

United States Transuranium and Uranium Registries



Annual Report

April 1, 2015 - March 31, 2016



College of

Pharmacy

WASHINGTON STATE UNIVERSITY



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Compiled and Edited

Sergei Y. Tolmachev and Stacey L. McComish

October 2016

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USTUR

A unique resource since 1968



Learning from Plutonium and Uranium Workers

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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, 2015 – March 31, 2016. This is the fourth fiscal year (FY) of the USTUR's 5-year grant proposal (April 1, 2012 – March 31, 2017).

50-year Anniversary

The year 2018 will mark 50 years of research at the USTUR. During the 2015 Scientific Advisory Committee (SAC) Meeting, the USTUR proposed the following activities in 2016: (1) conduct a one-day special session on the USTUR's research, *USTUR: Five Decade Follow-up of Plutonium and Uranium Workers*, and (2) host a USTUR booth at the 61st Annual Meeting of the Health Physics Society, Spokane, WA. The DOE awarded the USTUR an additional \$30,000 to sponsor anniversary events.

FY2016 Grant

As directed by the Department of Energy (DOE) Associate Under Secretary for the Office of Environment, Health, Safety and Security (AU-13), the budget for FY2016 (April 1, 2015 – March 31, 2016) remained at the same level as the budget granted for FY2015, i.e., \$900,000.

External funding of \$20,406 (out of \$25,000) was available in FY2016 from DOE Project 2.4 Mayak Worker Dose Reconstruction, Joint Coordinating

Committee on Radiation Effects Research (JCCRER).

Organization and Personnel

The organizational structure of the USTUR Research Center as of March 31, 2016 is provided in Appendix A. A total of 5.7 full time equivalent (FTE) was supported in FY2016 by the available funding.

Scientific Advisory Committee

The annual Scientific Advisory Committee (SAC) meeting was held September 1-2, 2015 at the Courtyard by Marriott in Richland, WA. The committee reviewed the USTUR's progress since the previous meeting (September 2014) and made recommendations for the upcoming year. Dr. Thomas L. Rucker began his first term on the SAC as the radiochemistry representative on October 1, 2015.

Registrant Donations

Three donations were received by the USTUR in FY2016: Case 0806 (43rd whole-body), Case 0787 (301st partial-body) and Case 0845 (302nd partial-body).

NHRTR Inventory

As of March 31, 2016, 9,067 tissue samples from 42 whole- and 105 partial-body donations were inventoried. These Registrants passed away between 1982 and 2016.

The inventory of USTUR acid solutions (previously analyzed, acid-digested tissue samples) was completed.

Radiochemistry Operation

Significant progress was made by the Radiochemistry Group on tissue analyses. A total of 411 tissue samples from 4 whole-body donations, 9 partial-body donations, and one living Registrant were analyzed for plutonium, americium, and uranium using in-house α -spectrometry. Radiochemical survey analyses of 4 whole-body donors and full analyses of 9 partial-body cases were completed.

Health Physics Database

Standardization of exposure records and bioassay data for 4 living Registrants and all (43) deceased whole-body donations has been completed. Of a total of 302 partial-body donations, data records have been standardized for 142 cases. Data entry was completed for all worksites except Hanford and Rocky Flats. As of March 31, 2016, the database holds a total of 81,500 data records.

New Graduate Research

Sara Dumit, WSU Pharmaceutical Sciences PhD student, joined the USTUR research team. Her graduate research will focus on the development, parameterization, and validation of a plutonium decorporation model. This research will be conducted in a close collaboration with European Radiation Dosimetry Group (EURADOS), Working Group 7 (WG7) on Internal Dosimetry.

New Academic Cooperation

In December 2015, Washington State University, through the United States Transuranium and Uranium Registries, and Kyushu University (Fukuoka, Japan), through the Central Institute of Radioisotope Sciences and Safety (CIRSS), signed an academic and research collaboration agreement. The purpose of this agreement is to promote academic exchange and cooperation in the research and education between two universities.

Research Results

Three papers were published by the USTUR in top-ranking peer-reviewed journals. These publications covered the recent research conducted at the Registries itself and through its scientific collaborations, covering the topics of: (i) uranium in man, (ii) ^{241}Am *in-vivo* measurements, and (iii) ^{137}Cs contribution to radiation dose. During FY2016, two invited, five podium, and two poster presentations at national conferences were given by USTUR faculty.

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, 2015, the USTUR began the fourth grant year of the USTUR's 5-year grant proposal (April 1, 2012 – March 31, 2017).

Fiscal year (FY) 2016 (April 1, 2015 – March 31, 2016) 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, 2015 – March 31, 2016

Total funding granted by DOE/AU-13 to WSU/COP/USTUR from April 1, 2012 until March 31, 2016 (FY2013 – FY2016) was \$3,600,000.

External Funding

Contract

U.S. Department of Energy Project 2.4 Mayak Worker Dose Reconstruction, Joint Coordinating Committee on Radiation Effects Research (JCCRER):

Macrodistribution and Long-Term Retention of Refractory Plutonium in the Human Respiratory Tract

GA227795

Amount awarded: \$25,000

Period: October 1, 2014 – September 30, 2015

Available in FY2016: \$20,406.

Operating budget

With \$20,406 available from FY2015, the USTUR net operating budget for FY2016 was \$920,406. Total operating expenses for FY2016 were \$953,442 resulting in a negative balance of \$33,036.

Grant Administration

FY2017 Grant Renewal Proposal

On January 27, 2016, a grant renewal proposal to manage and operate the United States Transuranium and Uranium Registries and the associated National Human Radiobiology Tissue Repository (NHRTR), in FY2017 (April 1, 2016 – March 31, 2017), was submitted to the DOE/AU-13 through the WSU's Office of Research Support and Operations (ORSO). The total amount requested for the FY2017 was \$900,000.

Submitted

Dr. George Tabatadze submitted a grant pre-proposal titled "Digital Autoradiography Technique for Quantitative Analysis of Radionuclide Distribution within Human and Animal Tissue Structures" to WSU through the 2016 New Faculty Seed Grant Program. This is one-year research project, starting (if granted) on May 16, 2016 with the requested budget of \$30,000. The proposal is under review. The award results are to be announced by May 2, 2016.

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 September 2, 2016). 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) and one technical report (USTUR-0398-16) for the external contract (GA227795) were distributed on a timely basis to sponsoring agencies and the university during the period April 1, 2015 – March 31, 2016. The FY2015 annual report (USTUR-0402-16) for the DE-HS0000073 grant was published, electronically distributed, and uploaded to the U.S. DOE Office of Scientific and Technical Information (OSTI) website (OSTI ID 1255087).

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 will organize several special activities, which will increase the USTUR's visibility in the scientific community.

During the 2015 Scientific Advisory Committee (SAC) Meeting, the USTUR proposed the following activities to celebrate the USTUR's 50th anniversary:

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, 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.

Special Session

The USTUR is organizing a one-day special session at the 2016 Annual Meeting of the Health Physics Society in Spokane, WA on July 19, 2016. The session, "USTUR: Five Decade Follow-up of Plutonium Workers," will open with keynote presentations by Ronald Kathren and Eugene Carbaugh. The morning session will focus on internal projects, conducted by USTUR staff, and the afternoon will focus on research carried out through collaborative relationships with external researchers. The day will finish with a roundtable discussion on "50 years of USTUR history." It will be led by the former director of radiochemistry at Los Alamos Scientific Laboratory, Jim McInroy (1975-1992), and four former Registries directors: Bryce Breitenstein (1976-1982), Margery Swint (1982-1989), Ronald Kathren (1989-1999), and Ronald Filipy (1999-2005). Conference attendees will be invited to ask questions, and the roundtable panel members will provide their recollections and insight as they respond.

A series of articles will be published in *Health Physics News*. These will publicize the upcoming special session.

Conference Booth

The USTUR will host an informational booth at the 2016 Health Physics Society Meeting in Spokane. USTUR

staff will answer questions about the Registries, and



50th anniversary pin

will have informational brochures available. They will also hand out pens, specially-designed 50th anniversary pins, and pins with the USTUR's logo to conference attendees.

Health Physics Journal

Papers presented at the 2016 Health Physics Society Meeting will be compiled and published as a special issue of the Health Physics journal in 2017.

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. In 2018, the USTUR will again update this series with a sixth volume, which will reproduce journal articles and various publications from January 1997 through December 2017.

Registrant Statistics

Stacey L. McComish, *Associate in Research*

As of March 31, 2016, the Registries had 879 Registrants in all categories (Table 1). Of that number, 52 were living and 351 were deceased. The 52 living Registrants included 7 individuals who were registered for eventual whole-body donation, 40 for partial-body donation, and 5 for 'Special Studies,' i.e., a bioassay study with no permission for autopsy. There were also 476 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, 2016

Total Living and Deceased Registrants:	403
Living Registrants:	52
Potential Partial-body Donors:	40
Potential Whole-body Donors:	7
Special Studies:	5
Deceased Registrants:	351
Partial-body Donations:	302
Whole-body Donations:	43
Special Studies:	6
Inactive Registrants:	476
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 B), also serves to maintain contact between the USTUR and living Registrants.

During this fiscal period, two Registrants renewed, two were placed in the inactive category, and one new Registrant joined the program. Additionally, it was determined that one special studies case had passed away several years ago. His status was changed to deceased.

Registrant Deaths

The USTUR was notified of three Registrant deaths. Two were partial-body donations. These autopsies were performed near the municipality where the Registrants passed away, and tissues were sent to the USTUR laboratory for radiochemical analysis. One was a whole-body donation. This autopsy was performed by the USTUR's consultant pathologist, Dr. Eric Kiesel.

Case 0787: This partial-body donor worked with actinides for over 29 years. His most significant intake was an inhalation of refractory plutonium dioxide during a fire. He also had several minor wounds.

Case 0806: This whole-body donor was enrolled shortly before he passed away. His wife recalled signing paperwork in the past. His EEOICPA/NIOSH dose reconstruction records indicated that he met the current USTUR criteria for enrolling a new Registrant (>2 nCi internal deposition). We subsequently received his exposure records from the worksite. He had a wound incident and an acid burn; each resulted in a single positive urinalysis result. He also had a suspected inhalation of

plutonium. He worked with actinides for approximately 15 years.

Case 0845: This partial-body donor worked with uranium, plutonium, and thorium at various points during his 40-year career. A single positive urine measurement indicates that he may have inhaled soluble ^{239}Pu .

Registrant Status

The average age of living whole- and partial-body Registrants was 81 years and 83 years, respectively. The average age at death for the USTUR's 347 deceased Registrants was 69 years.

In FY2001, the USTUR reviewed exposure records and work histories for all active Registrant files, and prioritized them into three categories:

Category 1: Registrants who had a significant actinide intake as indicated by positive bioassay results.

Category 2: Registrants who had relatively high external radiation dose, and professed exposure to asbestos, beryllium, or chemical solvents. (These Registrants had only minimal actinide body burdens.)

Category 3: Registrants who were not likely to have had any actinide intakes. The autopsy agreements of these Registrants were not renewed.

The distribution of living Registrants by worksite and category is shown in Figure 1.

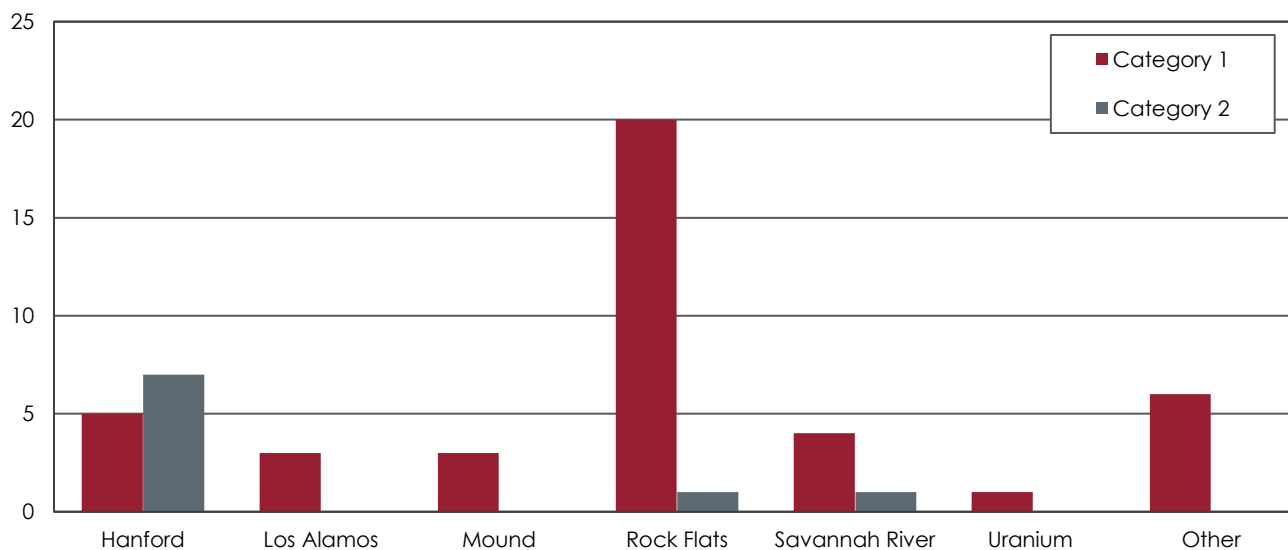


Fig. 1. Number of active Registrants by worksite and category.

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.

Data Entry

The USTUR currently holds documents containing health physics and bioassay records for the 43 whole-body and 302 partial-body Registrant tissue donors. Beginning in 2012, the USTUR adopted the following strategy for populating the health physics database:

- The most recent donation is given the highest priority and is completed immediately
- Existing donation cases are completed based on specific worksites: Rocky Flats, Los Alamos, Hanford, etc. with higher priority given to whole-body cases than partial-body donations
- In special circumstances, priority is given to specific case(s), which are subjects of particular scientific interest.

Since the expansion and restructuring of the USTUR's internal health physics database in 2008, standardization of health physics records and bioassay data was completed for a total of 185

USTUR donations: 43 whole-body (all whole-body cases) and 142 partial-body (47% of all partial-body cases). In total, 80,162 health physics records from deceased Registrants have been entered into the database.

In addition, data entry was completed for four living Registrants (3 potential partial-body and 1 special study case) with a total of 1,338 records.

Figure 2 shows the FY2008 - FY2016 progress and the overall status of the health physics database for deceased Registrants as of March 31, 2016.

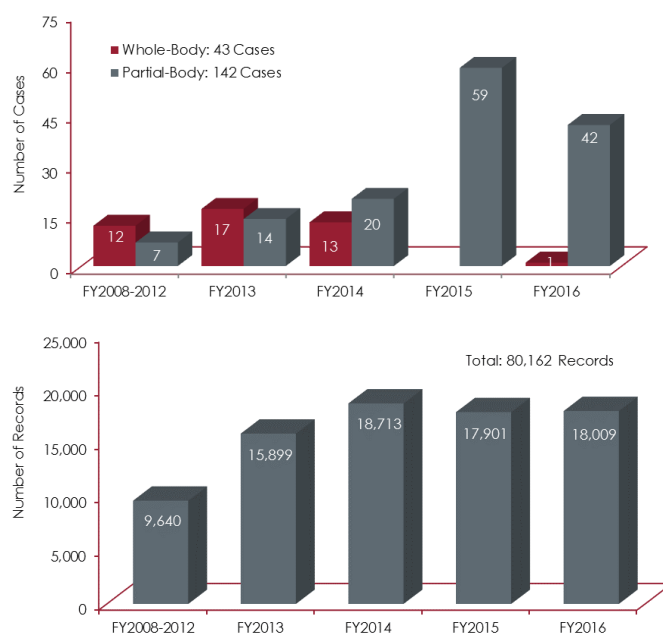


Fig. 2. FY2016 progress and overall status of the USTUR health physics database for deceased Registrants.

The summary statistics of all completed donation cases, categorized based on the type of intake, primary radionuclide of exposure, and material type (solubility class) are presented in Figure 3.

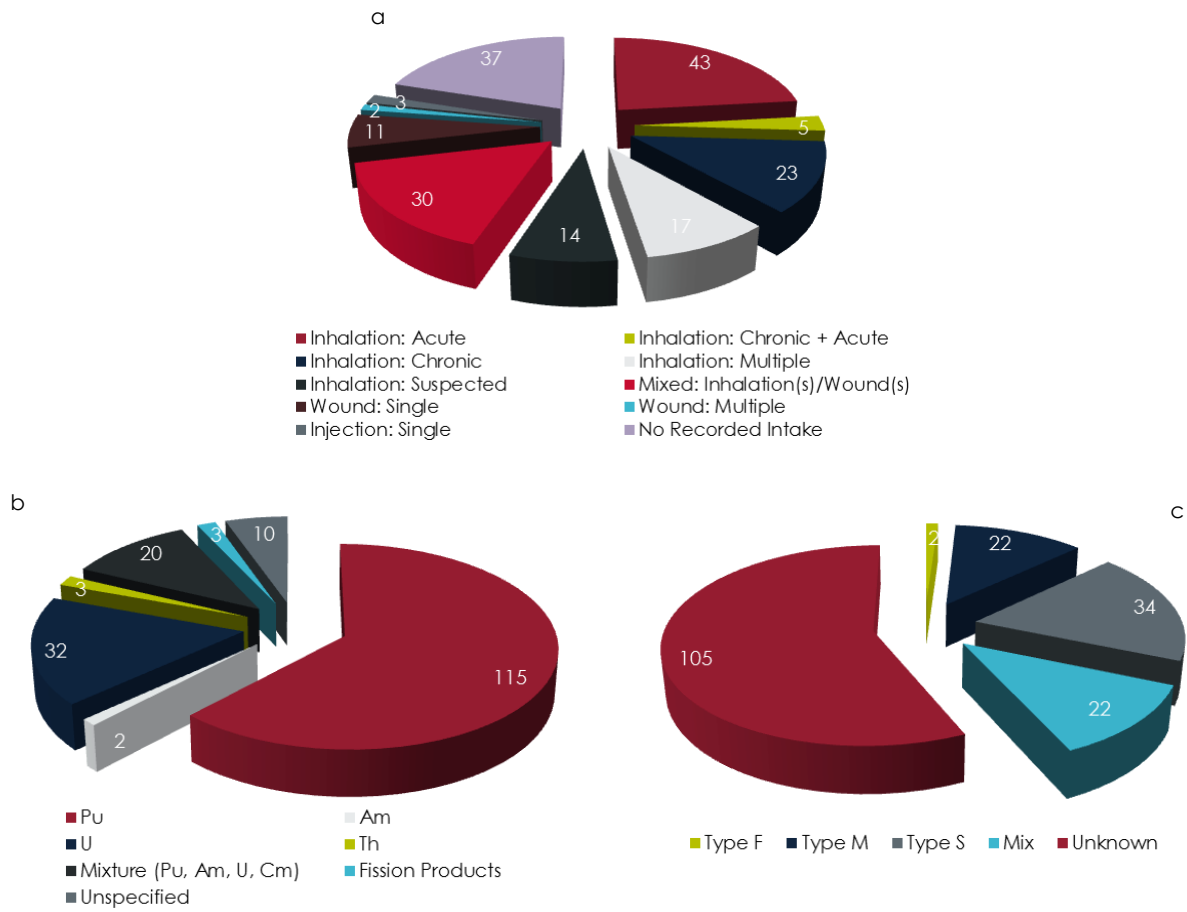


Fig. 3. Summary statistics of the health physics database: completed donation cases by (a) intake; (b) primary radionuclide; (c) material type.

NHRTR: National Human Radiobiology Tissue Repository

Stacey L. McComish, Associate in Research

National Human Radiobiology Tissue Repository (NHRTR) activities focused on dissection and hygienic packaging of tissues, and inventory of: (i) USTUR tissue samples, (ii) USTUR acid solutions, (iii) USTUR planchets, (iv) USTUR pathology slides, and (v) tissues from the terminated radium worker and plutonium injection studies received from Argonne National Laboratory (ANL). Samples were inventoried using THEMIS (THE Management Information System).

Tissue Dissection

During FY2016, Florencio Martinez completed the dissection of one whole-body (0806) and two partial-body (0787, 0845) donations. Ms. Katherine Banks and Mr. Michael Funk, WSU Tri-Cities College of Nursing students, assisted Mr. Martinez, and carried out vacuum packaging of the tissue samples.

Table 2. Inventoried samples as of March 31, 2016

Tissue Type	Samples		
	Parent	Sub-	Total
USTUR donations			
Soft tissues	4,716	518	5,234
Bones	4,351	94	4,445
Acid solutions	5,684	2,015	7,699
Planchets	316	759	1,075
Slides	1,392	2,079	3,471
ANL tissues	1,427	428	1,855
LASL acids	999	4	1,003
Blank and QC acids	322	161	483
Miscellaneous	289	56	345
Total	19,494	6,121	25,615

THEMIS Inventory

As of March 31st, 19,494 parent samples and 6,121 subsamples had been inventoried using the THEMIS database (Table 2). Parent samples best represent the number of unique tissues available at the USTUR; therefore, the following discussions about tissues and acid solutions exclude subsamples.

USTUR Tissues

Information on 381 parent samples was entered into THEMIS during FY2016. This brought the total number of inventoried USTUR tissues to 9,067 samples from 42 whole-body, 105 partial-body, and 2 living or inactive cases. The six most common types of USTUR tissues were skeletal, fat/muscle/skin, alimentary, circulatory, glands, and respiratory (Figure 4). Tissues were typically stored in a frozen state, and skeletal samples were most common due to the large number of bones in the human body, as well as due to the dissection protocol. Typically, long bones were dissected into four samples that were inventoried as unique parent samples.

On average, whole-body cases had 149 ± 98 tissue samples per case and partial-body cases had 27 ± 23 tissue samples per case.

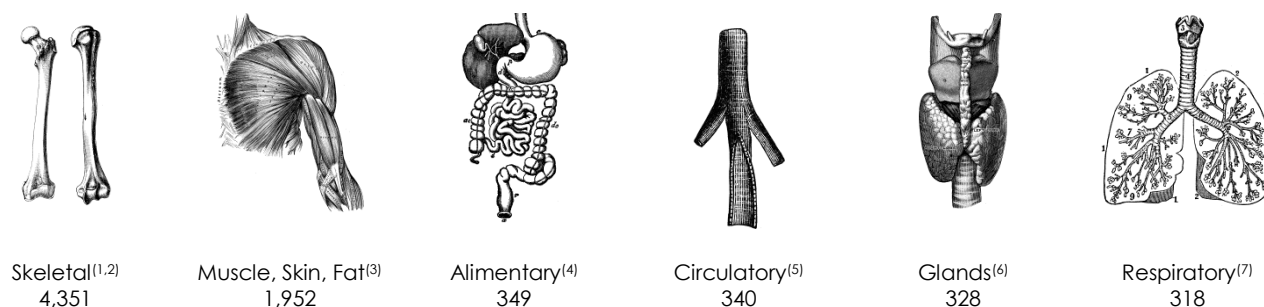


Fig. 4. The six most common types of tissues at the USTUR.

USTUR Acid Solutions

During FY2016, USTUR staff finished inventorying USTUR acid solutions – previously analyzed acid-digested tissue samples. This represents three years of dedicated work by student laboratory assistants. During FY2016, information on 1,502 acid solutions from 15 whole-body, 126 partial-body, and 10 inactive or living cases was entered into THEMIS. An additional 41 acid blanks and 21 QA/QC samples were also inventoried. This brought the total number of inventoried acid solutions to 6,006. As was the case for USTUR tissues, skeletal samples were the most common type of acid solution.

USTUR Planchets

The NHRTR holds several thousand α -spectrometric counting sources (planchets), accumulated by the Registries. A planchet is the final product of an actinide tissue analysis. It is a stainless steel disk (diameter = 5/8") onto which α -radioactivity was electrodeposited following radiochemical actinide separation. An individual planchet has deposited activity from one of the following actinide elements: plutonium (Pu), americium (Am), uranium (U), or thorium (Th).

Laboratory staff continued to inventory batches of planchets using the THEMIS database. Each of

these batches consisted of up to eight planchets that shared a case number and a blank. A 'dummy' blank sample was logged into THEMIS for organizational purposes, and planchet batches were entered as subsamples.

During FY2016, information on 534 planchet batches, associated with 226 blanks, was entered into THEMIS. This brought the total number of inventoried batches to 759, associated with 316 blanks. Analyte and tracer activities were available for 666 of these batches (Table 3).

Table 3. Tracer and Analyte Activities

Element	Activity (Bq)		
	Tracer	Analyte	Total
Pu	82	96.9	178.9
Am	116.2	30.3	146.5
Pu/Am	0.18	0.012	0.192
U	17.6	4.8	22.4
Th	unknown	unknown	unknown
n.a.	0.5	7.6	8.1

USTUR Pathology Slides

The USTUR holds thousands of paraffin embedded tissue blocks and microscope slides that were provided by pathologists following USTUR Registrant autopsies. In FY2016, Ryan Blake organized the pathology slides and associated tissue blocks by case number using 5-slide plastic mailers and

Argonne National Laboratory Samples

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Radiochemistry Operation

George Tabatadze, *Research Associate*

Sergei Y. Tolmachev, *Director/Principal Radiochemist*

During FY2016 (April 1, 2015 – March 31, 2016), Radiochemistry Group activities were mainly focused on radiochemical tissue analysis.

Personnel

As of April 1, 2015, 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).

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 $^{239+240}\text{Pu}$), americium (^{241}Am), uranium (^{234}U , ^{235}U , and ^{238}U), and thorium (^{232}Th) by α -spectrometry (AS, in-house) or by inductively coupled plasma mass spectrometry (ICP-MS, external).

During FY2016, 411 tissue samples, including 102 bones and 309 soft tissues from 14 donations, were analyzed for ^{238}Pu , $^{239+240}\text{Pu}$, and ^{241}Am using AS. Twenty-six samples were also analyzed for ^{234}U , ^{235}U , and ^{238}U .

Whole-body Donations

One hundred and forty-nine tissue samples from 4 whole-body donations, received between 2005 and 2012, were analyzed: Case 0407 (51 samples), Case 0757 (35), Case 0834 (37), and Case 0990 (26). A total of 39 bones and 110 soft tissues were analyzed. All samples were analyzed for ^{238}Pu , $^{239+240}\text{Pu}$, and ^{241}Am . Case 0990 was also analyzed for ^{234}U , ^{235}U , and ^{238}U . Analysis of Case 0407 was carried out as a part of the JCCRER contract.

Analysis of 78 tissue samples from 4 whole-body donations has begun, but is not yet completed: Case 0303 (42 samples), Case 0391 (32), Case 0407 (2), and Case 0503 (2).

Partial-body Donations

Two hundred and sixty-one tissue samples from 9 partial-body donations, received between 1998 and 2015, were analyzed: Case 0272 (32 samples), Case 0377 (35), Case 0381 (16), Case 0412 (31), Case 0636 (36), Case 0743 (34), Case 0787 (30), Case 0805 (33), Case 0837 (14). One additional sample from a living Registrant – Case 0820 (1) – was analyzed.

A total of 63 bones and 199 soft tissues were analyzed for ^{238}Pu , $^{239+240}\text{Pu}$, and ^{241}Am .

Analysis of 76 tissue samples from 4 partial-body donations has begun, but is not yet completed:

Case 0658 (28 samples), Case 0785 (3), Case 0800 (29), and Case 0958 (40).

Radiochemistry Case Analysis Progress

As of March 31, 2016, the USTUR had received 43 whole- and 302 partial-body donations, including one whole- and two partial-body donations accepted during FY2016.

In FY2016, radiochemical survey analyses of 4 whole-body donors were completed and 2 are in progress. 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. Additional samples were analyzed from Case 0503 (completed in FY2015). Table 4 summarizes whole-body case analysis progress.

Table 4. FY2016 whole-body case analysis progress

Case No	Year of Donation	Radiochemistry Status	
		FY2015	FY2016
0303	2008	Incomplete	Incomplete
0391	2006	Intact	Incomplete
0407†	2008	Incomplete	Incomplete
0503	1994	Complete	Complete
0757†	2012	Intact	Incomplete
0834†	2007	Intact	Incomplete
0990†	2005	Incomplete	Incomplete

† - Survey analysis completed in FY2016

Full analyses of 9 partial-body cases were completed and 3 are in progress. Additional samples were analyzed from Case 0785 (completed in FY2014). Table 5 summarizes partial-body case analysis progress.

Table 5. FY2016 partial-body case analysis progress

Case No	Year of Donation	Radiochemistry Status	
		FY2015	FY2016
0272	2013	Incomplete	Complete
0377	2015	Intact	Complete
0381	1998	Incomplete	Complete
0412	2005	Incomplete	Complete
0636	2012	Incomplete	Complete
0658	2007	Intact	Incomplete
0743	2013	Incomplete	Complete
0785	2008	Complete	Complete
0787	2015	Intact	Complete
0800	2009	Intact	Incomplete
0805	2014	Intact	Complete
0820	Living	N/A	N/A
0837	2003	Incomplete	Complete
0958	2009	Intact	Incomplete

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.

Figures 5 and 6 compare overall radiochemical analysis status of whole- and partial-body donations at the beginning (April 1, 2015) and the end (March 31, 2016) of the reporting period.

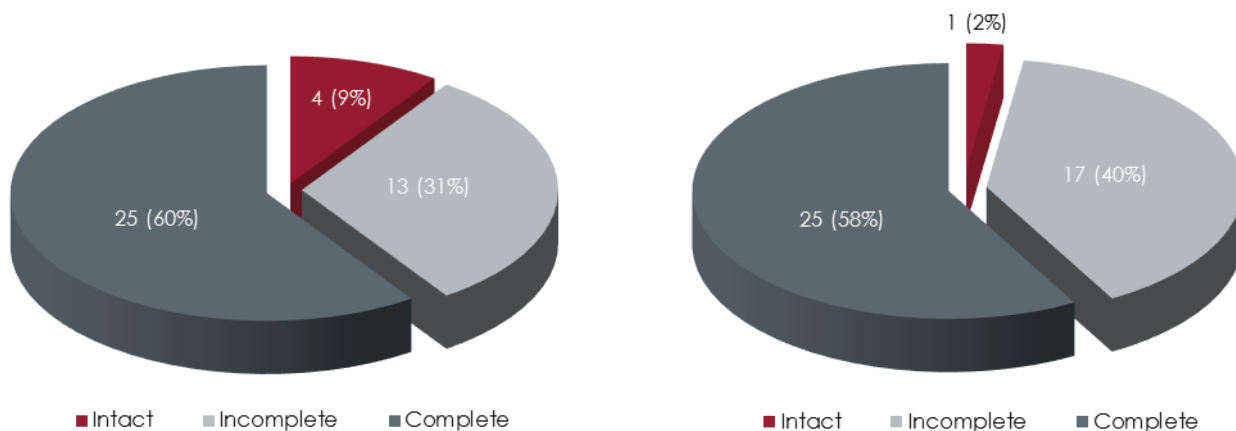


Fig. 5. Radiochemical analysis status for whole-body donations: as of April 1, 2015 (left); and as of March 31, 2016 including one new donation during FY2016 (right).

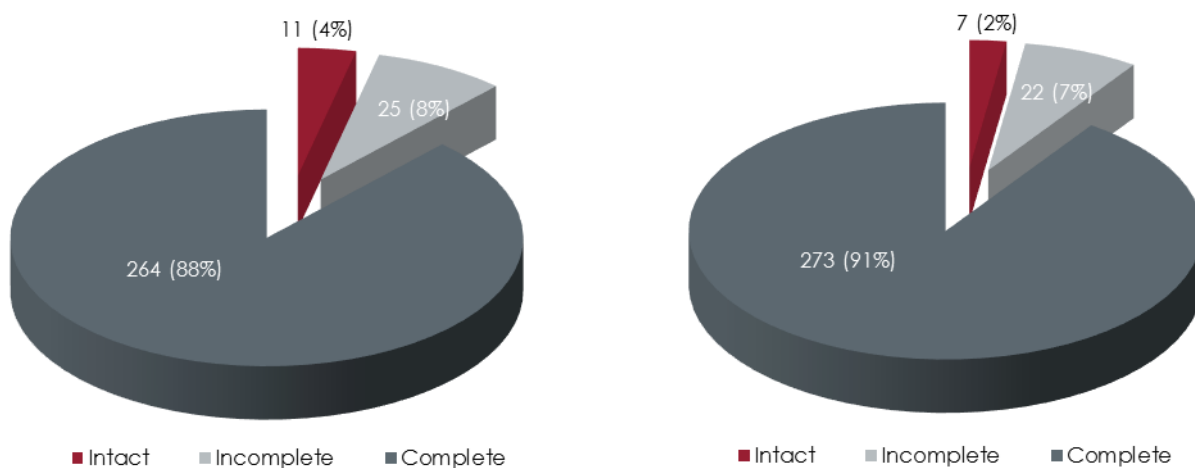


Fig. 6. Radiochemical analysis status for partial-body donations: as of April 1, 2015 (left); and as of March 31, 2016 including two new donations during FY2016 (right).

Student Involvement

Stacey L. McComish, *Associate in Research*

Student workers played an instrumental role at the USTUR. Their duties ranged from inventorying tissues at the laboratory to backing up Registrant files at the office. Most students were part of a collaborative relationship with the WSU Tri-cities nursing program; however, several students from other departments and institutions assisted at the USTUR during FY2016.

Autopsy Assistants

Four WSU Tri-cities nursing students assisted with one autopsy (Case 0806). The students were grateful for the opportunity to participate in autopsy, and the USTUR benefited from the extra help weighing and packaging tissues removed during the autopsy.

Laboratory Assistants

Tissue Handling

Students worked closely with the USTUR prosector, Florencio Martinez, to assist with dissections, vacuum package tissues, and inventory samples. Nursing students are ideal for this position because they have all the necessary training and a good knowledge of anatomy and physiology.

Acid Solutions

Individual acid-digested tissue samples (acid solutions) are stored in 100 – 1,000-ml glass bottles. Historically, these bottles were packed in cardboard boxes filled with vermiculite as an absorbent material. Since 2012, students have been repackaging acid solutions in corrugated plastic boxes. As a part of this process, the

vermiculite was wiped off the bottles and damaged bottle lids were replaced. The lids were then sealed with melted paraffin wax and bottles were wrapped in acid-resistant absorbent mats. Each bottle was inventoried using the THEMIS database, and a contents list was affixed to the outside of the box.

Planchets Inventory

As a part of tissue analyses, individual actinide elements (plutonium, americium, uranium, thorium) are electrodeposited onto stainless steel planchets for alpha spectroscopy counting. Student workers inventoried the planchets using the THEMIS database.

Office Assistants

Document Scanning

Students continued to scan Registrant hard files to full-color pdfs as a digital back up. This fiscal year, 63 deceased Registrant files were scanned, bringing the total number of scanned files to 262 (75% of deceased Registrants). Once all Registrant files have been scanned, the electronic files will be copied to a fireproof/waterproof hard drive.

Student Employee List

Seven students worked at the USTUR during FY2016. Individual names, affiliations, and duties are listed in Table 6.

Table 6. Student Employees

Student	Program	Task
Ryan Ashley	CBC [†]	Acids
Katherine Banks	WSU Nursing	Tissues
Ryan Blake	Hanford High	Planchets
Colette de Vries	WSU Nursing	Tissues/Acids
Elizabeth Gage	WSU Nursing	Acids/Scanning
Diana McGlynn	WSU Nursing	Acids/Planchets
Leyla Resat	Hanford High	Planchets

[†]Columbia Basin College, Pasco, WA.

Graduate Research

Sergei Y. Tolmachev, *Research Associate Professor*



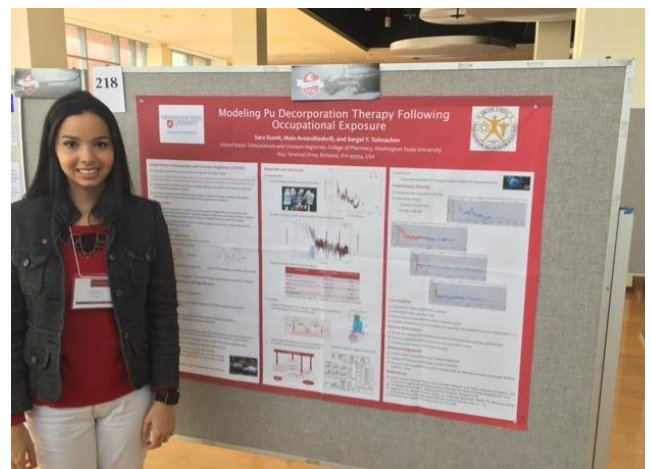
After COP Graduate Research Seminar, WSU Spokane

On November 1st, WSU Pharmaceutical Sciences PhD student, Sara Dumit, joined the USTUR research team. 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.

At the USTUR, Ms. Dumit's PhD research will focus on the development, parameterization, and validation of a plutonium decorporation model. Ms. Dumit is a first COP graduate student who will conduct a project at the USTUR. Dr. Tolmachev was assigned by COP/WSU as a major scientific advisor and Dr. Sayed S. Daoud (COP, Spokane) will chair the Graduate Committee. Other members of the Committee are: Prof. Kathryn E. Meier (COP, Spokane), Dr. Jeannie M. Padowski (COP, Spokane), and Dr. Daniel J. Strom (College of Arts and Sciences, WSU/Tri-Cities).

This research will be conducted in close collaboration with European Radiation Dosimetry Group (EURADOS), Working Group 7 (WG7) on Internal Dosimetry. Dr. Bastian Breustedt of Karlsruhe Institute of Technology (Germany) agreed to serve as an *ad-hoc* advisor.

Ms. Dumit presented her preliminary findings three times during March 2016. She summarized her work as a seminar presentation to College of Pharmacy faculty and students as a part of COP's graduate research seminar class in Spokane, WA. She presented a poster at the Brazilian Graduate Students Conference (BRASCON) at Harvard University in Cambridge, MA. Ms. Dumit helped to organize the BRASCON meeting in her role as a recruiting coordinator. She also presented her BRASCON poster at WSU's Graduate & Professional Student Association (GPSA) Research Exposition in Pullman, WA.



Sara Dumit presenting at GPSA Research Exposition, WSU Pullman

Fifty-two Year Follow-up Study

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

On February 5 – 6, 2016, the USTUR conducted a 52-year follow up measurement for a living Registrant – Case 0820. The external γ -counting was carried out at the In-Vivo Radiobioassay and Research Facility (IVRRF) in Richland, WA under a sub-contract to the USTUR (\$3,316).

This individual was involved in plutonium process operations at a defense nuclear facility over the course of 10 years. His major plutonium intake resulted from a contaminated puncture wound on his right hand. Plutonium deposition in the wound was initially measured as 296 nCi of ^{239}Pu . The contaminated tissue was excised, and the remaining activity was estimated to be about 43 nCi. A follow-up wound count in 2003 indicated a significantly higher plutonium activity of approximately 87 nCi. This case was among five cases published by Falk *et al.* (Health Phys. 91(2):128-143; 2006).

At the IVRRF, multiple in-vivo measurements were performed for the wound site (hypothenar pad of the right hand), lungs, liver, and skeleton. ^{239}Pu and ^{238}Pu were estimated from measured ^{241}Am



Case 0820: In-vivo wound counting at the IVRRF

activities based on original plutonium material composition. The fractions of ^{241}Am , ^{239}Pu , and ^{238}Pu activities in the material were determined from the radiochemical analysis of the surgically removed wound tissue specimen, performed by the USTUR in December 2015.

For this case, 12 ± 1 nCi of ^{241}Am activity was retained in the wound site, 1.6 ± 0.2 nCi was measured in the liver, and 13 ± 1 nCi in the skeleton. Activities of ^{239}Pu and ^{238}Pu were estimated for the liver, skeleton and wound site. The results are summarized in Table 7.

Table 7. Results of follow-up in-vivo measurements

Organ/Tissue	IVRRF external γ -counting, nCi		USTUR estimation, nCi	
	^{241}Am	$^{239}\text{Pu}^\ddagger$	$^{239}\text{Pu}^\ddagger$	^{238}Pu
Liver	1.6 ± 0.2		6.8 ± 1.0	0.10 ± 0.02
Skeleton	13 ± 1		55.6 ± 5.9	0.85 ± 0.08
Wound Site	12 ± 1	30 ± 3	51.3 ± 5.4	0.78 ± 0.07

‡ - ^{239}Pu - the primary radionuclide of exposure

The ^{239}Pu activity estimated by the USTUR is higher than that estimated by the IVRRF. Since radiochemical analysis has an advantage over external γ -counting for ^{239}Pu detection, the value of 51.3 nCi is a better estimate of the ^{239}Pu activity retained in the wound site. These results were reported to the Registrant on March 10, 2016.

Plutonium Decorporation Study

Sara Dumit, *PhD Student*

Maia Avtandilashvili, *Research Associate*

Sergei Y. Tolmachev, *Research Associate Professor*

High levels of exposure to plutonium can cause severe health effects. Individuals with significant internal contamination typically undergo treatment with chelating agents such as calcium salt of ethylenediaminetetraacetic acid (Ca-EDTA) and calcium or zinc salts of diethylenetriaminepentaacetic acid (Ca/Zn-DTPA) to accelerate plutonium excretion and thus decrease radiation dose to sensitive tissues.

A combination of radiation exposure history, bioassay results, and medical data with post-mortem measurements of plutonium in the human body allows us 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 involving plutonium nitrate [$^{239}\text{Pu}(\text{NO}_3)_4$] material. His plutonium body burden was estimated by worksite as 7,400 Bq three months after the accident and 8,100 Bq at the time of his retirement, 31 years post-accident.

Decorporation therapy was started immediately. One to two grams of Ca-EDTA were intravenously administered twice a day for 4 weeks. Three weeks post-accident, the contaminated wound was excised, removing 7,344 Bq of ^{239}Pu . Nine months

post-accident, two grams of Ca-EDTA were injected twice a day for 2 weeks. Seven years post-accident, the Registrant was treated with weekly intravenous injections of one gram of Zn-DTPA for 10 weeks.

The Registrant was monitored for 44 years, including 13 years post-employment. A total of 478 urine samples was collected and analyzed for plutonium and other actinides. Seventy-four in-vivo lung and 101 wound measurements were performed. The Registrant died 51-y post-intake at the age of 79 from a lung disease. This individual smoked 0.5 pack of cigarettes per day for 38 years.

From the post-mortem tissue radiochemical analysis, the ^{239}Pu whole-body activity was estimated to be $2,728 \pm 84$ Bq. Of this, 71.0% was deposited in the skeleton, 22.1% in the liver, and 4.9% in the respiratory tract. The results confirmed that the internal deposition of plutonium was caused by inhalation and wound intake, and provided additional information on material solubility type.

The IMBA Professional Plus® software⁽¹⁾ was applied to simultaneously fit bioassay data and post-mortem plutonium activities measured in the skeleton, liver and lungs. The ICRP 130 human respiratory tract model⁽²⁾, NCRP 156 wound model⁽³⁾, and Leggett plutonium systemic model⁽⁴⁾

were used with default assumptions of material type. Since small particles are typically generated during an explosion, a 1 μm particle size was used instead of ICRP 130's default value of 5 μm . Inhalation and wound intake regimes were used simultaneously. Results of the calculations were consistent with the ICRP 68 Type S material. The residual fraction of the total intake, not removed by decorporation treatment, was estimated to be 34,134 Bq with 97% contributed by inhalation. The residual committed effective dose received by this individual was calculated to be 1.09 Sv.

A total of 683 Bq was eliminated via urinary excretion during decorporation treatment. Accounting for this, a total plutonium intake of 34,817 Bq was calculated. This results in a projected committed effective dose of 1.11 Sv. In this case, decorporation therapy was not efficient, as only 2% of radiation dose reduction was achieved.

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Modeling Multiple Inhalations

Maia Avtandilashvili, *Research Associate*

Internal dose reconstruction from bioassay monitoring data is a non-trivial, iterative process that involves a large number of variables and may require substantial time and effort. The step-by-step procedure of how to perform the assessment of intake and doses from measurement data was described elsewhere⁽¹⁾. A simplified version of internal dose assessment procedure is depicted in Figure 7.

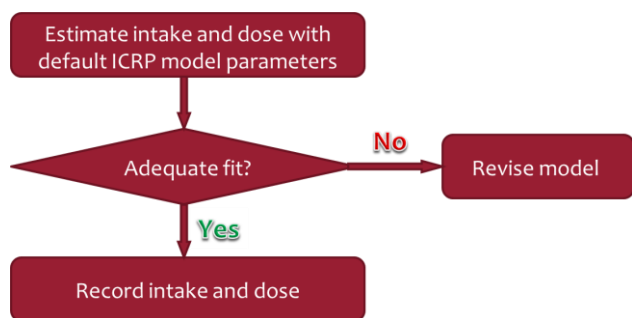


Fig. 7. Internal dose assessment.

In this study, bioassay and autopsy tissue analysis data from USTUR partial-body donor 0837 were evaluated using IMBA Professional Plus internal dosimetry software⁽²⁾ to estimate the intake, the committed effective dose, and the equivalent doses to the key target organs.

This individual worked with plutonium and americium over the course of 20 years. He was primarily involved in plutonium recovery and metal reprocessing operations. Several skin contamination incidents were reported for this worker with only two of them resulting in positive bioassay measurements. In addition, an acute

inhalation incident was suspected given the positive plutonium lung count.

Bioassay data obtained for this case include 59 urinalyses (Figure 8) and 40 in-vivo lung count results (Figure 9).

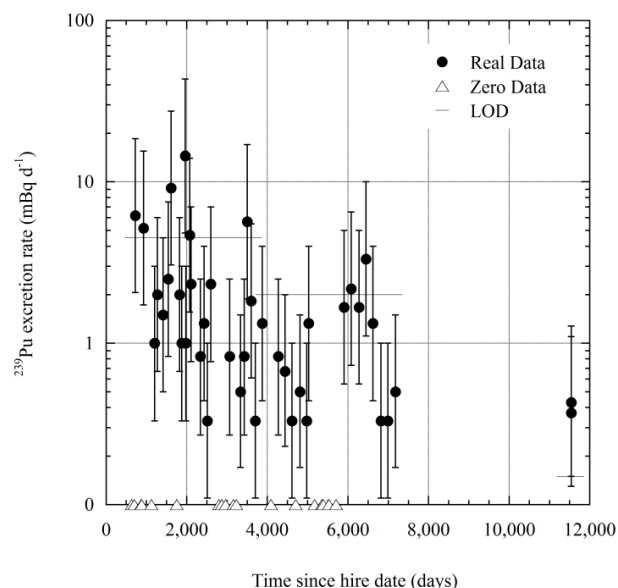


Fig. 8. Urinalysis data.

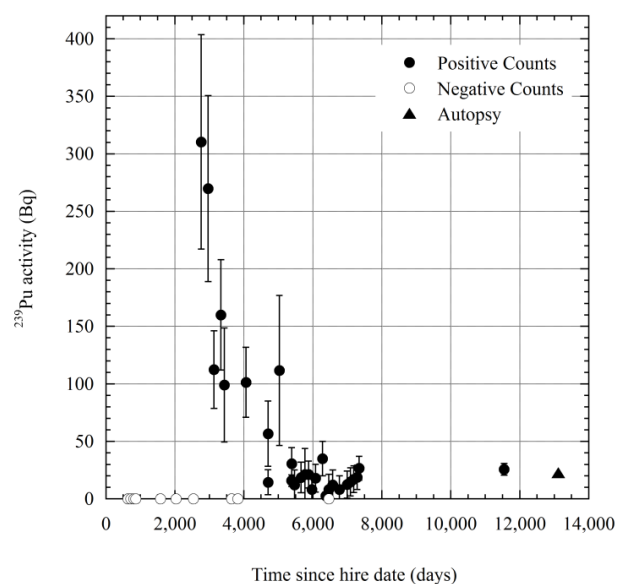


Fig. 9. In-vivo lung count data.

Worksite personnel estimated the plutonium systemic and lung deposition at time of employment termination to be 111 Bq and 33 Bq, respectively.

The Registrant died from heart disease 16 years after his retirement.

Four soft tissue samples – including the right lung, hilar lymph nodes, liver, and right kidney – and five bone samples from the patella, clavicle, and femur were collected at autopsy and radiochemically analyzed. Results are summarized in Table 8.

Tissue analysis results were examined to determine the solubility of deposited Pu material. The LN_{TH} to lungs concentration ratio of 4.5 does not support either type M or type S absorption behavior. For inhalation of ICRP Type M material, the ratio would be approximately 1, while for Type S, it should be close to 20 or higher. However, the calculated ratio of Pu activity in the liver to Pu activity in the lung (0.35) indicates inhalation of

insoluble Pu material. Most likely, this individual was exposed to a mixture of materials with different solubility types.

For the intake assessment, a complex exposure scenario consisting of three acute inhalation intake regimes was reconstructed in IMBA, based on available information from the health physics records.

As a starting point, the default assumptions recommended by ICRP for Pu inhalation were adopted for all intake regimes: AMAD = 5 μ m, absorption type M. The revised human respiratory tract model (HRTM) structure and parameters⁽⁴⁾ were used to represent both absorption to blood and particle transport.

Application of the revised HRTM coupled with the ICRP 67 Pu systemic model⁽⁵⁾ resulted in a non-credible overall fit to the urine and lung data. However, the models reasonably predicted the post-mortem activities in the liver and skeleton.

Table 8. Tissue analysis results

Tissue	Sample mass, g	Concentration, Bq kg ⁻¹	Activity, Bq
Lungs	490.10	16.3 ± 0.3	21.6
Thoracic LN	6.59	74.0 ± 4.0	1.1
Lungs including LN_{TH}			2.2
Liver	574.50	5.4 ± 0.1	7.5
Kidneys	101.89	0.064 ± 0.009	0.015
Skeleton – based on:		0.9 ± 0.1	9.3^a
Patella	40.38	0.85 ± 0.09	
Clavicle (SE)	6.65	1.4 ± 0.2	
Clavicle (shaft)	19.41	0.91 ± 0.15	
Clavicle (AE)	7.83	4.16 ± 0.24	
Femur (shaft)	175.75	0.81 ± 0.17	

^a Based on total skeletal weight (9.85 kg) predicted from height (1.73 m)⁽³⁾

Absorption model parameters for the third (suspected) inhalation intake regime were customized to obtain a reasonable fit to the lung data. Significant retention of Pu in the lungs indicated a more insoluble material for this intake. Type S default parameters resulted in a better fit compared to Type M. However, the overall fit was still non-credible.

A good fit to all lung data was achieved by simultaneously adjusting the absorption and particle transport model parameters. In the blood absorption model, the Super S absorption behavior was assumed for the third intake regime: $f_r = 0.01$, $s_r = 1 \text{ d}^{-1}$, $s_s = 0.000005 \text{ d}^{-1}$. In the particle transport model, the fractions deposited in the alveolar and interstitial compartments were changed from the default values of 0.63 and 0.37 to 0.9 and 0.1, respectively.

This resulted in a credible fit to the lung data and predicted liver and skeletal activities at the time of death. However, the fit to the urine data and, consequently, the overall fit were still poor.

In order to fit the urine data, it was necessary to add three hypothetical intake regimes on the dates consistent with the elevated urine data points (all three with absorption type M). The resulting overall fit to all data was acceptable based on the predefined significance level of 5% (total P-value = 0.07). However, the P-value for urine data was still slightly below this level (P-value = 0.04).

To optimize the final fit, the absorption parameters were adjusted for the second real intake regime: $f_r = 0.3$, $s_r = 0.5 \text{ d}^{-1}$, $s_s = 0.0012 \text{ d}^{-1}$.

This resulted in a credible fit to all data. Total χ^2 -sum was calculated at 52.5 for a number of degrees of freedom (NDF) of 40. The corresponding total P-value was 0.09 (0.06 for urine, 0.28 for the lungs, 0.78 for the liver, and 0.58 for the skeleton). Maximum likelihood fits to the urine and lung data are shown in Figures 10 and 11.

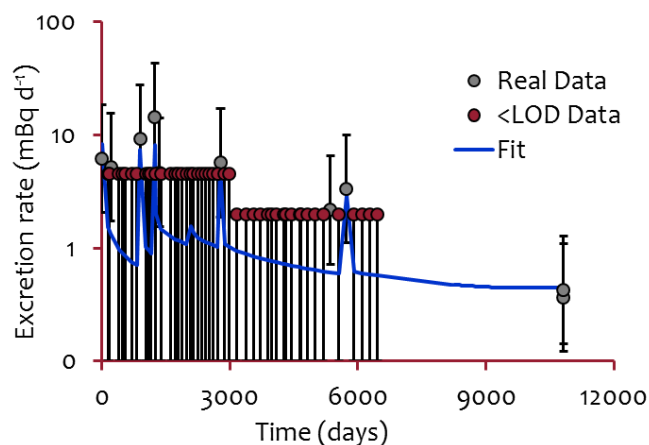


Fig. 10. IMBA maximum likelihood fit to the urine data.

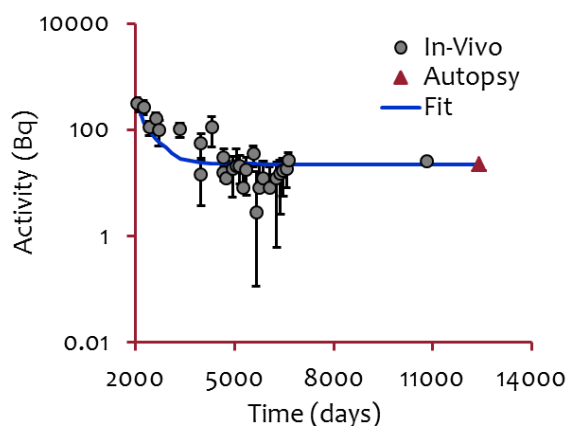


Fig. 11. IMBA maximum likelihood fit to the lung data.

The total intake and the corresponding committed effective and equivalent doses were calculated. The results of calculations are presented in Table 9.

The total intake from all six intake regimes was estimated at 4,905 Bq with approximately 86% contributed by the suspected inhalation of extremely insoluble Pu particles. This resulted in the committed effective dose of 50.2 mSv with 63.3%, 12.9%, 12.3%, and 7.1% contributed by the lungs, liver, skeleton and red bone marrow, respectively.

The terminal absorbed dose rate to the thoracic lymph nodes predicted with these assumptions (3.3 mGy y⁻¹) is about a factor of 1.7 higher than the absorbed dose rate estimated from the plutonium activity concentration measured in the autopsy sample (1.9 ± 0.1 mGy y⁻¹).

The predicted Pu retention in the whole body at time of death was 47 Bq, which is reasonably close (within 25% difference) to the whole body content estimated from the measured autopsy samples (the sum of Pu activities in the lungs, liver, kidney and skeleton).

Table 9. IMBA calculation results

Intake Regime	Year of Employment	Assumptions		Intake, Bq	Percent of Total Intake
		Absorption	Particle Transport		
IR1 - Real	2	M	Default	324	6.6%
IR2 - Hypothetical	5	M	Default	74	1.5%
IR3 - Real	6	Optimized M Super S	Default	251	5.1%
IR4 - Suspected	8		Optimized	4,202	85.7%
IR5 - Hypothetical	10	M	Default	34	0.7%
IR6 - Hypothetical	18	M	Default	20	0.4%
Total				4,905	

References

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New Collaborative Agreement

Sergei Y. Tolmachev, *Research Associate Professor*



Prof. Momoshima (Kyushu University) and Dr. Tolmachev (Washington State University)

On December 10, 2015, Washington State University, through the United States Transuranium and Uranium Registries, and Kyushu University (KU, Fukuoka, Japan), through the Central Institute of Radioisotope Sciences and Safety (CIRSS), signed an academic and research collaboration agreement. The purpose of this agreement is to promote academic exchange and cooperation in the research and education between two universities. Both institutions will undertake to promote and develop academic cooperation including: (i) academic staff and student exchange to carry out collaborative research and educating projects; (ii) conducting joint research projects; and (iii) publications and materials exchange related to joint research projects.

Dr. Tolmachev (USTUR director) and Prof. Noriyuki Momoshima (CIRSS director) signed a 5-year agreement on behalf of Washington State University and Kyushu University, respectively.

The USTUR and CIRSS will closely collaborate in the fields of radioecology and environmental dosimetry. It has been agreed that CIRSS members will visit the USTUR facility in Richland in November 2016 to discuss a graduate research project between KU and the USTUR.



Kampai!

Following the signing ceremony, Dr. Tolmachev gave an invited talk on uranium in man at the International Workshop on Uranium, Thorium, and Plutonium Sciences organized and sponsored by CIRSS/KU.

2015 Advisory Committee Meeting Summary

Stacey L. McComish, *Associate in Research*

The 2015 Annual Scientific Advisory Committee (SAC) meeting was held on September 1-2 at the Hampton Inn, Richland, WA. Each year, the SAC meeting enables valuable discussions with our advisory committee and scientific colleagues about the progress and goals of the Registries.

2015 Meeting Attendees

Advisory Committee

Robert Bistline, *Occupational Health*

Herman Gibb, *Epidemiology*

William Hayes, *Chair/Radiochemistry*

Timothy Ledbetter, *Ethics*

Roger McClellan, *Toxicology*

Unable to attend: Richard Toohey, *Chair/Health Physics*

Incoming SAC Member

Thomas Rucker, *Radiochemistry*

Department of Energy

Joey Zhou, *Program Manager*

USTUR Staff

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*

Florencio Martinez, *Prosecutor*

WSU College of Pharmacy

Kathryn Meier, *Associate Dean for Graduate Education, College of Pharmacy*

WSU Tri-Cities

Keith Moo-Young, *Chancellor*

Invited Guests

Cheryl Antonio, *MSA*

Ilke Arslan, *PNNL*

Antone Brooks, *WSU/PNNL*

Eugene Carbaugh, *Dade Moeller*

Darrell Fisher, *Dade Moeller*

Wayne Glines, *Dade Moeller*

Ron Kathren, *Emeritus WSU*

Brian Miller, *PNNL*

William Morgan, *PNNL*

Karen Phillips, *HPMC*

Marianne Sowa, *PNNL*

Paul Stansbury, *WSU/Dade Moeller*

Dan Strom, *PNNL*

Brandon Williamson, *Office of River Protection*

Presentations

2014 SAC Recommendations & 2015 USTUR Overview - Tolmachev, S.

The SAC's recommendations from last year's meeting, and the way the USTUR addressed each recommendation, were presented. This was followed by an overview of 2015 activities, which included: our grant renewal, a summary of NHRTR accomplishments, radiochemistry and health physics database updates, visits from DOE officials, and research that was underway.

Administrative & Financial Developments - Parker, M.

Budgetary information such as salary increases, personnel support, monthly expenditures, and grant funding was summarized.

USTUR Registrant Statistics - McComish, S.

As of the SAC meeting, the USTUR had 403 living and deceased Registrants. Statistics including age and years of follow-up were presented, and recent donations were briefly described.

Health Physics Database Progress Report - Avtandilashvili, M.

Progress toward entering data from each Registrant's dosimetry file into the USTUR's electronic Health Physics Database was summarized. As of August 2015, 72,142 records from 160 cases had been entered into the database. A record was a single piece of information from the dosimetry file, such as a urine measurement, a lung count, a dosimeter readout, or an incident that may have resulted in an intake.

National Human Radiobiological Tissue Repository - McComish, S.

As of August 2015, 20,289 parent samples had been logged into the THEMIS inventory database. Inventoried samples included USTUR and ANL tissues, and USTUR acid-dissolved tissues, histological slides, and planchets.

Radiochemistry Progress Report – Tabatadze, G.

Operation of the radiochemistry laboratory was described. Topics included tissue analyses, equipment upgrades, facility maintenance, and

validation of the USTUR's ability to detect high-fired plutonium oxide.

WSU Grad Certificate Program in Radiation Protection - Stansbury, P.

A graduate certificate program in radiation protection is under development at WSU Tri-Cities. Most of the courses have been approved, 10 students have completed the "Intro to Radiological Sciences" course, and the ability to offer courses via distance learning is being pursued.

WSU/COP Updates - Meier, K.

Having consolidated the College of Pharmacy in Spokane during 2013-2015, the college is in the process of hiring new faculty, with an aim to grow research. The college has also added a branch campus in Yakima, WA, and is expanding the Pharmaceutical Sciences program. An update on the new medical school, which will be established in Spokane, was also given.

Research at University of Iowa - Schultz, M.

Not presented.

From Single Bone to Skeleton - Tolmachev, S.

Half of the skeleton from a whole-body donation is radiochemically analyzed, whereas only a few bones from partial-body donations are available for analysis. Thus, the known activity of a whole-body donor's individual bones relative to the activity of the entire skeleton can be used to identify which bone from a partial-body donation provides the best estimate of the total skeletal activity. In this presentation, the use of the patella to estimate the total skeletal activity is explored.

Case 0837: Modeling Multiple Intakes - Avtandilashvili, M.

A step-by-step dose assessment for a Registrant with multiple plutonium intakes was illustrated. The dose assessment used the Integrated Modules for Bioassay Analysis software (IMBA) to fit urine analyses, in-vivo lung counts, and post-mortem tissue activities.

Uranium 'Missing Dose' - McComish, S.

There exists a possibility that USTUR Registrants who were exposed to plutonium also worked with, and had intakes of, uranium. This presentation explores the question: should we analyze tissues from plutonium workers for uranium or just for plutonium/americium?

Research & Operation: Plan for FY2016 - Tolmachev, S.

The USTUR's research and operational goals for the next year were summarized. They included: maximizing scientific research at the USTUR, publishing scientific papers, accepting and analyzing donated tissues, celebration of the Registries' 50th anniversary, and population of databases.

Discussion: USTUR in 2016 and Beyond

A discussion about the USTUR's vision for the next 5 to 10 years was facilitated by Dr. Tolmachev, and input from meeting participants was encouraged.

At the conclusion of the meeting, the SAC provided the following comments and recommendations to the staff:

Observations

1. Significant progress has been made in designing and populating the databases.
2. The display of the information contained in the health physics and radionuclide databases is beneficial in encouraging research opportunities.
3. Amplification for the presentations would be helpful.
4. The strong use of students to support the program is encouraging.
5. The increased level of participation in a broad range of conferences is encouraging.
6. The level of communication with DOE HQ is encouraging.
7. We are pleased by an effort to prioritize the prospective value of the analysis of tissues.

Recommendations

1. Strengthen ties with WSU Tri-Cities Campus and Teaching Programs.
2. The staff is technically skilled and proficient in their area of work. We recommend that they continue to broaden their skills in development and promotion of scientific research in use of the data:
 - More participation in society meetings and committees.
 - More involvement in university programs and teaching.

3. The research data needs and uses should be articulated in a formal document in order to match up with data gaps in the database and prioritization of future analyses. This could be done in a Data Quality Objectives document.
4. We recommend that the use of the data collected at the Registries to support dosimetric research be captured formally in the goals and purposes of the USTUR. This could go a long way toward fundraising.
5. Make use of WSU's public affairs office to publicize USTUR accomplishments and human interest stories related to advancing the mission to improve radiation protection.
6. Collaboration with the Oak Ridge National Laboratory Center for Radiation Protection Knowledge is recommended for developing data use priorities.
7. We recommend a status report on National Death Index information request.
8. It is recommended that the research topics presented in the "USTUR in 2016 and Beyond" discussion be put in the form of hypotheses and in a way to demonstrate progress toward the mission.
9. Booths at conferences that display inventories of tissues are recommended to spur data use for research purposes.
10. Provide information about the process for gaining access to tissues on the website.

SAC Membership

William Hayes finished his third and final term on the SAC. The vacancy on the committee was filled by Thomas Rucker, who has a broad scientific background including radiochemistry and dose assessment.

Professional Activities/Services

During FY2016, 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 Y. Tolmachev, continued to serve on the advisory committee for the WSU Graduate Certificate Program in Radiation Protection at the Tri-City (TC) Campus. 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 was appointed as Visiting Professor at Kyushu University (Fukuoka, Japan) through the Central Institute of Radioisotope Sciences and Safety (CIRSS). This was one-year appointment effective April 1, 2015.

Adjunct Professor Appointment

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

Radiation Instrumentation Class

In December 2015, Dr. George Tabatadze provided a 2-hour lecture and 3-hour laboratory practice to students in the Radiation Instrumentation class (ENVR_SCI 520). The class was offered by the Department of Environmental

Sciences as a part of WSU Tri-Cities' Graduate Certificate Program in Radiation Protection. The topic of the lecture was solid-state charged particle detectors.

Internal and Environmental Dosimetry Class

On February 29, 2016, Dr. Maia Avtandilashvili provided a 2-hour lecture to students in WSU's Internal and Environmental Dosimetry class (ENVR_SCI 523). Dr. Avtandilashvili introduced students to the Integrated Modules for Bioassay Analysis (IMBA) internal dosimetry software, and gave examples of how IMBA can be used as a tool to estimate radionuclide intakes from bioassay data such as urinalysis or in-vivo body count results.

Professional Committees

Herbert M. Parker Foundation

On January 21, 2016, Dr. Sergei Tolmachev was elected to serve as a member of the Board of Trustees for the Herbert M. Parker Foundation <https://tricity.wsu.edu/parkerfoundation/> :

"The Herbert M. Parker Foundation for education in the radiological sciences was created in 1987 to memorialize Mr. Parker and his many significant contributions to radiation protection, radiation biology, the environment, and radiotherapy. In 1997, the Herbert M. Parker Foundation was incorporated into the Washington State University Foundation as an endowment. The proceeds of this endowment support scientific and educational activities that further develop

technical advances and enhance public understanding of science and technology as applied to health and the environment".

HPS International Collaboration Committee

Dr. George Tabatadze continued to serve as an advisor for the International Collaboration Committee (ICC) of the Health Physics Society (HPS). He had actively participated in planning the special session for the 2015 HPS annual meeting in Indianapolis, IN, including arrangements for the special speaker visit from the Georgian chapter of the Health Physics Society (Georgian Health Physics Association - GHPA).

Scientific Meetings

CCHPS Meeting

Dr. Maia Avtandilashvili and Dr. George Tabatadze were invited to speak at the Columbia Chapter of Health Physics Society monthly meeting at Tri-Cities Cancer Center on November 19, 2015. Upon request from the chapter, they gave podium presentations previously presented at the 2015 Health Physics Society Annual Meeting and Annual Radiobioassay and Radiochemical Measurements Conference.

GNAS / CNERS Meeting

On December 24, 2015, Dr. Maia Avtandilashvili gave an invited presentation at the meeting of the Georgian National Academy of Sciences' Committee on Nuclear Energy and Radiation Safety in Tbilisi, Georgia (Republic). Her presentation was designed to inform the Georgian scientific community about the USTUR:

its history, objectives, and recently conducted research.

ICRP Symposium

Dr. Sergei Tolmachev attended the International Commission on Radiological Protection's (ICRP) 3rd International Symposium on the System of Radiological Protection in Seoul, South Korea, October 20-22, 2015. This symposium was "an opportunity to hear about ICRP's recommendations and work-in-progress directly from ICRP members, to have your views on this work heard, and to network with ICRP members and radiological protection colleagues from all parts of the world" (ICRP website). Topics included the science behind radiation doses and new developments in understanding radiation effects. Between sessions, Dr. Tolmachev discussed plans for future collaborative research.

International Council on Radiation Research

USTUR director, Sergei Tolmachev, gave a poster presentation at the 2015 International Council on Radiation Research (ICRR) meeting in Kyoto, Japan, May 25-29, 2015. His poster summarized the tissue collections at the National Human Radiobiology Tissue Repository (NHRTR) and provided guidance on how to request these materials for scientific research.

Health Physics Society Meeting

USTUR faculty were authors of three podium presentations, which were given at the 60th Annual Health Physics Society Meeting in Indianapolis, IN, July 12-16, 2015.

Radiobioassay and Radiochemical Measurements Conference

The USTUR's George Tabatadze and Elizabeth Thomas attended the 61st Annual Radiobioassay and Radiochemical Measurements Conference (RRMC) in Iowa City, IA, October 25 - 30. The USTUR laboratory recently analyzed a MAPEP soil sample to validate the Registries' tissue analysis protocol for high-fired plutonium oxide. Dr. Tabatadze presented the results of this effort at the meeting.

Editorial and Ad-hoc Review Services

Japanese Journal of Health Physics

Dr. Sergei Y. 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 was invited to serve as a member of the Editorial Board for the Journal of Austin Biometrics and Biostatistics: <http://austinpublishinggroup.com/biometrics/editorialBoard.php>

PLoS One Journal

Dr. Sergei Tolmachev was invited to provide scientific expertise as an *ad-hoc* reviewer to the PLOS One journal (impact factor 3.234). One paper was reviewed by Dr. Tolmachev.

Radiation Protection Dosimetry Journal

Dr. Sergei Tolmachev was invited to provide scientific expertise as an *ad-hoc* reviewer to the Radiation Protection Dosimetry journal (impact factor 0.913). Two papers were reviewed by Dr. Tolmachev.

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 2015 to March 2016. The names of USTUR faculty are underlined. 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 D of this report.

Published

USTUR-0360-14

Kathren RL, Tolmachev SY. Natural uranium tissue content of three Caucasian males. *Health Phys.* 109 (3): 187-197; 2015.

USTUR-0367-14

Nogueira P, Rühm W, Vrba T, Buchholz W, Fojtík P, Etherington G, Broggio D, Huikari J, Marzocchi O, Lynch T, Lebacqz A, Li C, Oško J, Malátova I, Franck D, Breustedt B, Leone D, Scott J, Shutt A, Hauck B, Capello K, Pérez-López B, Francisco Navarro-Amaro J, Pliszczyński T, Fantínová K, Tolmachev SY, López-Ponte M. EURADOS Am-241 skull measurements intercomparison. *Radiation Measurements* 82: 64-73; 2015.

USTUR-0371-14

Brooks AL, Church BW, Smith JN, Tolmachev SY. ¹³⁷Cs environmental half-life without remediation: Impact on radiation dose. *Japanese Journal of Health Physic.* 51(1): 51-59; 2016.

USTUR-0383-15

Zhou J. Response to Hein and Schubauer-Berigan. *Int J Radiat Biol.* 91(11): 911-912; 2015.

USTUR-0375-15A

Avtandilashvili M, Puncher M, McComish SL, Tolmachev SY. Modeling Uranium Hexafluoride Inhalation. *Health Phys.* 109 (1 Suppl): S58; 2015.

USTUR-0376-15A

Tabatadze G, Miller B, Tolmachev SY. Radionuclide distribution measurement within anatomical bone structures using digital autoradiography. *Health Phys.* 109 (1 Suppl): S59; 2015.

USTUR-0381-15A

Miller B, Tabatadze G, Dion M, Frost S, Orozco J, Press O, Sandmaier B, Miederer M, Brochhausen C, Tolmachev SY. Quantitative Single-Particle Digital Autoradiography with the ionizing-Radiation Quantum Imaging Detector. *Health Phys.* 109 (1 Suppl): S108; 2015.

USTUR-0382-15

Tolmachev SY, McComish SL. United States Transuranium and Uranium Registries Annual Report: April 1, 2012 – March 31, 2014. United States Transuranium and Uranium Registries; USTUR-0382-15, Richland, WA 2015.

USTUR-0385-15

McComish SL, Tolmachev SY. United States Transuranium and Uranium Registries 2015

Newsletter, Issue 21. College of Pharmacy, Washington State University, Richland, WA. Mailed October 2015.

USTUR-0398-16

Tolmachev SY, Avtandilashvili M. Case 0407: Refractory Plutonium Distribution in the upper airways of the human respiratory tract. Technical Report USTUR-0398-16, Richland, WA, 2016.

USTUR-0402-16

Tolmachev SY, McComish SL. United States Transuranium and Uranium Registries Annual Report: April 1, 2014 – March 31, 2015. United States Transuranium and Uranium Registries; USTUR-0402-16, Richland, WA, 2016.

Presented

Invited

USTUR-0373-14A

Tolmachev SY, McComish SL. National Human Radiobiology Tissue Repository. Podium presentation at the 1st International Workshop on Sample/Tissue Archiving of Radiobiology (STAR2015), Kyoto, Japan, May 24-25, 2015.

USTUR-0387-15P

Tolmachev SY. Uranium content, distribution, and biokinetics in human body. Poster presentation at the International Workshop on Uranium, Thorium, and Plutonium Sciences, Kyushu, Japan, December 10, 2015.

Podium

USTUR-0375-15A

Avtandilashvili M, Puncher M, McComish SL, Tolmachev SY. Modeling uranium hexafluoride inhalation. Podium presentation at the 60th Annual Meeting of the Health Physics Society, Indianapolis, IN, July 12 – 16, 2015.

USTUR-0376-15A

Tabatadze G, Miller B, Tolmachev SY. Radionuclide distribution measurement within anatomical bone structures using digital autoradiography. Podium presentation at the 60th Annual Meeting of the Health Physics Society, Indianapolis, IN, July 12 – 16, 2015.

USTUR-0381-15A

Miller B, Tabatadze G, Dion M, Frost S, Orozco J, Press O, Sandmaier B, Miederer M, Brochhausen C, Tolmachev SY. Quantitative Single-Particle Digital Autoradiography with the ionizing-Radiation Quantum Imaging Detector. Podium presentation at the 60th Annual Meeting of the Health Physics Society, Indianapolis, IN, July 12 – 16, 2015.

USTUR-0386-15A

Tabatadze G, Thomas EM, Tolmachev SY. Analysis of high fired plutonium oxide and other actinides in MAPEP soil samples. Podium presentation at the 61st Annual Radiobioassay and Radiochemical Measurements Conference, Iowa City, IA, October 25 – 30, 2015.

USTUR-0374-15A

Zhou J, McComish SL, Tolmachev SY. A novel approach to evaluate excess of mesothelioma deaths in a small population of former nuclear

workers. Podium presentation at the 143rd American Public Health Association Annual Meeting, Chicago, IL, October 31 – November 4, 2015.

USTUR-0399-16P

Dumit S, Avtandilashvili M, Tolmachev SY. Plutonium Decorporation Following Complex Exposure: Inception. Podium presentation at the WSU College of Pharmacy Graduate Research Seminar Series, Spokane, WA, March 4, 2016.

Poster

USTUR-0372-14A

Tolmachev SY, McComish SL. The National Human Radiobiology Tissue Repository: Human Tissue Collection at the US Transuranium and Uranium Registries. Poster presentation at the 15th International Congress of Radiation Research (ICRR2015), Kyoto, Japan, May 25-29, 2015.

USTUR-0372-14A

Tolmachev SY, McComish SL (*previously presented*). The National Human Radiobiology Tissue Repository: Human Tissue Collection at the US Transuranium and Uranium Registries. Poster

presentation at the WSU College of Pharmacy Research Day, Spokane, WA, August 21, 2015.

USTUR-0348-13A

Avtandilashvili M, McComish SL, Tolmachev SY (*previously presented*). Uncertainty analysis on lung doses for US nuclear workers s. Poster presentation at the WSU College of Pharmacy Research Day, Spokane, WA, August 21, 2015.

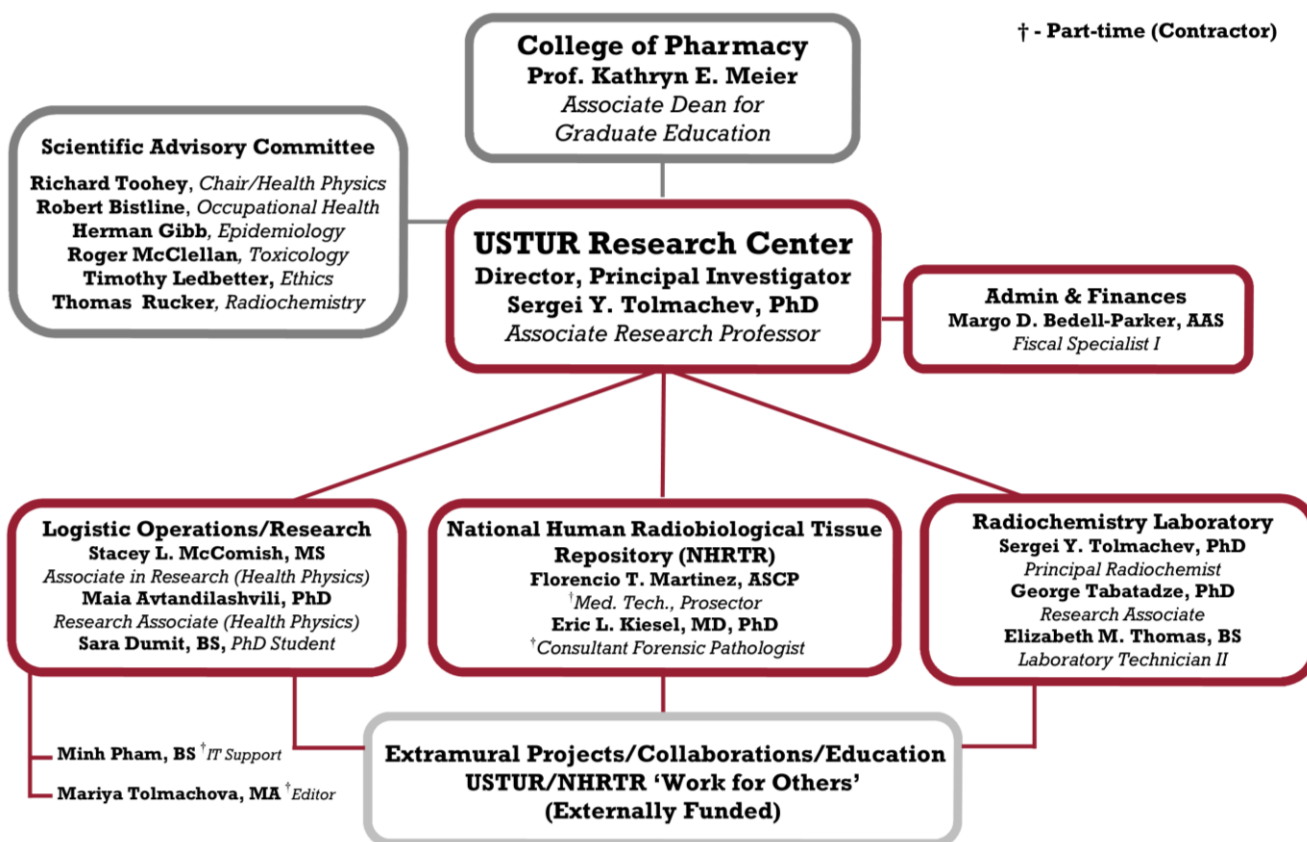
USTUR-0400-16P

Dumit S, Avtandilashvili M, Tolmachev SY. Modeling Pu Decorporation Therapy Following Occupational Exposure. Poster presentation at the Brazilian Graduate Student Conference (BRASCON), Harvard University, Cambridge, MA, March 12 – 13, 2016.

USTUR-0400-16P

Dumit S, Avtandilashvili M, Tolmachev SY (*previously presented*). Modeling Pu Decorporation Therapy Following Occupational Exposure. Poster presentation at the WSU Graduate and Professional Student Association (GPSA) Research Exposition, Pullman, WA, March 25, 2016.

Appendix A



USTUR Research Center organization structure as of March 31, 2016.

Appendix B

USTUR NEWSLETTER

October 2015

Issue 21

USTUR-0385-15

Direct from the Director

I am very pleased to have this opportunity of getting in touch with you again, and to talk about the history of the Registries. Perhaps not all of you know that the Registries are approaching a half-century mark. The idea to follow up nuclear workers (volunteer Registrants) who had documented accidental intakes of plutonium and other actinides was voiced in July 1966 during the "Plutonium Contamination in Man" meeting in Denver, CO. The predecessor of what is now the USTUR was formally established in August 1968 as the National Plutonium Registry at the Hanford Environmental Health Foundation (HEHF) in Richland, WA under contract to the United States Atomic Energy Commission (AEC). Today, the USTUR is the second longest research program funded by U.S. Department of Energy, Office of Domestic and International Health Studies. Studies of the Japanese atomic bomb survivors at the Radiation Effects Research Foundation (RERF) in Hiroshima and Nagasaki, Japan have been supported by DOE since 1947. This year, the USTUR was recognized by a visit of high level DOE officials. We had a fruitful discussion about past, present, and future of the USTUR.

To celebrate the USTUR's 50th anniversary, we proposed the following activities for 2016 - 2018: (i) to organize a one-day special session on the USTUR's research, *USTUR: Five Decade Follow-up of Plutonium and Uranium Workers*, at the Health Physics Society (HPS) 2016 Annual Meeting in Spokane, WA; (ii) to participate in the HPS Annual Meeting exhibition to promote the USTUR program; (iii) to publish a special issue of the Health Physics journal dedicated to USTUR history and research.

This plan was highly welcomed by members of Scientific Advisory Committee and DOE management. Additional funding was requested by the Registries to sponsor these activities. We all are very excited, and I am sure in the next year's newsletter I will have more to tell you about the 50th anniversary celebration. All these could not happen without your generous contribution, and I would like to thank all of you who have remained with the Registries for so many years. Our thanks goes to you as we wish you the very best of the holiday season.



Sergei Y. Tolmachev



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Direct from the Director

Page 2

DOE Officials Visit

Page 3

Publications
Uranium Hexafluoride
Environmental Uranium
Plutonium in the Lungs

Page 4

Manhattan Project National
Historical Park
New to SAC
A Big Thank You

DOE Officials Visit

In March, Patricia Worthington, Isaf Al-Nabulsi, and Joey Zhou toured the USTUR. Dr. Worthington is the director of DOE's Health and Safety Office; Dr. Al-Nabulsi manages the Japanese atomic bomb survivor studies; and Dr. Zhou is the USTUR's program manager. Sergei Tolmachev gave a presentation on the USTUR's history, current research, and future plans. Significance of the USTUR's research and its impact on national and international radiation protection regulatory bodies was emphasized. During a laboratory tour, Dr. Tolmachev demonstrated the USTUR Case 0102 skull phantom.

The 0102 skull phantom is a plastic cast of a head, which contains head bones from a USTUR donor who was exposed to americium. Since the amount of americium in the phantom is precisely known, it is utilized to calibrate radiation detectors that measure the amount of americium in a person's skull. The skull phantom recently travelled throughout Europe, to Canada, and back to Richland, WA as a part of a multi-country study that compared how well 22 different facilities were able to accurately measure the amount of americium in the phantom.

Following this visit, DOE's Acting Associate Under Secretary for Environment, Health, Safety, and Security - Matthew Moury - expressed interest in touring the USTUR. In August,



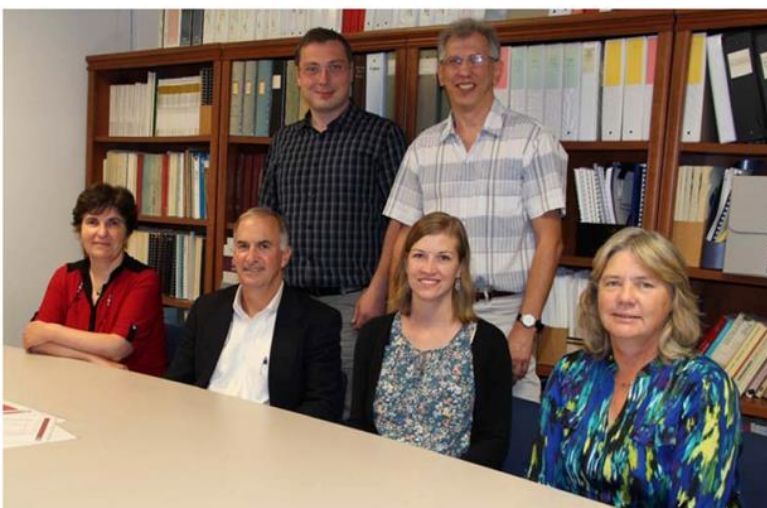
USTUR director, Sergei Tolmachev, demonstrates the USTUR head phantom to Dr. Worthington (left), Dr. Zhou (middle), and Al-Nabulsi (right).

Dr. Moury visited the USTUR where he spent two hours learning about the USTUR's mission, research achievements, and touring the laboratory facility.

Communication with DOE officials is extremely important. It promotes awareness of the research carried out at the USTUR and

opens the door for continued funding. The possibility of restoring the USTUR funding to 'historical' level (above \$1,000,000 per year) was briefly discussed.

DOE officials were impressed by the level and quality of the USTUR research, and the resources available at the Registries.



Back: George Tabatadze, Sergei Tolmachev. Front: Maia Avtandilashvili, Matthew Moury, Stacey McComish, Margo Parker.

Publications

Making an impact

4 papers published
4 in press or ready to submit
9 presentations



USTUR faculty have prioritized publishing data from Registrant donations during the past year. This includes submitting papers to scientific journals and giving presentations at workshops and meetings such as the Annual Meeting of the Health Physics Society.

USTUR Case Study: Uranium Hexafluoride

Most of what we know about the radiological and chemical toxicity of a highly corrosive compound of uranium called uranium hexafluoride, UF_6 for short, comes from animal studies. Only a handful of scientific publications on human exposure to UF_6 are available.

The USTUR recently published a paper that focused on the distribution and retention of uranium in a USTUR Registrant after accidental inhalation of UF_6 . An interesting

and unusual observation was that a small amount of uranium from the accident was found in the Registrant's brain 65 years later. This indicates that uranium can cross the blood-brain barrier. The presence of uranium from the accident in the individual's lungs is also significant. Current guidance suggests that UF_6 is cleared from the lungs so rapidly that none should have been left when he passed away.

Thinking Outside the Box: Environmental Exposures to Uranium



Uranium exists naturally in the world around us. This includes the air we breathe, and the food and water that we consume. Thus, our bodies contain a certain amount of uranium. The USTUR provides a unique opportunity to study just how much natural uranium is in the human body. This is done by identifying Registrants who worked only with plutonium, and, therefore, were not exposed to uranium at work.

In September, the USTUR published a paper about natural uranium in the tissues of three such

Registrants. The concentrations of uranium in air/water/soil vary with geographical location. Thus, it was not surprising that the Registrant who lived in the Rocky Mountain plateau—which is known for high natural levels of uranium—had more uranium in his body than two Registrants from New Mexico. Also, uranium did not accumulate in the kidneys. This is important because the models that describe the movement of uranium through the body often assume that uranium is retained in the kidneys.

Featured PRESENTATION

This year, the USTUR's director travelled to Washington, D.C. to present an overview of the USTUR at the Department of Energy's Annual Occupational Medicine Workshop. This was an excellent opportunity for the USTUR to improve its visibility by describing the Registries, its resources, and research to professionals who may not have otherwise heard of us. The workshop reached a broad audience by broadcasting presentations to offsite attendees through the internet.

Plutonium IN THE LUNGS

Last year, we reported that the USTUR is working with scientists from the U.K and Russia to determine what amount of plutonium remains in the lungs due to a binding mechanism. We continued this research this year. The lung tissues from two more USTUR Registrants were analyzed. Our findings will be used by the International Commission on Radiological Protection (ICRP) in Publication 130: *Occupational Intakes of Radionuclides Part I*. This particular example shows how significant the USTUR's research is. ICRP publications serve as guidelines for radiation safety professionals worldwide.

Three papers about the distribution of plutonium and binding in the lungs of USTUR Registrants will be published as a part of a special issue of the Radiation Protection Dosimetry journal.

DID YOU KNOW? Manhattan Project National Historical Park

Last December, Congress approved the creation of the Manhattan Project National Historical Park. This new park will preserve important sites associated with the Manhattan Project. One such site is Hanford's B-Reactor in Washington State. The B Reactor is the world's first full-scale nuclear reactor. Construction took just 13 months and it was completed in 1944. The B Reactor is open for public tours from April to September each year. Tours are free and have attracted more than 60,000 visitors from all 50 states and over 70 countries. From Enrico Fermi's office to the front face of the reactor, the tours offer an interesting glimpse into our nation's history. The Manhattan Project Historical Park will also include sites at Oak Ridge, TN, and Los Alamos, NM.



For more information about B Reactor tours visit: <http://manhattanprojectreactor.hanford.gov/>

New to the SAC

We would like to introduce you to **Thomas Rucker**. On October



1st, Tom joined the Scientific Advisory Committee as a radiochemistry representative. He has more than 40 years

of experience in analytical chemistry, radiochemistry, and radiological detection and measurement. His experience and expertise will be a valuable asset to the USTUR's radiochemistry program and we look forward to working with him.



A BIG THANK YOU!

To our Registrants for returning the work history questionnaire that we mailed in July. Our advisory committee had recommended that we gather information about where you worked before joining the nuclear industry. Job titles help us to understand better what workplace hazards you may have encountered. For example, work on home renovations or as a plumber may have resulted in exposure to asbestos.

THANK
YOU



Back row: George Tabatadze, Maia Avtandilashvili, Stacey McComish, Sergei Tolmachev. Front row: Florencio Martinez, Margo Bedell, Elizabeth Thomas.



**U.S. TRANSURANIUM and
URANIUM REGISTRIES**

www.ustur.wsu.edu

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1-509-946-6870 / 1-800-375-9317

Appendix C

UNITED STATES TRANSURANIUM AND URANIUM REGISTRIES

College of Pharmacy, Washington State University
2015 Scientific Advisory Committee Meeting
Hampton Inn, Richland, WA, September 1-2, 2015

Tuesday, September 1, 2015

07:45 – 08:30	Breakfast	
08:30 – 08:40	Executive Session (for SAC Members)	W. Hayes, SAC Acting Chair
08:40 – 08:50	Welcome & Introductions	S. Tolmachev, Director
08:50 – 09:00	WSU/TC Updates	K. Moo-Young, WSU/TC Chancellor
09:00 – 09:10	Updates from DOE/AU-13. Guidance for FY2015	J. Zhou, DOE Manager
09:10 – 10:00	2014 SAC Recommendations & 2015 USTUR Overview	S. Tolmachev, Director
10:00 – 10:15	Administrative & Financial Developments	M. Parker, Fiscal Specialist
10:15 – 10:30	USTUR Registrant Statistics	S. McComish, Assoc. in Research
10:30 – 10:45	Coffee Break	
10:45 – 11:00	Health Physics Database Progress Report	M. Avtandilashvili, Research Assoc.
11:00 – 11:15	National Human Radiobiological Tissue Repository	S. McComish, Assoc. in Research
11:15 – 11:45	Radiochemistry Progress Report	G. Tabatadze, Research Assoc.
11:45 – 12:00	Research at University of Iowa	M. Schultz, University of Iowa
12:00 – 13:30	Lunch	
13:30 – 13:45	WSU/COP Updates	K. Meier, COP Assoc. Dean
13:45 – 14:00	WSU Grad Certificate Program in Radiation Protection	P. Stansbury, WSU/Dade Moeller
14:00 – 14:15	From Single Bone to Skeleton	S. Tolmachev, Director
14:15 – 14:40	Case 0837: Modeling Multiple Intakes	M. Avtandilashvili, Research Assoc.
14:40 – 15:00	Coffee Break	
15:00 – 15:15	Uranium Missing Dose	S. McComish, Assoc. in Research
15:15 – 15:45	Research & Operation: Plan for FY2016	S. Tolmachev, Director
15:45 – 16:30	Discussion: USTUR toward FY 2018 - FY2022	USTUR, DOE, SAC, Guests
17:30 – 18:00	Appetizers and No-Host Reception, at J Bookwalter Winery, 894 Tulip Ln, Richland, WA	
18:00 – 21:00	Dinner – at J Bookwalter Winery	

Meetings, Breakfast, and Lunch will be held in the Colombia Pointe at the Hampton Inn, Richland WA

UNITED STATES TRANSURANIUM AND URANIUM REGISTRIES

College of Pharmacy, Washington State University
2015 Scientific Advisory Committee Meeting
Hampton Inn, Richland, WA, September 1-2, 2015

Wednesday, September 2, 2015 – SAC, DOE and USTUR Management

07:45 – 09:00	Breakfast	All
09:00 – 09:10	SAC Membership	S. Tolmachev, <i>Director</i>
09:10 – 09:45	SAC Q & A	W. Hayes, <i>SAC Acting Chair</i>
09:45 – 12:30	SAC Executive Session	W. Hayes, <i>SAC Acting Chair</i>
09:45 – 12:30	Tour to USTUR Laboratory Facility, Richland Airport	USTUR/Guests
12:30 – 13:45	Lunch	
13:45 – 15:45	SAC Debriefing	W. Hayes, <i>SAC Acting Chair</i>

Wednesday, September 2, 2015 – All

18:00 – 21:00 Hosted Dinner Party – Hampton Inn River Room, 486 Bradley Blvd, Richland

Appendix D

USTUR-0360-14

Natural Uranium Tissue Content of Three Caucasian Males

R.L. Kathren^{1,2}, S.Y. Tolmachev¹¹United States Transuranium and Uranium Registries, Washington State University, Richland, WA²Retired.

Uranium content and concentrations were measured in the tissues of three Caucasian male whole body donors to the U.S. Transuranium and Uranium Registries with no known intake other than from natural environmental sources. Average total body uranium content in the three cases was $81.3 \pm 22.3 \mu\text{g}$, of which $37.2 \pm 2.1 \mu\text{g}$ (46%) was in the skeleton. The skeleton had a mean concentration of $3.79 \pm 0.45 \mu\text{g U kg}^{-1}$ wet weight and $11.72 \pm 1.49 \mu\text{g U kg}^{-1}$ ash. Distribution was in bone volume and not predominately on bone surfaces. Soft tissue concentrations ranged over about an order of magnitude, averaging about $0.5 \mu\text{g kg}^{-1}$ wet weight for all tissues except the thoracic lymph nodes, which averaged 32.3 times the mean for soft tissue of the three cases. Observed thyroid tissue concentrations were about an order of magnitude greater than the average soft tissue concentration in two of the three background cases, suggestive of a possible long-term depot in this organ. Kidney content of uranium averaged $0.38 \pm 0.21 \mu\text{g}$ for the three cases, an order of magnitude lower than the $7 \mu\text{g}$ recommended for Reference Man. The lower content and concentration in the kidney do not support a significant long-term depot for uranium in that organ. Assuming equilibrium between intake and excretion, the tissue data suggest a transfer coefficient from blood to skeleton of 0.14 with a residence half-life in the skeleton of 4,950 d (13.56 y), significantly greater than the 1,500 d (4.1 y) half-time proposed by ICRP.

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EURADOS Am-241 Skull Measurements Intercomparison

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In 2011 a measurement intercomparison was launched by EURADOS WG7, with the objective of providing the participants with the tools to calibrate their detection systems for detection of ²⁴¹Am in the skull bone, and evaluate the variability due to the used of the different calibration phantoms. Three skull phantoms were used in this intercomparison: the USTUR Case 0102 skull phantom, the BfS skull phantom and the CSR skull phantom. Very good agreement was found between the results of the twelve participating laboratories, with relative deviations of less than 15% for the BfS phantom and less than 17% for the USTUR phantom when measurement efficiency in defined positions was compared. However, the phantoms' measured absolute ²⁴¹Am activities showed discrepancies of up to a factor of 3.4. This is mainly due to the physical differences between the standard calibration phantoms used by the participants and those used in this intercomparison exercise.

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¹³⁷Cs environmental half-life without remediation: Impact on radiation dose

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¹³⁷Cs is an important long-term contributor to radiation dose and risk following a nuclear accident. Its high abundance (about 6 atoms per 100 fissions), the 30.17 year physical half-life and its biological availability all made it of special concern in the Fukushima accident. After this event, extensive amounts of time and money were invested to clean-up and limit the transport of ¹³⁷Cs into the food chain. However, since the biological and environmental half-lives of ¹³⁷Cs are short, they limit its availability and exposure in people. This paper demonstrates how historical data on the environmental half-life of ¹³⁷Cs in both milk and humans

changes, in the absence of remedial action, and modifies dose and risk. ^{137}Cs activity in milk from selected dairy farms and total body burdens in the farmers exposed to fallout in Utah were determined. The activity in milk decreased each year from spring to summer, while the activity in the farmers increased with time and varied by a factor of about ten (100–1,400 Bq). Fallout provided a continuing resupply of ^{137}Cs into humans. If resupply were to be prevented or limited by remediation, ^{137}Cs would clear from the body as a function of the effective half-life of 104 days measured in Fukushima. Blocking the entry of ^{137}Cs would have reduced the body-burden in Utah farmers by a factor of almost ten. Data in this manuscript provides a baseline, from which the influence of remedial actions on dose and risk associated with evacuation and cleanup can be compared.

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Modeling Uranium Hexafluoride Inhalation

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The United States Transuranium and Uranium Registries' whole-body donor (Case 1031) was exposed to a single acute inhalation of uranium hexafluoride (UF_6) produced from an explosion at a processing facility. Inductively coupled plasma mass-spectrometric analysis of tissue samples collected at the autopsy 65 years after the accident indicated unusually long-term retention of inhaled slightly-enriched uranium material (0.85% ^{235}U) in the deep lungs and thoracic lymph nodes inconsistent with the International Commission on Radiological Protection (ICRP) human respiratory tract model predictions for soluble uranium compounds. The tissue measurement and bioassay monitoring data from this case were analyzed with the ICRP biokinetic models using both conventional (maximum likelihood) and Bayesian statistical analysis methods. Maximum likelihood analysis using the current ICRP human respiratory tract model resulted in an estimated intake of 79 mg of uranium composed of 86% soluble, Type F material and 14% insoluble, Type S material. For the Bayesian approach, the Markov Chain Monte Carlo (MCMC) method was applied to the data to estimate posterior probability distributions of intake and case-specific lung model parameters, using the revised human respiratory tract model that is being utilized by ICRP to calculate revised effective dose coefficients for workers. The MCMC results were fairly consistent with the maximum likelihood analysis, supporting the fact that the inhaled uranium material was predominantly Type F with a small but significant Type S component: 95% posterior ranges of the rapid fraction and slow dissolution rate were 0.12-0.91, and 0.00022-0.00036 d^{-1} with the median values at 0.37 and 0.00031 d^{-1} , respectively. The derived posterior distributions of dissolution parameter values were used to calculate the

corresponding 95% range of effective dose per unit intake of uranium resulting from inhalation of the UF₆ mixture. It was demonstrated that the ICRP effective dose coefficient recommended for UF₆ was located below the lower 2.5%-quantile of this range. Hence, the use of the dissolution parameter values obtained here may be more appropriate for radiation protection purposes when individuals are exposed to a UF₆ mixture that contains an insoluble uranium component.

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Radionuclide Distribution Measurement within Anatomical Bone Structures Using Digital Autoradiography

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The ionizing-radiation Quantum Imaging Detector (iQID) is a radiation camera originally developed for gamma-ray imaging applications such as scintigraphy and single-photon emission computed tomography. Recently, the detector's response was extended to a broader range of ionizing radiation, including: neutrons, spontaneous fission, conversion electrons, alpha and beta-particles. The iQID digital autoradiography imager allows for real-time quantitative autoradiography at a resolution up to 20 μm when imaging alpha particles. With conventional autoradiography technique, imaging may take up to several months without knowledge that a sufficient number of decays has occurred to visualize the spatial distribution of alpha emitters. Quantification of the activity can also be difficult or impractical. The iQID allows studying radionuclide microdistribution in the anatomical bone structures, such as cortical and trabecular bone volumes and surfaces at sub mBq levels. The initial feasibility imaging experiments were performed using bone samples from individuals exposed to radium (Ra-226), plutonium (Pu-239), and americium (Am-241). The bone samples are available at the National Human Radiobiology Tissue Repository (NHRTR), which is a part of the U.S. Transuranium and Uranium Registries (USTUR). For the internally deposited Ra-226, Pu-239, and Am-241, activity distribution was visualized and quantified in various bone sections. Radionuclide activity distribution ranged between 0.002 and 0.003 mBq mm⁻² for Pu-239, 0.1 and 0.7 mBq mm⁻² for Ra-226, and 1.0 and 10.0 mBq mm⁻² for Am-241. The initial feasibility studies are promising and prompt for additional sample imaging, especially those with small-scale heterogeneous distributions where traditional counting methods do not apply.

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Quantitative Single-Particle Digital Autoradiography with the ionizing-Radiation Quantum Imaging Detector

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Presented is a novel digital autoradiography camera and imaging methodology called iQID (ionizing radiation Quantum Imaging Detector). The imager comprises a scintillator in direct contact with a micro-channel plate (MCP) image intensifier and a lens for imaging the intensifier screen on to a CCD or CMOS camera sensor, all within a compact light-tight enclosure. iQID is sensitive to a broad range of radiation including gamma-/X-rays, neutrons, spontaneous fission, conversion electrons, alpha and beta particles. Individual photons or particles absorbed in the scintillator crystal or phosphor screen produce a flash of light that is amplified via the image intensifier by a factor of 10⁴–10⁶ and then imaged on to the camera. Scintillation flashes associated with individual events are finely sampled with an array of pixels and referred to as an event cluster. iQID's ability to localize charged particles, both spatially and temporally, on an event-by-event basis enables alpha-particle radioactivity distributions to be quantified at millibecquerel-levels in small volumes, e.g., 10 × 10 × 10 μm³, even with short-lived isotopes. Images are constructed in real time at high spatial resolutions with an unrestricted dynamic range. The intrinsic spatial resolution of the detector has been measured to levels as high as 20 μm with alphas. iQID is a portable, laptop-operated system that requires no cooling and leverages the ever-increasing advances in CCD and CMOS camera sensor technology. The most recent system developed uses a 4-megapixel camera (2048 × 2048 pixels) that acquires full-resolution images at rates up to 90 frames per second. Large-area iQID configurations (up to 200 mm diameter) accommodate autoradiography studies requiring simultaneous imaging of an array of tissue sections. An overview of the technology and recent imaging studies with alpha (²³⁹Pu, ²⁴¹Am, ²²⁶Ra, ²³²Th, and ²¹¹At) and beta emitters (⁹⁰Y and ¹⁷⁷Lu) will be presented that demonstrate the application of iQID as an integral imaging tool for radiobiology applications and microdosimetry in targeted radionuclide therapy.

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