Health Physics* 2016, 111 (1 Suppl): S41.

USTUR-0392-16A

Estimation of Actinide Skeletal Content from a Single Bone Analysis

S.Y. Tolmachev[1], R.L. Kather[1],

[1]*United States Transuranium and Uranium Registries, Washington State University, Richland, WA, USA.*

Estimation of the total skeletal actinide content (A_{sk}) is important to support biokinetic modeling of actinides. A_{sk} is calculated as a product of radionuclide activity concentration (C_{rad}) and skeletal weight (W_{sk}), $A_{sk} = C_{rad} \times W_{sk}$. The large uncertainties are typically associated with the estimated activity, as generally only few bones are analyzed and ICRP reference weight of 10.5 kg or height-weight equation are used to estimate the skeleton weight. Several approaches are published for plutonium and americium activities estimation in a human skeleton based on the analyses of limited number of bones collected at autopsy and various assumptions on skeleton weight. Alternatively, A_{sk} can be estimated from a single bone analysis if a fraction of total skeleton activity (deposition coefficient, K_{dep}) is known for this particular bone. The use of $K_{dep} = A_{bone}/A_{sk}$, allows simple straightforward calculation of total skeleton activity from a single bone analysis with reduced uncertainties. In addition, a linear regression equation, $A_{sk} = a \times A_{bone} + b$, can be used. In this study, K_{dep} values were calculated for patella bone using data from 16 whole body donors

to the United States Transuranium and Uranium Registries (USTUR) with known exposure to ^{238}Pu, ^{239}Pu, and ^{241}Am. Total ^{238}Pu, ^{239}Pu, and ^{241}Am skeletal activities were calculated using a standardized methodology. The average K_{dep} values (±standard deviation) for ^{238}Pu, ^{239}Pu, and ^{241}Am were calculated as 0.0037±0.0015, 0.0033±0.0012, and 0.0040±0.0013, respectively. With repeated ANOVA test, no significant difference was found among K_{dep} for ^{238}Pu, ^{239}Pu, and ^{241}Am ($p=0.126$) resulting in the average K_{dep} = 0.0037±0.0013 (n=48) for the actinides. Thus, the measured activity of plutonium or americium in patella can be reliably used to estimate the total skeletal content. Actinide total skeletal content can be simply obtained by multiplying the measured activity in the patella by $1/K_{dep}$ = 273±98. Using linear regression analysis for log-transformed data (n=48), the excellent correlation, with a slope of 0.957±0.023, and 2.411±0.036 intercept, was found between activity in patella and that in the skeleton ($r^2=0.973$).

(Abstract) *Health Physics* 2016, 111 (1 Suppl): S40.

USTUR-0393-16A

Red Marrow Dosimetry for Former Radium Workers

R.E. Toohey[1], R.E. Goans[2], C.J. Iddins[3], N. Dainiak[3], S.L. McComish[4], S.Y. Tolmachev[4]

[1]M.H. Chew & Associates, Livermore, CA, USA
[2]MJW Corporation, Amherst, NY, USA
[3]Oak Ridge Institute for Science and Education, Oak Ridge, TN, USA
[4]United States Transuranium and Uranium Registries, Washington State University, Richland, WA, USA.

A collaboration between the Radiation Emergency Assistance Center and Training Site (REAC/TS) at the Oak Ridge Institute for Science and Education (ORISE) in Oak Ridge, TN and the United States Transuranium and Uranium Registries (USTUR) at Washington State University in Richland, WA has resulted in the discovery of a possible long-term biodosimeter that could be useful for population screening and/or epidemiological studies. The pseudo-Pelger-Huet (pseudo-P-H) anomaly consists of characteristic bi-lobed nuclei in neutrophils that can be easily assessed by light microscopy of a peripheral blood (PB) smear. Since PB cell culture is not required (as with dicentric chromosome analysis), a marked reduction in time to obtain results is achieved. A set of 166 PB smears from former workers in the luminizing industry was provided by the USTUR from the National Human Radiobiology Tissue Archive and examined at REAC/TS; the anomaly was characterized as the percentage of pseudo-P-H cells among neutrophils. The radium intakes of most of the subjects are given in R. E. Rowland's publication “Radium in Humans: A Review of U.S. Studies” (1994). The published intakes, based on whole-body counts, had to be modified to accommodate changes in the ICRP biokinetic model for radium since they were originally calculated. Red marrow doses were computed from the adjusted intakes of ^{226}Ra and ^{228}Ra by using the ingestion dose coefficients given in ICRP Publication 67. However, because many of the workers started in their teens, doses were adjusted for age at intake; the dose coefficient for a 15-year-old was used for intakes occurring before age 25, and the adult dose coefficient was used for intakes at age 25 and above. Starting dates of exposure ranged from 1914 to 1950, and ages at first exposure ranged from 13 to 40 years. Exposure durations ranged from 1 to 1800 weeks and the vast majority of these PB samples were drawn between 1973 and 1975 at the time of the whole-body counts. Calculated red marrow doses ranged from zero to 13.6 Gy-eq, computed with a radiation weighting factor of two for alpha particles producing tissue reaction effects. A companion paper by R. E. Goans et al. presents the dose-response data for the pseudo-P-H anomaly in these cases. Acknowledgements: this work was supported by the U.S. Department of Energy under contract number DE-AC05-06OR23100 with Oak Ridge Associated Universities and award number DE-HS0000073 to Washington State University.

(Abstract) *Health Physics* 2016, 111 (1 Suppl): S56-S57.

USTUR-0394-16A

Reanalysis of radiation and mesothelioma in the U.S. Transuranium and Uranium Registries

J. Zhou[1], S.L. McComish[2], S.Y. Tolmachev[2]

[1]*US Department of Energy, Washington, DC, USA*
[2]*United States Transuranium and Uranium Registries, Washington State University, Richland, WA, USA.*

It has been noted for years that there is an excess of mesothelioma deaths among the Registrants of the U.S. Transuranium and Uranium Registries (USTUR). The previous analyses to link the excess of mesothelioma to radiation were done inappropriately in part due to the small number of mesothelioma cases and the use of the U.S. general population as a comparison group. The reanalysis applied an internally matched case control approach to evaluate the cluster of mesothelioma cases in association with cumulative external radiation exposures. First, all causes of USTUR Registrants' deaths were classified into 4 groups: mesothelioma (Meso), lung cancers (LC), other cancers (OC), and non-cancers (NC). Second, for each case of mesothelioma, controls were identified in the LC (2 ~ 3 controls per case), OC (2 ~ 5 controls per case), and NC (2 ~ 5 controls per case) groups matching gender (male), race (white), years of employment (± 2.5 years), first hire (± 5 years), birth year (±5), and age at death (±5 years). Third, a paired t-test (one sided) was used to examine whether there were statistically significant differences in cumulative external radiation doses between cases and respective controls in LC, OC, and NC groups. In practice, a permutation paired t-test (PPTT) was developed to run the significance tests based on a large number of paired t-tests. For each paired t-test, one control for each case was randomly selected from multiple (2 ~5 controls per case) matching controls. This procedure was repeated 5,000 times, and the percentage of statistically significant ($p \leq 0.05$) paired t-tests was counted. Inference was reached based on whether or not 5% or more of PPTTs were statistically significant. PPTTs were not significant for Meso vs. LC and Meso vs. OC; PPTTs were significant, however, for Meso vs. NC with larger than 9.0% of significant paired t-tests. A

follow up conditional logistic regression for the Meso and NC groups showed a non-statistically significant odd ratio (OR) of 1.001 (95% CI: 0.997 ~ 1.006) between cumulative external radiation doses and mesothelioma. The internally matched case control analysis suggested that the excess of mesothelioma deaths among USTUR Registrants was not associated with cumulative external radiation exposures.

(Abstract) *Health Physics* 2016, 111 (1 Suppl): S42.

USTUR-0395-16A

The importance of plutonium binding in human lungs

A. Birchall[1], M. Puncher[2], S.Y. Tolmachev[3]

[1]*Global Dosimetry, Oxfordshire, UK*
[2]*Public Health England, Oxfordshire, UK*
[3]*United States Transuranium and Uranium Registries, Washington State University, Richland, WA, USA.*

Epidemiological studies have shown that the main risk arising from exposure to plutonium aerosols is lung cancer, with other detrimental effects in the bone and liver. A realistic assessment of these risks, in turn, depends on the accuracy of the dosimetric models used to calculate doses in such studies. A state of the art biokinetic model for plutonium, based on the current ICRP biokinetic model, has been developed for such a purpose in an epidemiological study involving the plutonium exposure of Mayak workers in Ozersk (Russia). One important consequence of this model is that the lung dose is extremely sensitive to the fraction (f_b) of plutonium which becomes bound to lung tissue after it dissolves. It has been shown that if just 1% of the material becomes bound in the upper airways, this will double the lung dose. Furthermore, fb is very difficult to quantify from experimental measurements. This paper summarises the work carried out so far to quantify f_b. Bayesian techniques have been used to analyse data from different sources, including both humans and dogs, and the results suggest a small, but non zero, fraction of <1%. A Bayesian analysis of 20 Mayak workers exposed to plutonium nitrate suggests an fb between 0 and 0.3%. Based on this work, the ICRP are currently considering the adoption of a value of 0.2% for the default bound fraction for all actinides, in the forthcoming recommendations on internal dosimetry. In an attempt to corroborate these findings, further experimental work has been carried out by the United States Transuranium and Uranium Registry (USTUR). This work has involved direct measurements of plutonium in the upper airways of workers who have been exposed to plutonium nitrate. Without binding, one would not expect to see any activity remaining in the upper airways at long times after exposure since it would have been cleared by the natural process of mucociliary clearance. Further supportive work on workers exposed to plutonium oxide is planned. This paper will ascertain to what extent these results corroborate the previous inferences concerning the bound fraction.

(Abstract) *Health Physics* 2016, 111 (1 Suppl): S58.

USTUR-0396-16A

The Pseudo Pelger-Huët Cell as a retrospective dosimeter: Analysis of a Radium Dial Painter Cohort

R.E. Goans[1], R.E. Toohey[2], C.J. Iddins[3], N. Dainiak[3], S.L. McComish[4], S.Y. Tolmachev[4]

[1]MJW Corporation, Amherst, NY, USA
[2]M.H. Chew & Associates, Livermore, CA, USA
[3]Oak Ridge Institute for Science and Education, Oak Ridge, TN, USA
[4]United States Transuranium and Uranium Registries, Washington State University, Richland, WA, USA.

Recently the pseudo-Pelger Huët anomaly (PHA) in peripheral blood neutrophils was described as a new radiation-induced, stable biomarker. In this study, we have examined PHA in peripheral blood slides from a cohort of 166 former radium dial painters, 35 of whom had zero marrow dose. The slides were made available in collaboration with the U.S. Transuranium and Uranium Registry (USTUR). Members of the radium dial painter cohort had ingestion of ^{226}Ra and ^{228}Ra at an early age (average age 20.6 ± 5.4 y; range 13-40 y) during the years 1914-1955. Exposure duration ranged from 1-1,820 weeks with marrow dose 3-13,500 mGy-Eq. The peripheral blood slides were prepared in 1960-1965 during medical follow-up and were quite suitable for light microscope evaluation after 50+ y. PHA in neutrophils is characterized by oval, symmetric bilobed nuclei, which are joined by a thin mitotic bridge. PHA is known to be caused by a decreased amount of the lamin B receptor (LBR). The B-type lamins are the building blocks of the cell's nuclear lamina, and the LBR gene is known to be located on the long arm of chromosome 1, 1q42.12. PHA expressed as a percentage of total neutrophils in this cohort rises in a nonlinear fashion over five decades of red marrow dose. Six subjects in this cohort eventually developed malignancies: five osteosarcomas and one mastoid cell neoplasm. The PHA percentage in these cases rises linearly with RBE-weighted red marrow dose (r^2=0.71). No sarcomas are seen for RBE-weighted red marrow dose under 10,000 mGy-Eq (500 mGy). In the context of these experiments, Receiver Operating Curve (ROC) methodology may be used to evaluate the PHA% as a binary laboratory test to determine whether there is alpha dose to bone marrow. A cutpoint of 5.74% PHA is found for identification of the dose category (AUC 0.961, sensitivity 97.8%, specificity 74.2%, PPV 94.3% for this dataset). PHA from peripheral blood is therefore a reasonable dose surrogate to evaluate alpha dose to bone marrow. Acknowledgements: this work was supported by the U.S. Department of Energy under contract number DE-AC05-06OR23100 with Oak Ridge Associated Universities and award number DE-HS0000073 to Washington State University.

(Abstract) *Health Physics* 2016, 111 (1 Suppl): S57.