USTUR - 0402-16

United States Transuranium and Uranium Registries

Annual Report

April 1, 2014 - March 31, 2015

College of
Pharmacy
WASHINGTON STATE UNIVERSITY

United States Transuranium and Uranium Registries

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Compiled and Edited

Sergei Y. Tolmachev and Stacey L. McComish

January 2016

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

USTUR

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Learning from Plutonium and Uranium Workers
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Inside This Report

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Executive Summary

Sergei Y. Tolmachev, *USTUR Director*

On April 1, 2012, the United States Transuranium and Uranium Registries (USTUR) began operating on a 5-year grant from the Department of Energy (DOE) to Washington State University (WSU), College of Pharmacy (COP) for the operation and management of the Registries. This report summarizes organization, activities, and scientific accomplishments for the USTUR and the associated National Human Radiobiology Tissue Repository (NHRTR) for the period of April 1, 2014 – March 31, 2015. This is the third fiscal year (FY) of the USTUR's 5-year grant proposal (April 1, 2012 – March 31, 2017).

FY2015 Grant

As directed by DOE Associate Under Secretary for the Office of Environment, Health, Safety and Security (AU-13, former HS-13), the budget for FY2015 (April 1, 2014 – March 31, 2015) remained at the same level as the budget granted for FY2014, i. e., $900,000.

Registrant Donations

Two donations were received by the USTUR in FY2015: Case 0805 (299th partial-body donation) and Case 0377 (300th partial-body donation).

Scientific Advisory Committee

The annual Scientific Advisory Committee (SAC) meeting was held September 5-6, 2014 at the Courtyard by Marriott in Richland, WA. The committee reviewed the USTUR's progress since previous meeting (September 2013) and made recommendations for the upcoming year. Richard Toohey's participation (scientific representative in Health Physics) on the SAC was renewed for a second three-year term. He will also continue to serve as the chair of the committee. Dr. Thomas L. Rucker accepted an invitation to serve on the committee as the radiochemistry representative. Dr. Rucker will replace Mr. William Hayes, whose appointment ends on September 30, 2015.

New Appointments

As of April 1, 2014, the USTUR personnel were limited to 5.0 full time equivalent (FTE) positions. In August 2014, George Tabatadze joined the USTUR as a research associate in radiation measurements to support the USTUR Radiochemistry Program under Dr. Tolmachev's supervision. This has a non-tenure track faculty appointment. Dr. Tabatadze earned his PhD in Health Physics from Idaho State University (Pocatello, ID) and was a Visiting Assistant Professor in the Department of Nuclear Engineering and Health Physics at ISU. In total, 5.7 FTE effort was supported in FY2015 by the available funding.

Dr. Eric Kiesel replaced Dr. Daniel Selove as the USTUR's consultant pathologist. After working with the Registries for 20 years, Dr. Selove accepted a new position and was no longer able to perform USTUR autopsies. The organization structure of the USTUR Research Center as of March 31, 2015 is given in Appendix A.

NHRTR Inventory

In June, the USTUR completed the dissection, hygienic packaging (vacuum sealed), and electronic inventory of tissues donated to the Registries. As of March 31, 2015, 8,904 tissue samples from 41 whole- and 103 partial-body donations were inventored. These Registrants passed away between 1982 and 2015.

Radiochemistry Operation

Significant progress was made by the Radiochemistry Group in tissue analyses. A total of 364 tissue samples from 15 whole-body and 8 partial-donations were analyzed for plutonium, americium, uranium, and thorium using α-spectrometry (in-house) and inductively coupled plasma mass spectrometry (ICP-MS, external). Radiochemical survey analyses of 4 whole-body donors and full analyses of 5 partial-body cases were completed.

Health Physics Database

After three years, standardization of exposure records and bioassay data from all (42) deceased whole-body donations has been completed. Of a total of 300 partial-body donations, data records have been standardized for 100 cases. Data entry was completed for all worksites except Hanford, Rocky Flats, Los Alamos, and Savannah River. As of March 31, 2015, database holds a total of 62,151 data records.

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) internal dosimetry of uranium, (ii) actinide microdistribution in the human respiratory tract, and (iii) mesothelioma incidence among USTUR donors. During FY2015, two invited, two podium and one poster presentations at national conferences were given by USTUR faculty.

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 a further year. 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 USTUR federally funded grant (DE-HS0000073) were distributed to the sponsoring agency and university. The FY2013 – FY2014 annual report (USTUR-0382-15) was published and electronically distributed among scientific collaborators, and published on the USTUR website.

Highlights of FY2015

Stacey L. McComish, *Associate in Research*

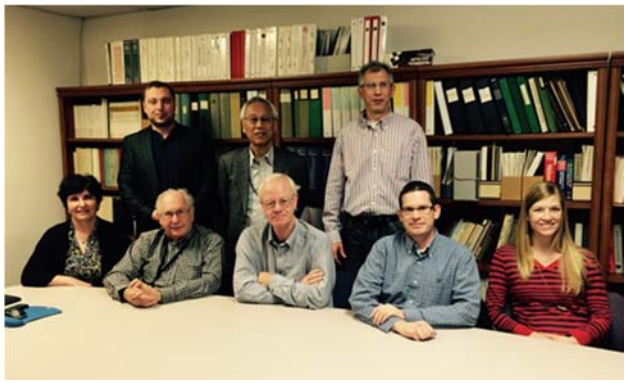
DOE Office of Health and Safety Director Visits

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.

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

Kyushu University Professor Visits

Professor Noriyuki Momoshima, Director of the Central Institute of Radioisotope Sciences and Safety (CIRSS) at Kyushu University (Fukuoka, Japan) visited the USTUR on November 4 – 5, 2014. Dr. Tolmachev and Prof. Momoshima discussed possibilities to sign an agreement of academic cooperation between the CIRSS and the USTUR. The purpose of the agreement will be to promote academic exchange and cooperation in research and education between the two institutions. Prof. Momoshima also participated in a weekly USTUR/PNNL scientific meeting.



At USTUR/PNNL weekly meeting. Front row(left to right): M. Avtandilashvili, A. L. Brooks (PNNL/WSU retired), W. F. Morgan (PNNL), B. W. Miller (PNNL), S. L. McComish; back row (left to right): G. Tabatadze, N. Momoshima (Kyushu University), S. Y. Tolmachev.

DOE Occupational Medicine Workshop

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, March 16-17, 2015. This was an excellent opportunity for the USTUR to improve its visibility by describing the Registries, its resources, and its research to professionals who may not have otherwise heard of the USTUR. The workshop reached a broad audience by broadcasting presentations to offsite attendees through the internet.

USTUR Brochures

The USTUR's informational brochures (Appendix B) were redesigned with up-to-date information and a simple, easy-to-read layout. The NHRTR brochure (USTUR-0378-15) summarized samples available at the USTUR, and was intended for potential collaborative researchers. The Registrant brochure (USTUR-0377-15) was intended for exposed workers who would like to learn more about the USTUR and/or potentially donate tissues to the program.

The COP/WSU provided graphical design and printed 300 copies of each brochure at no charge to the Registries.

Scientific Meetings

In FY2015, USTUR faculty attended three scientific meetings. Additionally, the USTUR's DOE program manager, Joey Zhou, attended two meetings.

Health Physics Society

USTUR faculty authored one presentation at the 59th Annual Meeting of the Health Physics Society (HPS) in Baltimore, MD, July 13-17, 2014. Maia Avtandilashvili presented a case study of a worker who was exposed to plutonium as a result of a wound in the workplace. Dr. Avtandilashvili tested the NCRP wound model by modeling the worker's urinary excretion and organ retention using the Integrated Modules for Bioassay Analysis (IMBA) Professional Plus software. Additionally, Joey Zhou presented a critique of a study, published in April 2013, on mesothelioma among USTUR Registrants.

Radiation Research Society

Dr. Sergei Tolmachev was invited to speak during the "Radiation Archives" session at the 2014 Radiation Research Society Annual Meeting. His presentation focused on samples available at NHRTR from both USTUR donations as well as collections such as tissues from the terminated Radium Worker study at Argonne National Laboratory. He also discussed recent USTUR research, how interested persons can request materials, and handed out USTUR brochures.

European Radiation Dosimetry Group

Stacey McComish attended the plenary meeting of the European Radiation Dosimetry Group's (EURADOS) Working Group 7 (WG7) on internal dosimetry in Warsaw, Poland, October 1-2, 2014. Dr. Tolmachev and Ms. McComish were participants in WG7's task group on biodosimetry, and were contributing to a review article on the biodosimetry of internal emitters. Additionally, they attended the task group meeting on microdosimetry. Brian Miller of PNNL gave a presentation about the digital autoradiography technique that he developed. Dr. Miller has been collaborating with the USTUR, and presented a digital autoradiograph of the ^{226}Ra distribution in a bone from the radium collection at the National Human Radiobiology Tissue Repository (NHRTR).

American Public Health

Dr. Joey Zhou gave a presentation at the American Public Health Association meeting in New Orleans, LA, November 15-19, 2014. His presentation was titled, "Incorrect Analyses of Radiation and Mesothelioma in the US Transuranium and Uranium Registries."

Financial Report

Margo D. Bedell-Parker, *Fiscal Specialist I*

On April 1, 2014, the USTUR began the third grant year of the USTUR's 5-year grant proposal (April 1, 2012 – March 31, 2017).

Total fiscal year (FY) 2015 (April 1, 2014 – March 31, 2015) funding sources were:

Federal Resources

Grant

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

Manage and Operate the United States Transuranium and Uranium Registries

DE-HS0000073

Amount awarded: $900,000
Period: April 1, 2014 – March 31, 2015

Total funding granted by DOE/AU-13 to WSU/COP/USTUR from April 1, 2012 until March 31, 2015 (FY2013 – FY2015) was $2,700,000.

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 Soluble Plutonium in the Human Respiratory Tract

GA227795

Amount awarded: $50,000
Period: April 1, 2014 – September 30, 2014.

Operating budget

With the DOE/JCCRER award of $50,000, the USTUR net operating budget for FY2015 was $950,000. Operating expenses for FY2015 were $949,980. With understaffed personnel (radiochemistry), and less than expected number of donations (two *vs* five), FY2015 was completed with a zero balance.

Grant Administration

FY2016 Grant Renewal Proposal

On January 22, 2015, 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 FY2016 (April 1, 2015 – March 31, 2016) was submitted to the Department of Energy Office of Domestic and International Studies (DOE/AU-13) through the WSU's Office of Grant and Research Development (OGRD). The total amount requested for the FY2016 was $900,000.

Submitted

A grant proposal to study binding of high-fired (insoluble) plutonium oxide ($^{239}PuO_2$) in the upper airways of the human respiratory tract was submitted to the Pacific Northwest National Laboratory (PNNL) as part of the DOE Project 2.4 Mayak Worker Dose Reconstruction, of the Joint Coordinating Committee on Radiation Effects Research (JCCRER) collaboration. The requested budget was $25,000 for a one-year grant period: October 1, 2015 – September 31, 2016.

Reporting Requirements Met

Four quarterly progress reports for the federally funded grant (DE-HS0000073) and one technical report (USTUR-0379-15) for the external contract (GA227795) were distributed on a timely basis to sponsoring agencies and the university during the period April 1, 2014 – March 31, 2015. FY2013 – FY2014 annual report (USTUR-0382-15) 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 1223801).

Registrant Statistics

Stacey L. McComish, *Associate in Research*

As of March 31, 2015, the Registries had a total of 878 Registrants in all categories (Table 1). Of that number, 57 were living and 347 were deceased. The 57 living Registrants included 7 individuals who were registered for eventual whole-body donation, 44 for partial-body donation, and 6 for 'Special Studies,' i.e., a bioassay study with no permission for autopsy. There were also 474 Registrants in an inactive category, which includes those lost to follow-up and those whose voluntary agreements were not renewed.

Registrant Renewals

The USTUR renews agreements with active Registrants every five years, to ensure that they still wish to participate in the program. The renewal process, along with the annual Registrant newsletter (Appendix C), also serves to maintain contact between the USTUR and living Registrants. During this fiscal period, eight Registrants renewed, three were placed in the inactive category, and one new Registrant joined the program.

Registrant Deaths

The USTUR was notified of two Registrant deaths; both were partial-body donors. Autopsies were performed near the municipality where the Registrants passed away, and tissues were sent to the USTUR laboratory for radiochemical analysis.

Case 0377: This donor worked with plutonium and had two possible intakes. The first was indicated only by a high urine sample; no exposure incident was documented in the file. The second involved airborne plutonium oxide dust, and workplace contamination.

Case 0805: This donor worked with plutonium for more than 40 years; however, he had no documented intakes of actinides in his exposure records. He died from heart disease.

Table 1. Registrant Statistics as of March 31, 2015

Total Living and Deceased Registrants:	404
Living Registrants:	57
Potential Partial-body Donors:	44
Potential Whole-body Donors:	7
Special Studies:	6
Deceased Registrants:	347
Partial-body Donations:	300
Whole-body Donations:	42
Special Studies:	5
Inactive Registrants:	474
Total Number of Registrants:	878

Registrant Status

The average age of living whole- and partial-body Registrants was 78 years and 82 years, respectively. The average age at death for the USTUR's 347 deceased Registrants was 68 years.

In FY2001, the USTUR reviewed the 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 work site and category is shown in Figure 1.

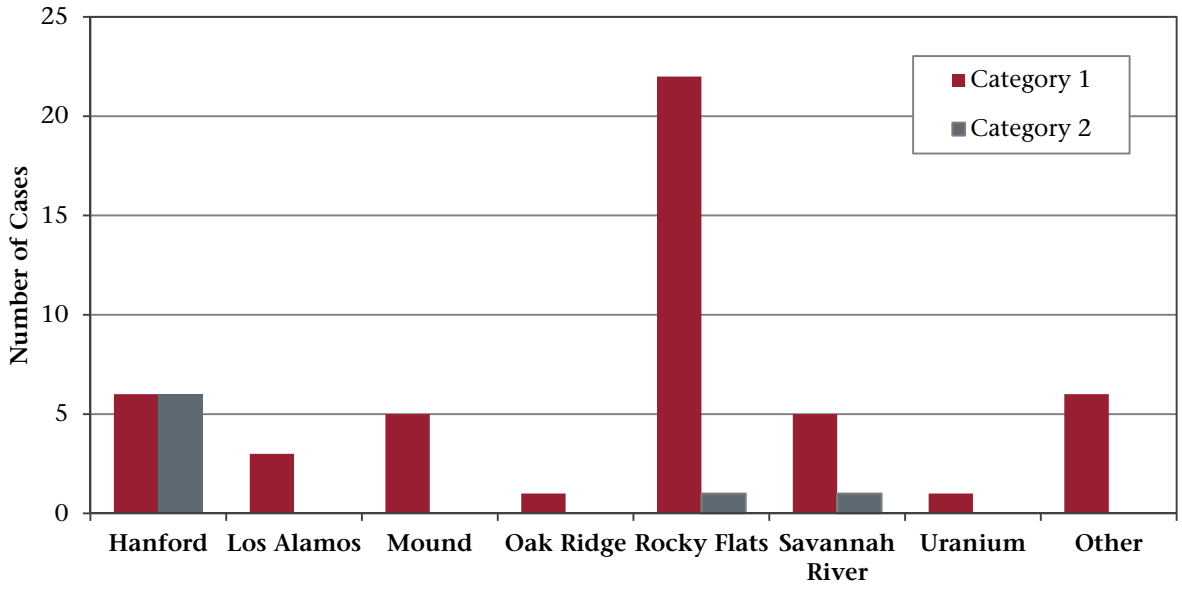


Fig. 1. Active Registrants by work site and category.

Health Physics Database

Maia Avtandilashvili, *Research Associate*

The USTUR Internal Health Physics Database is designed to standardize extensive sets of health physics data from 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 42 whole-body and 300 partial-body Registrant tissue donors. Starting in 2012, the USTUR adopted the following strategy for the health physics database population:

- The most recent donation is given the highest priority and is completed immediately
- Existing donation cases are completed based on specific worksite: 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 142 USTUR donations: 42 whole-body (all whole-body cases) and 100 partial-body (33% of all partial-body cases). In total, 62,151 health physics records from deceased Registrants have been entered into the database.

In addition, data entry was completed for two living Registrants (1 partial-body and 1 special study case) with a total of 1,020 records.

Figure 1 shows the FY2008 - FY2015 progress and the overall status of the health physics database for deceased Registrants as of March 31, 2015.

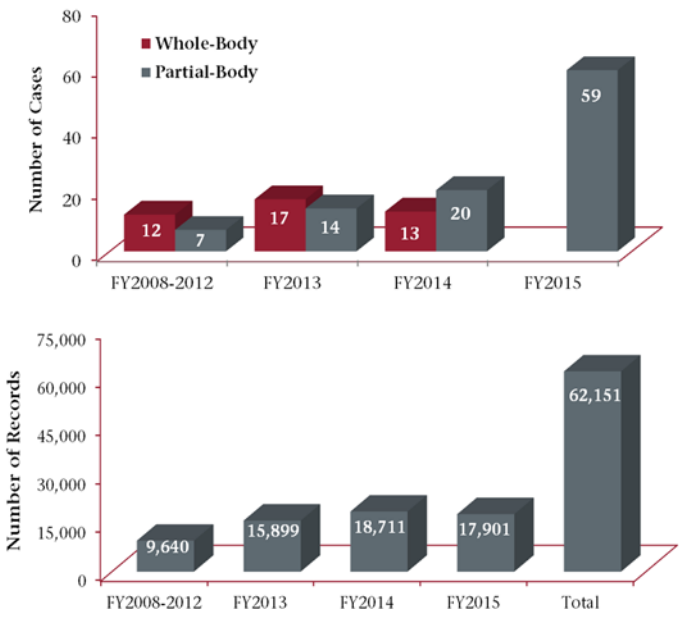


Fig. 1. FY2015 progress and overall status of the USTUR health physics database for deceased Registrants.

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 2.

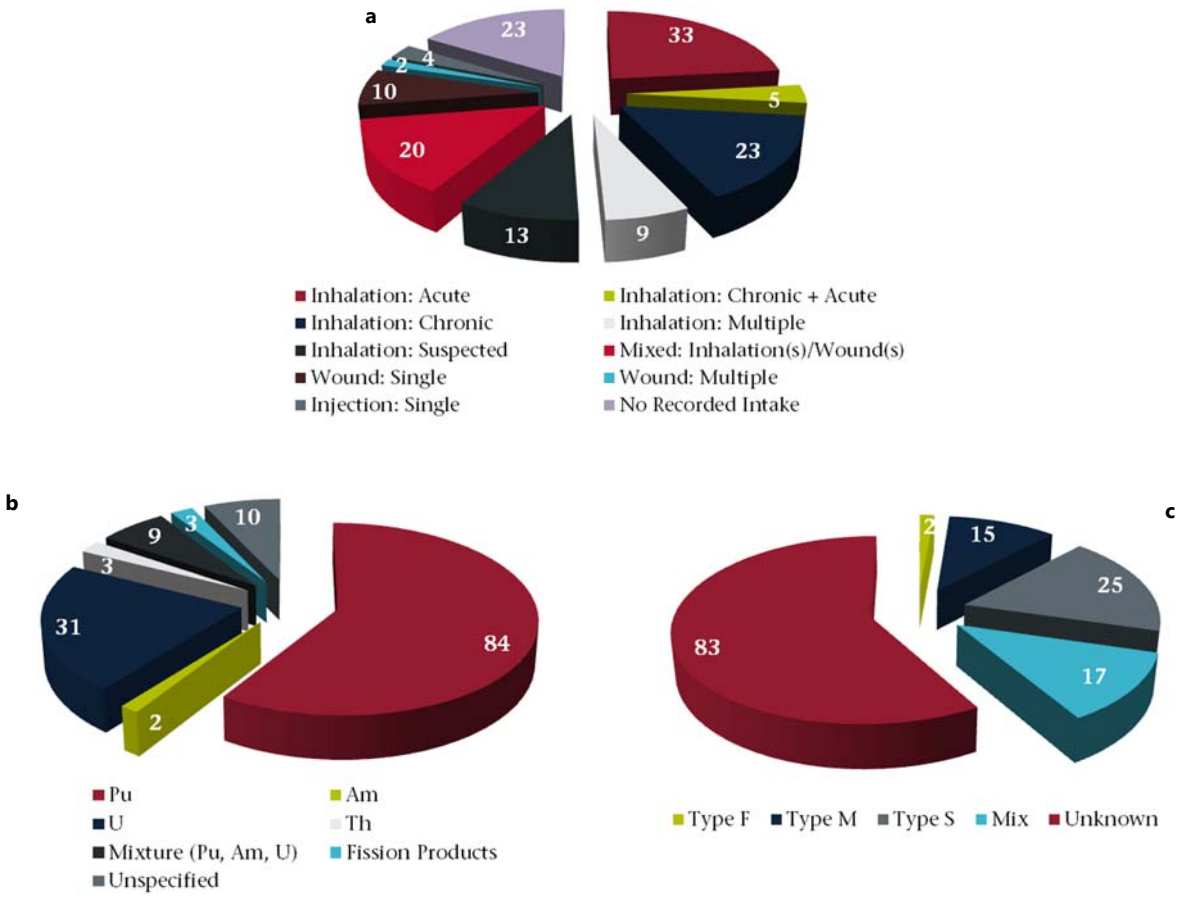


Fig. 2. Summary statistics of the health physics database: completed donation cases by (a) intake; (b) primary radionuclide; (c) material type.

NHRTR National Human Radiobiology Tissue Repository

Stacey L. McComish, Associate in Research

National Human Radiobiology Tissue Repository (NHRTR) activities focused on tissue prosection, consisting of dissection and hygienic packaging of tissues, and inventory of: (1) processed USTUR tissues, (ii) USTUR acid solutions, (iii) USTUR planchets, and (iv) tissues from the terminated radium worker and plutonium injection studies at Argonne National Laboratory (ANL). Samples were inventoried using THEMIS (THE Management Information System).

Tissue Prosection

In June 2014, USTUR staff finished the dissection, hygienic packaging (vacuum sealed), and inventory of tissues donated to the USTUR. The THEMIS inventory database allows USTUR staff to search for specific tissues, track sample movement within the NHRTR laboratory, and generate chain-of-custody forms for samples that are sent to external facilities for analysis. This accomplishment represented six years of dedicated work by Florencio Martinez and a team of students from the WSU Tri-Cities nursing program. Upon completion of the USTUR tissue inventory, laboratory staff commenced inventorying tissues from the terminated radium worker studies, which were received from ANL in 1992.

THEMIS Inventory

As of March 31st, 14,442 parent samples and 2,402 subsamples had been inventoried using the THEMIS database (Table 1). Parent samples best represent the number of unique tissues available at the USTUR; therefore, the following discussions about tissues and acid solutions exclude subsamples.

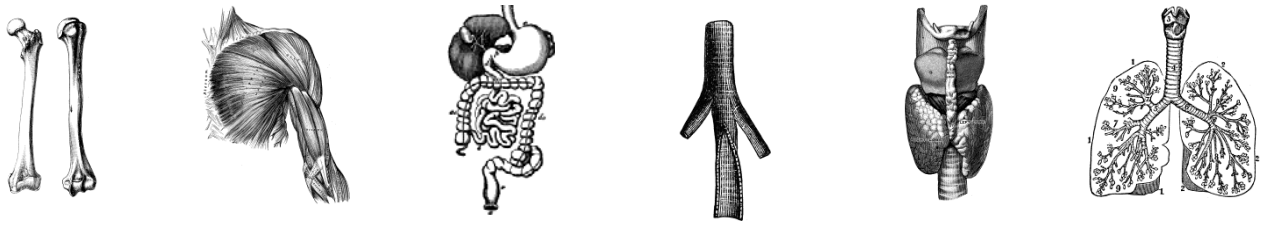
Table 1. Inventoried samples as of March 31, 2015

Tissue Type	Samples		
	Parent	Sub-	Total
USTUR donations			
Soft tissues	4,656	536	5,192
Bones	4,248	87	4,335
Acid solutions	4,210	1,466	5,676
Planchets	90	225	315
ANL tissues	982	46	1,028
Miscellaneous	256	42	298
Total	14,442	2,402	16,844

USTUR Tissues

As mentioned previously, USTUR staff finished inventorying USTUR tissues this fiscal year. Information on 464 parent samples was entered into THEMIS during FY2015. This brought the total number of inventoried USTUR tissues to 8,904 samples from 41 whole-body, 103 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 1). 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 the dissection protocol. Typically, long bones were dissected into four samples that were inventoried as unique parent samples.

On average, whole-body cases had 148 ± 100 tissue samples per case and partial-body cases had 27 ± 24 tissue samples per case.



Skeletal[1,2]	Muscle, Skin, Fat[3]	Alimentary[4]	Circulatory[5]	Glands[6]	Respiratory[7]
4,248	1,883	345	335	332	328

Fig. 1. The six most common types of tissues at the USTUR.

USTUR Acid Solutions

During FY2015, Information on 1,685 acid-digested tissue samples (acid solutions) from 35 whole-body, 79 partial-body, and 4 inactive or special cases was entered into THEMIS. This brought the total number of inventoried acid solutions to 4,210. 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).

Coin-holder with 8 individual planchets.

The planchet inventory was a two-step process. First, individual planchet numbers, pertinent dates, solution weights, tracers added, recoveries, and isotopic activities were tabulated in Microsoft Excel. Subsequently, batches of planchets were logged into 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. The two electronic inventories were designed to work hand-in-hand to the extent that the THEMIS inventory contains summary information about batches of planchets, and the MS Excel spreadsheet provides further details about specific planchets.

The MS Excel inventory was completed during FY2015. A total of 3,967 planchets were inventoried. They contained a total of 387 Bq of plutonium, 258 Bq of americium, 56 Bq of uranium, and 24 Bq of thorium (Table 2).

Upon completion of the MS Excel tabulation, student workers commenced inventorying batches of planchets using THEMIS.

Table 2. Actinide activity on USTUR planchets

Element	Number of Planchets	Activity, Bq		
		Total	Tracer	Analyte
Plutonium	1,608	387	172	215
Americium	1,636	258	197	62
Uranium	418	56	48	8.5
Thorium	301	24	24	0.76

Argonne National Laboratory Samples

In 1992, ANL transferred samples from its terminated radium worker studies to the USTUR[8]. During FY2015, 431 frozen samples from ANL were inventoried. This number includes 190 radium tissues, 142 'normal' samples – which we understand to be control samples – and 99 miscellaneous samples. During previous years, an additional 102 ANL samples had been inventoried. They included bone ash, paraffin and plastic embedded bone, dry bones, and slides.

References

1. Blaisedell AF. Our bodies and How We Live (Boston: Ginn &, 1904) 33. Retrieved October 6, 2015 from http://etc.usf.edu/clipart/15400/15417/femur_15417.htm
2. Blaisedell AF. Our bodies and How We Live (Boston: Ginn &, 1904) 31. Retrieved October 6, 2015 from http://etc.usf.edu/clipart/15400/15415/humerus_15415.htm
3. Gray H. Gray's Anatomy: Descriptive and Applied (Philadelphia: Lea & Febiger, 1913) 457. Retrieved October 6, 2015 from http://etc.usf.edu/clipart/53800/53895/53895_thorax.htm
4. Metheny DG. Potter's Compend of Human Anatomy 8th Ed. (Philadelphia: P. Blakiston's Son & Co., 1915) 330. Retrieved December 8, 2015 from http://etc.usf.edu/clipart/38700/38796/intestine_38796.htm
5. Brown EF. The Eclectic Physiology (New York: Van Antwerp, Bragg and Co., 1884) 70. Retrieved October 6, 2015 from http://etc.usf.edu/clipart/28500/28561/artery_28561.htm
6. Gray H. Gray's Anatomy: Descriptive and Applied (Philadelphia: Lea & Febiger, 1913) 1436. Retrieved October 6, 2015 from http://etc.usf.edu/clipart/54200/54280/54280_thyroid.htm
7. Cutter C. First Book on Analytic Anatomy, Physiology and Hygiene, Human and Comparative (Philadelphia: J. B. Lippincott & Co., 1875) 84. Retrieved October 6, 2015 from http://etc.usf.edu/clipart/50500/50561/50561_bronchia.htm
8. Rowland RE. Radium in Humans: A Review of U.S. Studies. Argonne National Laboratory. ANL/ER-3 September 1994.

Radiochemistry Operation

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

During FY2015 (April 1, 2014 – March 31, 2015), Radiochemistry Group activities were mainly focused on radiochemical tissue analysis.

Personnel

As of April 1, 2014, operation of the radiochemistry laboratory was supervised by Dr. Tolmachev (Principal Radiochemist) with only one full-time technical personnel - Ms. Elizabeth Thomas (Laboratory Technician II). On August 1, 2014, Dr. Tabatadze began work as a research associate in radiation measurements in support of the USTUR Radiochemistry Program. This resulted in 1.67 full time equivalent (FTE) technical personnel support for FY2015.

Tissue Sample Analysis

Tissue sample actinide analysis is a multi-step process. To complete the analysis, a tissue undergoes five diferent analytical steps: (i) drying and ashing, (ii) digestion and dissolution, (iii) radiochemical actinide separation, (iv) preparation of an α-counting source (planchet), and (iv) measurement of individual actinides – plutonium (^{238}Pu and $^{239+240}$Pu), americium (^{241}Am), uranium (^{234}U, ^{235}U, and ^{238}U), and thorium (^{232}Th) by α-spectrometry (AS, in-house) or by inductively coupled plasma mass spectrometry (ICP-MS, external). At the USTUR, samples are categorized as 'Processed' or 'Analyzed', where 'Processed' denotes that tissue samples have undergone at least one of the analytical steps, and 'Analyzed' denotes that sample actinide activities have been reported, *i.e.* tissue sample analysis was completed. The USTUR tissue sample analysis protocol is outlined in Figure 1.

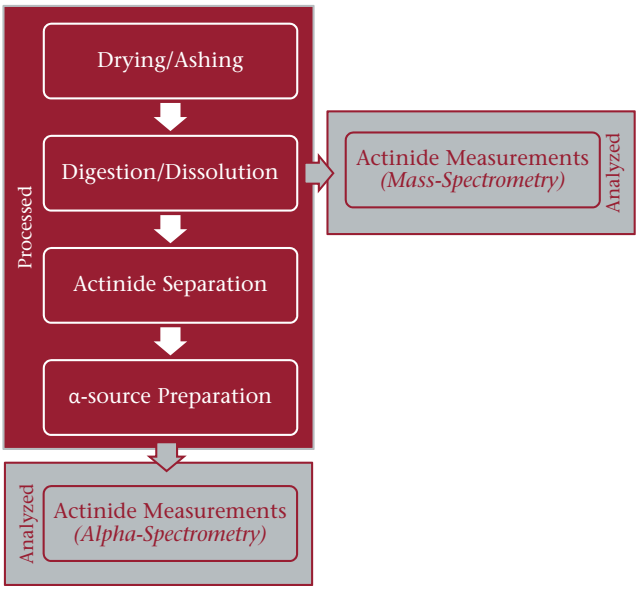


Fig. 1. Tissue sample radiochemical analysis protocol.

A total of 483 tissue samples, including 173 bones and 310 soft tissues from 21 donations, were processed during FY2015. Of 483 samples, 326 were analyzed for ^{238}Pu and $^{239+240}$Pu and ^{241}Am; 36 - only for ^{238}Pu and $^{239+240}$Pu; and 2 - for ^{232}Th using AS.

Whole-body Donations

Tissue samples from Case 0262 (died 1990; 2 samples), Case 0343 (2014; 39), Case 0456 (2009; 1), Case 0503 (1994; 55), Case 0631 (2011; 40), Case 0635 (2000; 2), Case 0679 (1997; 3), Case 0680 (1998; 2), Case 0745 (2005; 8), Case 0769 (1990; 1), Case 0804 (2013; 28), Case 0990 (2005; 26), and Case 1007

(1991; 35) were selected for radiochemical analysis. Of 13 selected donations, 12 were from cases where Registrants were exposed to plutonium, and one was a case with uranium exposure (Case 1007). Case 0745 and Case 0631 were analyzed as a part of the PNNL contract.

A total of 242 tissue samples, including 107 bones and 145 soft tissues were processed during FY2015. Of 242 samples, 179 were analyzed in-house for ^{238}Pu and $^{239+240}$Pu and ^{241}Am, and 2 - for ^{232}Th. Thirty-five digested tissue samples (acid solutions) from Case 1007 were sent to Laval University Radioecology Laboratory (Quebec, Canada) for ^{234}U, ^{235}U, and ^{238}U determination by ICP-MS.

Partial-body Donations

Tissue samples from Case 0272 (died 2013; 24 samples), Case 0340 (2008; 26), Case 0430 (2005; 30), Case 0636 (2012; 36), Case 0691 (2013; 44), Case 0743 (2013; 34), Case 0814 (2013; 26), and Case 0861 (2013; 21) were selected for radiochemical analysis. In all (8) selected donations, Registrants were exposed to plutonium.

A total of 241 tissue samples, including 66 bones and 175 soft tissues were processed during FY2015. Of 241 samples, 147 were analyzed for ^{238}Pu and $^{239+240}$Pu and ^{241}Am, and 36 for ^{238}Pu and $^{239+240}$Pu only.

Radiochemistry Status Changes

As of March 31, 2015, the USTUR had received 42 whole- and 300 partial-body donations, including two partial-body donations accepted during FY2015. Figures 2 and 3 compare overall radiochemical analysis status of whole- and partial-body donations at the beginning (April 1, 2014) and in the end (March 31, 2015) of the FY2015.

Cases are categorized as 'Intact,' 'Incomplete,' or 'Complete,' where 'Intact' denotes that no tissue samples have been analyzed, 'Incomplete' typically denotes that a selected sub-set of tissues was

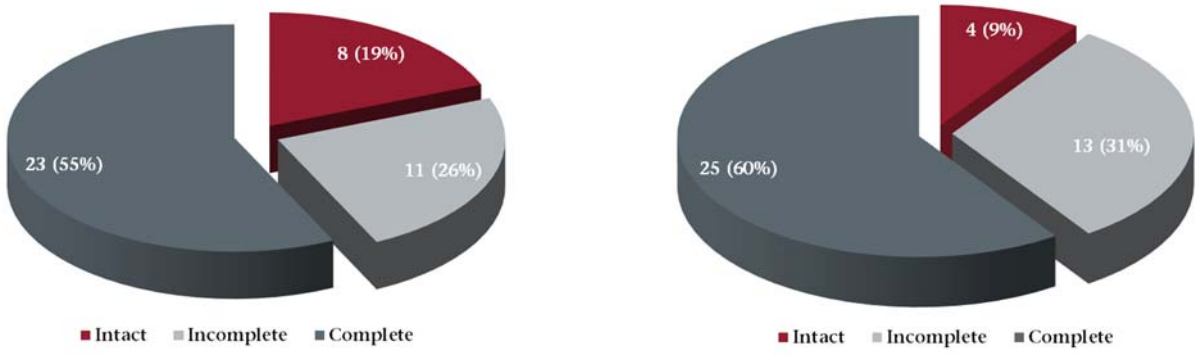


Fig. 2. Radiochemical analysis status for whole-body donations: as of April 1, 2014 (left); and as of March 31, 2015 (right).

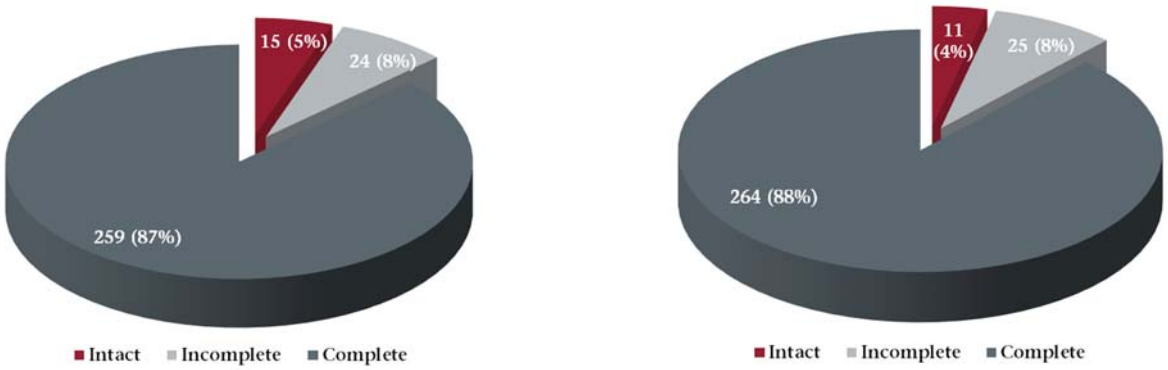


Fig. 3. Radiochemical analysis status for partial-body donations: as of April 1, 2014 (left); and as of March 31, 2015 including two new donations during FY2015 (right).

analyzed or case analysis is in progress, and 'Complete' denotes that a full selection of tissue samples was analyzed and results were reported.

Table 1 summarizes changes in radiochemical analysis status during FY2015 for individual cases.

Table 1. FY2015 case analysis progress

Case No	Year of Donation	Radiochemistry Status	
		FY2014	FY2015
Whole Body			
0343†	2014	Intact	Incomplete
0456†	2009	Incomplete	Incomplete
0503	1994	Incomplete	Complete
0631†	2011	Intact	Incomplete
0804†	2013	Intact	Incomplete
0990	2005	Intact	Incomplete
1007	1991	Incomplete	Complete
Partial Body			
0272	2013	Intact	Incomplete
0340	2008	Intact	Complete
0430	2005	Intact	Complete
0636	2012	Intact	Incomplete
0691	2013	Incomplete	Complete
0743	2013	Intact	Incomplete
0814	2013	Incomplete	Complete
0837‡	2003	Intact	Incomplete
0861	2013	Incomplete	Complete

† - Survey analysis complete in FY2015
‡ - Administrative status change

Student Involvement

Stacey L. McComish, *Associate in Research*

Prior to the Case 0805 autopsy: Florencio Martinez (USTUR), Kathryn Banks (WSU), Diana McGlynn (WSU), Danielle Gustin (WSU), Teresa Houck (WSU), Eric Kiesel (pathologist).

Students play an instrumental role at the USTUR. Their duties range from inventorying tissues at the laboratory to backing up Registrant files at the office. Most of our students are 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 FY2015.

Autopsy Assistants

Four WSU Tri-cities nursing students assisted with one autopsy (Case 0805). The students were grateful for the opportunity to observe an 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 arrive equipped with a solid training in anatomy and physiology.

Acid Solutions

Acid solutions before (left) and after (right) repackaging.

Historically, acid-dissolved tissues were packaged in cardboard boxes with vermiculite. Since 2012, students have been cleaning the vermiculite off of the acid solution bottles and repackaging them in corrugated plastic boxes. As a part of the repackaging process, damaged bottle lids were replaced, lids were sealed with melted paraffin wax, and bottles were wrapped in absorbent mat. Each bottle was inventoried using the THEMIS database, and a contents list was affixed to the outside of the box.

Planchets Inventory

During the radiochemistry process, actinides are electrodeposited onto planchets for alpha spectroscopy counting. Student workers inventoried the planchets using the THEMIS database.

Office Assistants

Document Scanning

In 2005, Registrant hard files were scanned to pdfs and saved on CDs. These disks served as a backup for the hard files. Since that time, scanning technology has dramatically improved, and student employees have been re-scanning all Registrant files to full-color PDFs and saving them to DVDs. This fiscal year, students scanned 147 deceased Registrant files, bringing the total number of scanned files to 199 (57% of deceased Registrants). Once all Registrant files have been scanned, the electronic files will be copied to a fireproof/waterproof hard drive.

Medication List

The USTUR holds copies of each Registrant's work site medical records; however, the Registries has little information about Registrants' health after they terminated employment at a national laboratory. One source of health information comes from a questionnaire that is mailed to Registrants every five years. One of the questions requests that Registrants list any medications that they are taking. The reported medications offer some insight into what conditions the Registrants may have experienced in the years between termination of employment and death. In order to make medication information more accessible, a nursing student, Abigail Wynne, commenced tabulating the name, dose, and frequency of medications used by each of our living and deceased Registrants. Upon completion of this task, the data will be imported into the USTUR's administrative database.

ACJ Scholarship

In 2013, Washington State University, College of Pharmacy established the Anthony C. James (ACJ) scholarship in honor of former USTUR Director, Tony James. As an independent study for her education at Eastern Washington University, Shannon Bedell, organized two fundraising events. During the "Twigs Tuesday" event, a local restaurant (Twigs Bistro and Martini Bar) donated 10% of a diner's order to the ACJ scholarship fund when a special card was presented. The second event was the "Anthony C. James Dinner and Auction". Guests purchased a ticket for this event, enjoyed a plated dinner, and bid on both silent and live auction items. As of January 2015, $13,616 had been raised at the events and by online donations.

Student List

Eight students worked at the USTUR during FY2015 (Table 1).

Table 1. Student Employees

Student	Program	Task
Katherine Banks	WSU Nursing	Tissues
Shannon Bedell	Eastern WA[†]	Tissues/ACJ
Ryan Blake	Hanford High	Planchets
Colette de Vries	WSU Nursing	Tissues/Acids
Danielle Gustin	WSU Nursing	Document scanning
Diana McGlynn	WSU Nursing	Acids/Planchets
Kieran Thomsen	CBC[‡]	Planchets/Scanning
Abigail Wynne	WSU Nursing	Medication list

[†]Eastern Washington University, Cheney, WA.
[‡]Columbia Basin College, Pasco, WA.

Modeling a Uranium Hexafluoride Inhalation

Maia Avtandilashvili, *Research Associate*

USTUR whole-body donor 1031 was accidentally exposed to large quantities of airborne uranium hexafluoride (UF_6) resulting from a massive explosion at a uranium processing plant[1,2]. The facility enriched ^{235}U from natural levels (0.72%)[3] to about 0.85%[4].

The Registrant was a non-smoker. He died decades post-accident from causes unrelated to his uranium exposure.

Bioassay data obtained for this case are relatively sparse and incomplete. No air concentration or external contamination levels were recorded. Follow-up bioassay data consist exclusively of uranium urinalyses results (Figure 1).

Uranium distribution in this individual's body at the time of death was quantified using inductively coupled plasma mass-spectrometric (ICP-MS) analysis of tissue samples collected at the autopsy. Uranium ($^{234,235,238}U$) concentrations and $^{235}U/^{238}U$ and $^{234}U/^{238}U$ isotopic ratios were determined for 29 samples including 8 bones, lungs, liver, brain, kidney, and other soft tissues. Table 1 summarizes the analysis results for major target tissues.

Remarkably, the $^{235}U/^{238}U$ atom ratios were elevated compared to the natural uranium (NU) composition ($^{235}U/^{238}U$ = 0.00725)[3] for all tissues, with the higher values measured in the lung and thoracic lymph node samples. The uranium composition observed in this donor's deep lung

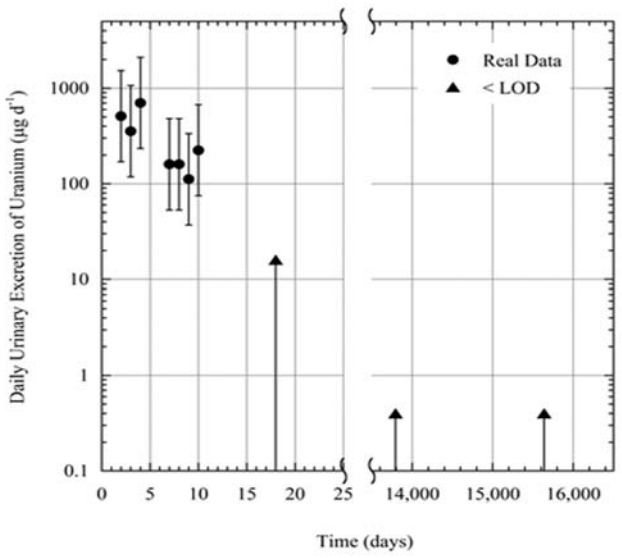


Fig. 1. Urinalysis data

tissues was consistent with the enrichment level reportedly achieved at the facility ($^{235}U/^{238}U$ = 0.00861)[4]. This demonstrates that a fraction of the accidentally inhaled slightly-enriched uranium material (SEU) still remained in the lungs 65 years post-intake. This is not consistent with an assumption of pure 'soluble', Type F uranium inhalation as recommended for UF_6[5,6]. Another observation from the autopsy tissue analysis data was that the uranium concentration in thoracic lymph nodes was two orders of magnitude higher than that in the lungs. This also contradicted an assumption of pure 'soluble' uranium inhalation unless the chemical form of the inhaled material had undergone some changes after deposition in the lungs that affected the dissolution rate.

Table 1. ICP-MS analysis results for selected tissues

Tissue	$^{235}U/^{238}U$ Isotopic Ratio	Concentration, μg kg^{-1}	Content, μg
Lungs	0.00854 ± 0.00004	0.580 ± 0.001	1.435 ± 0.002
Thoracic LN	0.00859 ± 0.00006	44.82 ± 0.090	1.023 ± 0.002
Liver	0.00761 ± 0.00020	0.505 ± 0.003	0.676 ± 0.004
Kidneys	0.00735 ± 0.00002	23.56 ± 0.090	6.48 ± 0.03
Brain	0.00793 ± 0.00010	0.289 ± 0.001	0.376 ± 0.001
Skeleton	0.00753 ± 0.00010	8.336 ± 0.009	75.79 ± 0.08
Total Body			105.41 ± 0.09

The residual fractions of accidentally inhaled SEU material retained in the tissues are presented in Figure 2.

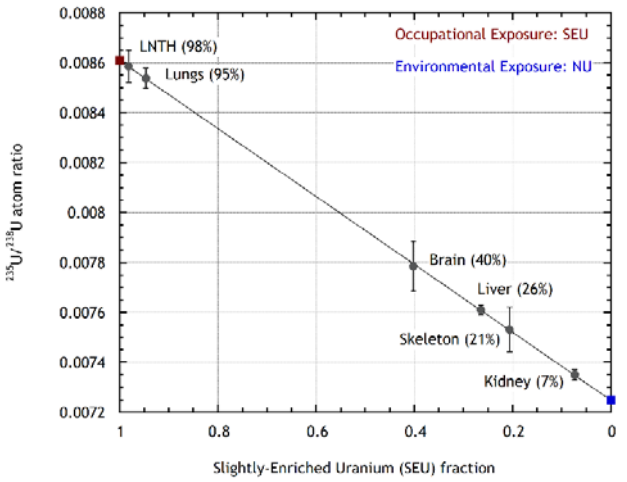


Fig. 2. Residual fractions of slightly-enriched material (SEU) in uranium mixture retained in tissues at time of death.

The IMBA Professional Plus® software was used to simultaneously fit the urine measurement and autopsy tissue analysis results. A complex exposure scenario was assumed consisting of an acute inhalation intake due to the accident and chronic environmental exposure to uranium from diet and air. For accidental inhalation, mixtures of uranium materials with different absorption types – F, M, and S[6] were tested.

Implementation of the ICRP Publication 66 human respiratory tract model[5] and ICRP Publication 69 systemic model for uranium[7] using a maximum likelihood analysis method resulted in a credible fit to urinary excretion data from this case and predicted the uranium content in this individual's major target organs except kidneys. It is likely that the ICRP 69 systemic model parameter values which were derived from kidney data covering a time period of no more than 1,000 days[8] may not adequately represent very long-term uranium retention in the kidneys.

The maximum likelihood analysis results are summarized in Table 2. Analysis resulted in an estimated accidental intake at 79.3 mg U consisting of 86% soluble and 14% insoluble compounds. It is likely that a small fraction of uranium oxides was present in the original mixture of inhaled uranium

Table 2. Maximum likelihood analysis results

Parameter	Estimate
Accidental Intake, mg	
Type F	68.2
Type M	$< 10^{-13}$
Type S	11.1
Environmental Intake Rate, mg d^{-1}	
Chronic Ingestion	0.0027
Chronic Inhalation	$< 10^{-18}$
Goodness-of-fit	
$\chi 2$ alpha-value	0.80

hexafluoride and its hydrolysis product, uranyl fluoride. For the worker's chronic exposure to environmental uranium, IMBA estimated a daily intake rate of 2.7 μg U per day for ingestion was within the range of expected values (1.3 to 4.4 μg d^{-1}) reported for the US residents[9-12]. However, the magnitude of the environmental inhalation intake was insignificant.

Committed effective dose due to the accidental intake was calculated at 3.7 mSv based on the assumption that the isotopic composition measured in the thoracic region of the respiratory tract represents the inhaled material. Approximately 74% of the total effective dose was contributed by the lungs.

References

1. Moore RH, Kathren RL. A World War II uranium hexafluoride inhalation event with pulmonary implications for today. *J. Occup. Med.* 27: 753-756; 1985
2. Kathren RL, Moore RH. Acute accidental inhalation of U: a 38-year follow-up. *Health Phys*. 51:609-619; 1989
3. Rosman KJR, Taylor PDP. Isotopic composition of the elements *Pure Appl. Chem*. 71:1593-1607; 1999
4. ORAUT. Summary site profile for the S-50 Liquid Thermal Diffusion Project ORAUT-TKBS-0054. Oak Ridge, TN, 2006
5. ICRP. Human respiratory tract model for radiological protection. Oxford: Elsevier Science; ICRP Publication 66; Ann ICRP 24 (1-3); 1994
6. ICRP. Dose coefficients for intakes of radionuclides by workers. Oxford: Elsevier Science; ICRP Publication 68; Ann. ICRP 24 (4); 1994
7. ICRP. Age-dependent doses to members of the public from intake of radionuclides - Part 3 ingestion dose coefficients. Oxford: Elsevier Science; ICRP Publication 69; Ann. ICRP 25 (1); 1995
8. Leggett RW. Basis for the ICRP's age-specific biokinetic model for uranium. *Health Phys*. 67:589-610; 1994
9. Wrenn ME, Durbin PW, Howard B, Lipsztein J, Rundo J, Still ET, Willis DL . Metabolism of ingested U and Ra. *Health Phys*. 48:601-633; 1985
10. Fisenne IM, Welford GA. Natural U concentrations in soft tissues and bone of New York City residents. *Health Phys*. 50 :739-746; 1986
11. Fisenne IM, Perry PM, Decker KM, Keller HW. The daily intake of $^{234,235,238}U$, $^{228,230,232}Th$ and $^{226,228}Ra$ by New York City residents. *Health Phys*. 53:357-363, 1987
12. Singh NP, Burleigh DP, Ruth HR, Wrenn ME. Daily U intake in Utah residents from food and drinking water. *Health Phys*. 59:333-337; 1990

Joint Committee on Radiation Effects Research

Stacey L. McComish, *Associate in Research*
Sergei Y. Tolmachev, *Director*

JCCRER research team visiting USTUR.

Dr. Tolmachev, Dr. Avtandilashvili, and Ms. McComish attended the Joint Coordinating Committee on Radiation Effects Research (JCCRER) Project 2.4 Mayak Worker Dose Reconstruction Meeting on June 9-13, 2014 in Richland, WA. Meeting participants included scientists from Pacific Northwest National Laboratory (PNNL), Public Health England (PHE, UK), and South Urals Biophysics Institute (SUBI, Ozersk, Russia). Extensive discussions on the progress and future plans of the collaborative project provided useful insights into the research efforts on reconstruction of Mayak worker doses.

The meeting participants discussed several topics of interest including updates on Mayak Worker Dosimetry Systems, Monte Carlo calculations using the Bayesian approach, uncertainty and sensitivity analyses, incorporation of dose uncertainty into the risk estimates for epidemiological studies, the effect of lung model parameters for different compounds, the urine bioassay program for Mayak workers, radionuclide distributions in autopsy samples, etc.

On June 11, 2014, the JCCRER Project team visited the USTUR's office and laboratory facility, and the associated National Human Radiobiological Tissue Repository (NHRTR). Dr. Tolmachev provided a tour of the records center, storage areas, examination areas, chemistry laboratory, and counting room. He also explained current activities underway at the USTUR.

During meeting sessions on June 12 and 13, 2014, the USTUR team had extensive discussions with the JCCRER Project team on a number of topics in the meeting agenda.

Dr. Tolmachev provided the meeting participants with an update on the ongoing analyses of two USTUR plutonium nitrate cases (0631 and 0745) under the current contract with PNNL to define the bound fraction in alveolar-interstitial compartment and upper airways. Dr. Alan Birchall (PHE, UK) suggested that a plutonium oxide inhalation case be analyzed and compared with the results obtained for nitrate cases. Dr. Tolmachev and Dr. Avtandilashvili proposed using USTUR Case 0407, who was exposed to high-fired PuO_2. The opportunity to accommodate this need for additional analyses by expanding the current contract with PNNL for the next fiscal year was discussed.

Dr. Tolmachev also provided his comments and suggestions on the scaling of autopsy sample weights

and pointed out the differences in the approaches used by the USTUR and SUBI.

In addition, Dr. Tolmachev actively participated in the discussion on the contribution of americium to the Mayak worker doses and suggested a couple of methods that could be utilized to develop ratios of americum to plutonium using different counting techniques.

Bone Microdosimetry: Feasibility Study

George Tabatadze, *Research Associate*

Estimation of the micro-distribution of α-emitting radionuclides in a skeleton is an important task to support biokinetic modeling and dose assessment. Digital autoradiography using ionizing-radiation quantum imaging detector (iQID) allows one to study the micro-distribution at mili-Becquerel levels[1].

Fig. 1. ionizing-radiation Quantum Imaging Detector (iQID): large field of view (FOV) detector with 115 mm:40 mm fiber-optic taper (left) and small FOV with 40 mm diameter image intensifier (right).

In this study, the iQID was used to investigate the radionuclide distribution in anatomical bone structures, such as cortical and trabecular bone volumes and surfaces, for bone volume-seeker (radium) and surface-seeker (plutonium and americium) radionuclides (Figure 1).

Macro-Scale Imaging

Three cases were chosen for the initial imaging study. USTUR Case 0246 with occupational exposure to ^{241}Am[2]; case CHI-1 from the plutonium (^{239}Pu) injection studies[3]; and case 03-210 with ^{226}Ra therapeutic injection[4]. Estimated intakes were 40 MBq, 14.8 kBq, and 9.5 MBq of ^{241}Am, ^{239}Pu, and ^{226}Ra, respectively.

To study the ^{241}Am distribution, bone samples from the clavicle acromial end and clavicle shaft were used. To represent two anatomical structures of the skeleton, specifically cortical bone and trabecular spongiosa, samples were cut into longitudinal sections. Dried bone sections were directly placed on the detector (scintillation film) for counting (Figure 2a). To study the ^{239}Pu distribution, two plastic embedded bone sections from femur middle shaft, representing cortical bone region, were used (Figure 2b). For the ^{226}Ra distribution study, cortical and trabecular bone regions were represented by two plastic embedded bone samples from femur distal end and tibia middle shaft, respectively (Fig. 2c,d). For ^{229}Pu and ^{226}Ra cases, unpolished plastic embedded bones were imaged without further preparation. All samples were counted for 60 to 400 hours.

For each bone, the ^{241}Am, ^{239}Pu, or ^{226}Ra activity distribution was visualized and quantified. Despite the noticeable thickness of samples, the initial imaging study was able to map the radionuclide distribution on a macro-scale (Figure 3a-3c). However, it was impossible to distinguish whether α-events (detected α-particles) originated from the surface or volume of a sample. The high-intensity α-event clusters shown in Figure 4 originate from the sample's surface, while the low-intensity areas represents α-noise. This interference originates from deep layers of the bone, and results from α-particles which passed through the marrow cavities. These cavities (void spaces) were drained of the bone

marrow during the sample drying process. Thus, dried bone specimens are not a good choice for the study of the micro-distribution of α-particles in bone, because the α-interference needs to be eliminated. This can be achieved by preparing micron-thick bone slides.

Fig. 2. Bone samples counted using iQID digital autoradiography (a) ^{241}Am Case 0246 (b) ^{239}Pu injection case 40-004/CHI-1, and (c,d) ^{226}Ra injection case 03-210.

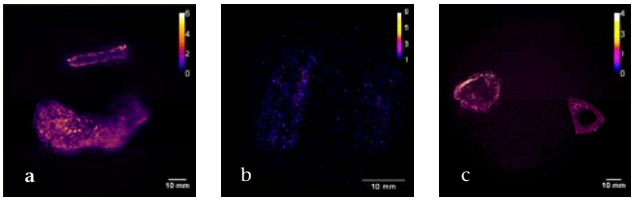


Fig. 3. Distribution of ^{241}Am (a), ^{239}Pu (b), and ^{226}Ra (c) within anatomical bone structures.

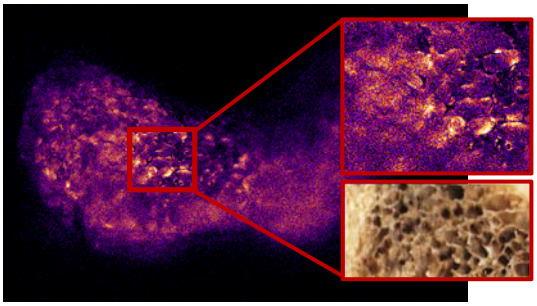


Fig. 4. Distribution of ^{241}Am in clavicle acromial end.

Micro-Scale Imaging

USTUR Case 0846 was selected to study the ^{241}Am micro-distribution in the human skeleton. For this individual, the estimated ^{241}Am whole-body activity was 66.6 kBq at the time of death. Two bones were chosen: the humerus and the clavicle.. Subsamples were acquired from the humerus proximal end, humerus proximal shaft, and clavicle acromial end (Fig. 5). These subsamples were sent to a commercial histology laboratory for plastic embedding, polishing, and cutting 100-micron-thick sections.

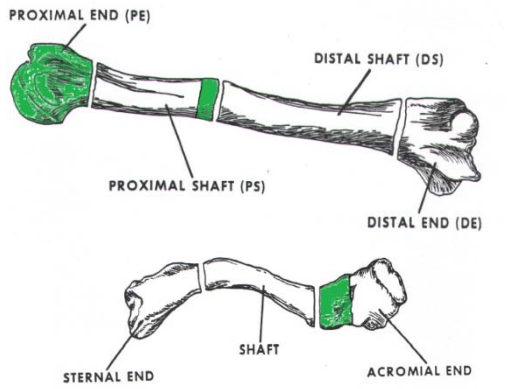


Fig. 5. Bone sub samples taken from humerus proximal end and proximal shaft (top); clavicle acromial end (bottom).

Bone sections were polished to a fine surface and their anatomical structures were imaged using a 2-D scanner and digital microscope (Figure 6). Microscopy imaging confirmed that the trabecular region structure and cellular integrity was preserved (Figure 7). All bone sections were imaged for 300 to 700 hours.

Fig. 6. 100-µm-thick sections of humerus proximal end (right) and proximal shaft (left).

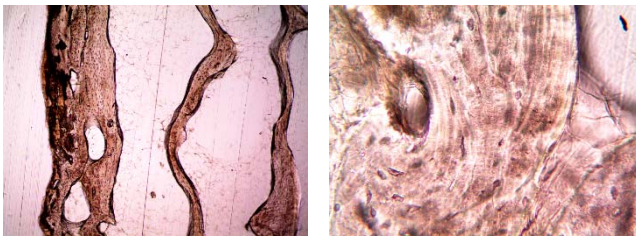


Fig. 7. Microscopic images of trabecular region of humerus proximal end taken at 10x magnification (left) and 100x (right).

Figure 8 shows spatial distribution of ^{241}Am in humerus proximal end. This iQID image shows significant improvements in mapping the ^{241}Am micro-distribution compared to that for Case 0246 (Figure 4). The difference is attributed to the reduced number of α-interferences originating from the sample volume. The study shows that iQID imaging using 100-µm-thick slides provides high-quality results on radionuclide micro-distribution within anatomical bone structures.

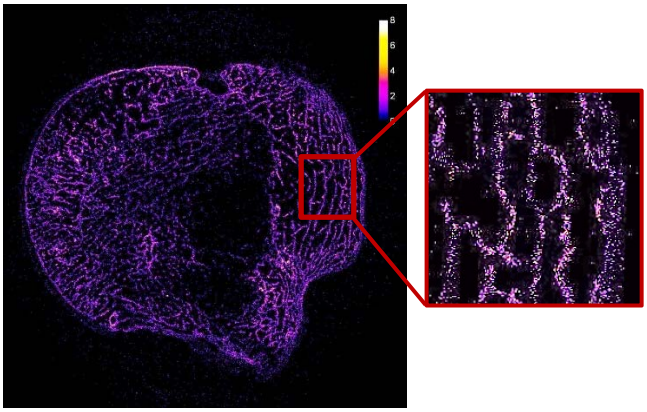


Fig. 8. Improved imaging of ^{241}Am micro-distribution in trabecular region of humerus proximal end.

References

1. Miller BW, Gregory SJ, Fuller ES, Barrett HH, Bradford Barber H, Furenlid LR. The iQID camera: An ionizing-radiation quantum imaging detector. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment.; p.146-152: 2014
2. Toohey RE., Kathren RL. Overview and Dosimetry of the Hanford Americium Accident Case. Health Phys. 69(3):310-317; 1995
3. Langham WH, Russell ER, Excretion Studies: in Report of Conference on Plutonium (J.J. Nickson, editor), Metallurgical Laboratory CN-3167 (July 1945)
4. Rowland RE, Radium in Humans: A Review of U.S. Studies. Argonne National Laboratory: Environmental Research Division; 1994.

2014 Advisory Committee Meeting Report

Richard E. Toohey, *Chair, Scientific Advisory Committee*

The 2014 Annual Scientific Advisory Committee (SAC) meeting was held September 5-6 at the Courtyard by Marriott in Richland, WA.

2014 Meeting Attendees

Advisory Committee

Richard Toohey, *Chair/Health Physics*

Robert Bistline, *Occupational Health*
Herman Gibb, *Epidemiology*
William Hayes, *Chair/Radiochemistry*
Timothy Ledbetter, *Ethics*
Roger McClellan, *Toxicology*

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, *Prosector*
Shannon Bedell, *Student Intern*

WSU College of Pharmacy

Philip Lazarus, *Chair, Dept. of Pharmaceut. Sc.*
Kathryn Meier, *Associate Dean*

WSU Tri-Cities

Akram Hossain, *Interim Vice Chancellor*

Invited Guests

Antone Brooks, *WSU/PNNL Low Dose Program*
Darrell Fisher, *PNNL*
Timothy Lynch, *MSA*
Jay MacLellan, *PNNL*
Brian Miller, *PNNL*
Bruce Napier, *PNNL*
Marianne Sowa, *PNNL*
Paul Stansbury, *WSU/Dade Moeller*
Dan Strom, *PNNL*
Next-of-Kin, *Family Representative*

Presentations

The meeting started at 8:30 am with Richard Toohey addressing the SAC members only. This was followed by welcome and introductions from S. Tolmachev, Director USTUR.

WSU/COP and USTUR - Lazarus, P.

S. Tolmachev introduced Dr. P. Lazarus from the College of Pharmacy. Dr. Lazarus gave an overview of the College of Pharmacy information and how the USTUR can relate to the college.

Washington State University Tri-Cities - Hossain, A.

The WSU Tri-Cities campus was represented by Prof. A. Hossain, from the Dept. of Civil and Environmental Engineering.

Updates from DOE – Zhou, J.

J. Zhou, Department of Energy representative for the USTUR gave information about taking a tour of

PNNL and the B-Reactor in Richland, WA. There is a change in the DOE organization chart. His office designation is being changed from HS-13 to AU-13.

2013 SAC Recommendations & 2014 USTUR Overview - Tolmachev, S.

S. Tolmachev started with the 2013 SAC recommendation and the 2014 USTUR Overview. Dr. Tolmachev review the 10 recommendations outlined from the SAC members in 2013.

S. Tolmachev, USTUR, reviewed the core functions of the USTUR and R. McClellan (SAC) reported that the issue of materials ownership has been resolved. All USTUR samples are the property of DOE, thus relieving WSU of disposal costs.

Administrative & Financial Developments - Parker, M.

M. Parker, USTUR, reported on the financial and administrative developments presentation. Information was given on the budget being now in balance. Fred Miller retired and not hiring a new person helped in the balancing of the budget over spending.

Anthony C. James Scholarship - Bedell, S.

S. Bedell, USTUR, gave a presentation on the Anthony C. James Scholarship endowment dinner. The dinner will be held on October 18, 2014 at Memories at Sunset, Richland, WA. S. Bedell is a student at Eastern Washington University completing an Internship at the USTUR for her degree.

USTUR Registrant Statistics - McComish, S.

S. McComish, USTUR, presented the USTUR Registrant Statistics. There are currently 405 registrants from 33 states, of whom 60 are living and 345 are deceased. In the past year, five registrant deaths were reported, and three autopsies performed. Two donors were not accepted, one being positive for hepatitis B virus and an autopsy could not be arranged for the other due to time constraints. Nine registrants changed their status to inactive.

Health Physics Database Progress Report - Avtandilashvili, M.

M. Avtandilashvili, USTUR, reported on the Health Physics database progress report. Data entry is complete for 104 of 340 deceased registrants, including 42 whole-body donors and 298 partial-body donors. There is now a total of 52,607 records in the database.

Radiochemistry Progress Report – Tabatadze, G.

Operation of the radiochemistry laboratory was described. Topics included tissue analysis progress, equipment upgrades, and facility maintenance. Analysis was completed for 337 samples.

National Human Radiobiological Tissue Repository - McComish, S.

S. McComish, USTUR presented the National Human Radiobiological Tissue Repository information. There are currently 16,145 samples in the repository. Tissues in the repository include 8,812 frozen samples and 148 fixed specimens.

Application of Digital Autoradiography - Miller, B.

B. Miller, PNNL gave a presentation on the application of digital autoradiography that permits rapid imaging of the distribution of radioactivity in a tissue sample.

USTUR/ JCCRER Project 2.4 Collaboration - Napier, B.

B. Napier, PNNL presented information regarding the USTUR/JCCRER Project 2.4 collaboration work done. Work is nearing completion on the dose estimates for almost 26,000 Mayak workers, of whom more than 8,000 have bioassay results available for internal dose estimation. Data on retention of plutonium in the lung has led to specification of the parameters for the bound fraction in the ICRP-66 Human Respiratory Tract model, which were previously unspecified.

Uranium Distribution in Humans - Kathren, R. (Presented by Tolmachev, S.).

S. Tolmachev gave Ron Kathren's presentation on Uranium Distribution in Humans. This presentation summarized data on the distribution of naturally occurring uranium in three whole-body donors. Findings indicate that there is no significant long-term retention of uranium in the kidney, there may be a long-term retention of uranium in the thyroid, and the half-time of skeletal retention of uranium is closer to 5,000 days than the 1,500 days currently assumed.

Case 0212: Testing NCRP Wound Model - Avtandilashvili, M.

M. Avtandilashvili, USTUR, reported information on Case 0212: Testing the NCRP Wound Model. Ten USTUR whole-body donors had documented wound intakes of Pu-239 (9) or Am-241 (1). Analysis of data from Case 0212 provided results for Pu-239 in the liver and skeleton within 25% of that predicted by the NCRP wound model, and within a factor of 2 for Pu-239 retained at the wound site.

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

P. Stansbury, WSUTC, explained how the WSU grad certificate program in radiation protection was coming into place at the Tri-Cities campus.

Research & Operation Plan for FY 2015 - Tolmachev, S.

S. Tolmachev, USTUR, gave information on the research and operations plan for FY2015. The goal for analysis is to process 450 samples and complete 400, or about 13% of the samples on hand. Priority will be given to completing three "old" intact cases (2003-2005) and to survey analyses (25-35 samples) of 10 (out of a total of 19) intact donations. Emphasis will also be placed on reports to the families of donors, updating of standard operating procedures, and DQO implementation. A total of 40-45 cases will be entered into the health physics database, including all new donations as received. Inventories of NHRTR frozen tissues from radium workers and all planchets will be completed, and will continue for acid solutions.

General discussion followed regarding the USTUR in 2014 and beyond. The SAC provided the following observations and recommendations to the staff:

Recommendations

1. Need to decide on a mechanism and proceed with gathering work histories.
2. Complete data quality objectives (DQO) for laboratory analyses (also needed for contract labs).
3. Develop marketing/public information materials for the USTUR, and new recruiting brochures.
4. Request funding for contract lab analyses to help clear the backlog of tissue samples.
5. Participate in Department of Energy (DOE) Office of Health, Safety and Security (HSS) and Energy Facility Contractors Group (EFCOG) occupational medicine conferences; hand out marketing materials.
6. Make use of WSU's public affairs office to publicize USTUR accomplishments and human interest stories, e.g. the science fair awardee.
7. If desired, could use National Death Index to get vital status of recovered Hanford Environmental Health Foundation (HEHF) registrants ($5 per search), then contact living persons for follow-up; however, try reasonable data search to see if registrant meets qualification before contacting.
8. Continue to pursue opportunities for WSU student participation in the USTUR program.
9. Clarify prioritization of samples for analysis.
10. Need strategic plan review/revision for long term. Clarify the value of Registries data now and in the future. Emphasize uniqueness of USTUR tissue collection as a resource for radiobiology research.
11. Continue presentations of USTUR data at scientific meetings; have marketing brochures handy.
12. Continue collaborative research opportunities.

Observations

1. Great use of nursing students from WSU-TC in dissections.
2. There appears to be increased interest in USTUR by WSU College of Pharmacy leadership, especially in research areas such as pharmacokinetics and genomics.
3. Staff established higher goals for analysis and data input, and mostly initiated efforts to achieve.
4. Found old (HEHF) registrant data and reconstituted registrant list.
5. Meeting was very well organized, especially regarding progress on previous SAC recommendations.
6. Excellent presentations by staff including Dr. Avtandilashvili, Brian Miller, and Dr. Tabatadze.

7. Resolved the issue of handling donations from registrants lost to follow-up.

SAC Membership

Richard Toohey's participation on the SAC was renewed for a second three-year term. He will also continue to serve as the chair of the committee.

Professional Activities/Services

During FY2015, 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.

Dr. Tolmachev participated in several advisory board meetings at the WSU TC campus. The following topics were discussed:

- Status of approval of courses and overall program by WSU Management and the Faculty Senate
- Status of course development
- Status of future year's grant funding
- Brainstorming for alternative delivery methods for distance learning and alternative delivery schedules
- Questions about CHP education requirements.

Adjunct Professor Appointment

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

International Committees and Meetings

EPA Science Advisory Board Radiation Advisory Committee

Dr. Sergei Tolmachev has been nominated as a candidate for augmenting the U.S. Environmental Protection Agency (EPA) Science Advisory Board (SAB) Radiation Advisory Committee (RAC).

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 has 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).

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 the 3rd term from August 2013 to July 2015.

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

Journal of Radioanalytical Nuclear Chemistry

Dr. Sergei Y. Tolmachev was invited to provide scientific expertise as an *ad-hoc* reviewer to the Journal of Radioanalytical Nuclear Chemistry. One paper was 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)
- Society of Nuclear and Radiochemical Sciences (Japan)
- European Radiation Dosimetry Group (EURADOS), Working Group 7 (WG7) on Internal Dosimetry (EU).

Publications/Presentations

The following manuscripts and presentations were published or presented during the period of April 2014 to March 2015. 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-0358-14

Avtandilashvili M, Puncher M, McComish SL, Tolmachev SY. US Transuranium and Uranium Registries case study on accidental exposure to uranium hexafluoride. *J Radiol Prot.* 35 (1): 129-151; 2015.

USTUR-0370-14

Vergucht E, De Samber B, Izmer A, Vekemans B, Appel K, Tolmachev S, Vincze L, Vanhaecke F. Study of the distribution of actinides in human tissues using synchrotron radiation micro X-ray fluorescence spectrometry. *Anal Bioanal Chem.* 407 (6): 1559-1566; 2015.

USTUR-0365-14

Zhou J. Bias in the Proportionate Mortality Ratio Analysis of Small Study Populations: a Case on Analyses of Radiation and Mesothelioma. *Int J Radiat Biol*. 90(11):1075-1079; 2014.

USTUR-0361-14A

Avtandilashvili M, McComish SL, Tolmachev SY. USTUR Whole-Body Case 0212: Testing NCRP Wound Model. *Health Phys*. 107 (1 Suppl): S108; 2014.

USTUR-0362-14A

Zhou J. Incorrect Analyses of Radiation and Mesothelioma in the U.S. Transuranium and Uranium Registries. *Health Phys*. 107 (1 Suppl): S47; 2014.

USTUR-0363-14A

Kathren RL, Tolmachev SY. Uranium Distribution and Concentrations in the Tissues of Whole-Body Donations to the USTUR. *Health Phys*. 107 (1 Suppl): S107; 2014.

USTUR-0366-14

McComish SL, Tolmachev SY. United States Transuranium and Uranium Registries 2014 Newsletter, Issue 20. College of Pharmacy, Washington State University, Richland, WA. Mailed November 2014.

Presented

July 2014

USTUR-0361-14A

Avtandilashvili M, McComish SL, Tolmachev SY. USTUR Whole-Body Case 0212: Testing NCRP Wound Model. Podium presentation at the 59th

Annual Meeting of the Health Physics Society, Baltimore, MD, July 13 – 17, 2014.

USTUR-0362-14A

Zhou J. Incorrect Analyses of Radiation and Mesothelioma in the U.S. Transuranium and Uranium Registries. Podium presentation at the 59th Annual Meeting of the Health Physics Society, Baltimore, MD, July 13 – 17, 2014.

September 2014

USTUR-0368-14A

Tolmachev SY (*invited*). The National Human Radiobiological Tissue Repository: a unique resource for scientists. Podium presentation at the 60th Annual Meeting of the Radiation Research Society, Las Vegas, NV, September 20 – 24, 2014.

November 2014

USTUR-0369-14A

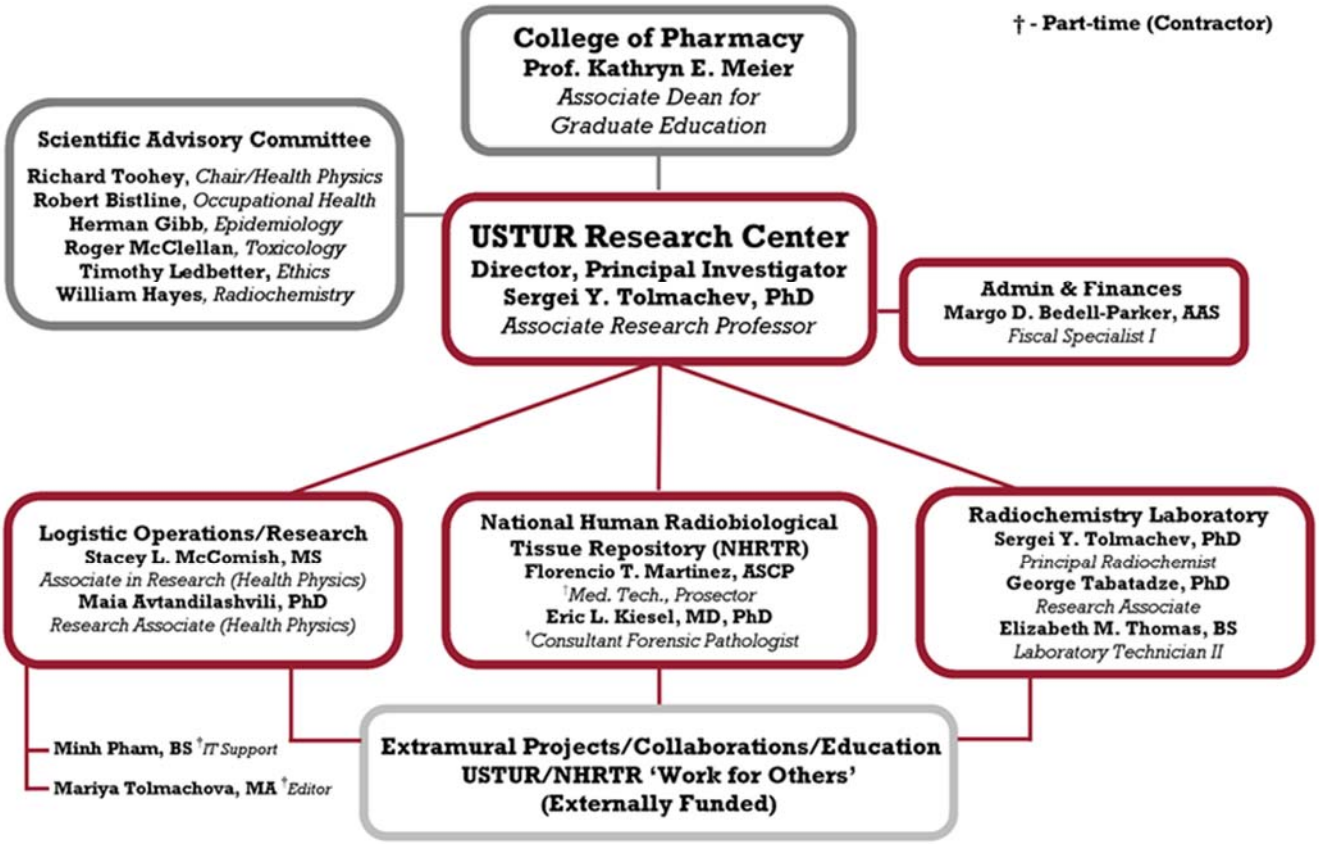
Zhou J. Incorrect Analyses of Radiation and Mesothelioma in the U.S. Transuranium and Uranium Registries. Poster presentation at the 142nd Annual Meeting of the American Public Health Association, New Orleans, LA, November 15-19, 2014.

March 2015

USTUR-0380-15P

Tolmachev SY (*invited*). US Transuranium and Uranium Registries and Research. Podium presentation at the DOE Annual Occupational Medicine Workshop and Webinar, Washington, DC, March 16-17, 2015.

Appendix A



USTUR Research Center organization structure as of March 31, 2015.

Appendix B

How are Tissues Obtained?

Registrants are volunteers who authorize the Registries to obtain their individual medical and radiation exposure records for research purposes, and to collect tissue samples after death. Tissue samples are obtained at an autopsy performed by an independent qualified pathologist.

Volunteer donors pre-plan the donation by granting the USTUR full consent to collect selected tissues after death; the entire body may also be donated. The consent can be withdrawn at any time by the donor. The donation program is similar to organ donations for medical purposes designated on a driver's license.

When a Registrant dies, the Registries are notified by the hospital, legally-recognized next-of-kin, or other authorities. The Registries then verify with the next-of-kin that the previously-consented autopsy is still desired, and that valid written permissions are on file. If the next-of-kin choose not to provide tissue donations, the Registries comply with the wishes of the family.

If the family agrees to proceed with the pre-planned autopsy. Except in the case of whole body donations, the body is returned to the family for burial or other disposition after autopsy. Autopsy results, research findings and any other information in the Registrant's file are provided to next-of-kin upon written request.

For more information

about the United States Transuranium and Uranium Registries please contact:

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Director, USTUR
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USTUR-0377-15 Printed 02/15

Facts about the United States Transuranium and Uranium Registries

UNITED STATES TRANSURANIUM AND URANIUM REGISTRIES

College of Pharmacy
WASHINGTON STATE UNIVERSITY

www.ustur.wsu.edu

What is the USTUR?

The United States Transuranium and Uranium Registries (USTUR) is a federal-grant program funded by the U.S. Department of Energy (DOE) Office of Domestic and International Health Studies.

Founded in 1968 operated by Washington State University's College of Pharmacy since 1992

The USTUR was designed as a program to improve radiation protection of nuclear workers. The Registries studies the distribution, dose, and possible health effects of exposure to plutonium, americium, uranium, and thorium (actinides) in radiation workers and other individuals with known exposures.

Use of the Registries

The uniqueness of the USTUR's research lies in its ability to link exposure, work history, medical, and industrial hygiene data with post-mortem measurements of the distribution of radioactive elements in the human body. The USTUR is the only program worldwide that can combine such comprehensive workplace and exposure data with post-mortem results to study the behavior of actinide radionuclides in the human body, and the resulting doses.

Registries research has been documented in more than 270 scientific articles and reports, and continues to benefit future radiation workers by:

- Studying the biological effects of radiation on cells and DNA.
- Validating the effectiveness of US radiation safety standards.
- Testing and improving the mathematical models that are used to calculate worker doses and determine the distribution and clearance of radioactive elements from the human body.
- Contributing to national and international organizations that provide guidance and recommendations on radiation protection.

Furthermore, USTUR research can be used to protect the public following events such as the Chernobyl and Fukushima nuclear accidents.

The NHRTR

The National Human Radiobiology Tissue Repository (NHRTR) is a tissue collection maintained by the Registries. It includes frozen and dried tissues, histological slides and blocks, and tissue solutions and other preparations obtained from volunteer donors with a known history of intake of radioactive elements such as radium, uranium, plutonium and americium. It is available to researchers who may be able to use materials from this unique collection of tissues and associated medical and radiation exposure histories in studies of cancer and other diseases, or other research.

Who is Eligible to Participate?

Individuals with a known history of intake of radioactive materials are suitable candidates for participation in the research of the Registries. Persons with documented internal depositions of at least 2 nCi (74 Bq) of actinides such as plutonium, americium, uranium, or thorium qualify as Registrants. Donations are also accepted from workers with at least 10 rem (0.1 Sv) external dose in combination with exposure to a non-radiological agent such as asbestos or beryllium.

How can researchers request the tissues and data?

The unique materials from the USTUR/NHRTR are available to reputable investigators for scientific research purposes. Scientific investigators may request, in writing, tissues or tissue samples from the NHRTR for legitimate research purposes.

Investigators must agree to maintain privacy of the Registrants and to follow all ethical human subjects considerations and legal requirements as well as the published policies of the Registries. If available, the Registries will provide the most suitable tissue requested (e.g. frozen, formalin-fixed, or dried) for study. The only stipulations are that the Registries be acknowledged as the source of the samples, radiochemical analysis, or other data used in scientific proposals or manuscripts submitted for publication, and that a USTUR faculty member be included as a coauthor if previously unpublished data generated by the USTUR are included in a manuscript. Scientific collaboration with the USTUR is encouraged as appropriate.

Where are the NHRTR materials kept?

The NHRTR is located in a modern laboratory research facility in Richland, WA. The facility includes an autopsy room and a radiochemistry laboratory for tissue preparation and analysis. Tissue samples are vacuum-packed and stored frozen at -30° or -70° C.

For more information

about the United States Transuranium and Uranium Registries & National Human Radiobiology Tissue Repository please contact:

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USTUR-0378-15 Printed 02/15

United States Transuranium and Uranium Registries & National Human Radiobiology Tissue Repository

College of Pharmacy
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www.ustur.wsu.edu

The USTUR

The United States Transuranium and Uranium Registries (USTUR) is a federal-grant program funded by the U.S. Department of Energy Office of Domestic and International Health Studies. Established in 1968 and operated by College of Pharmacy at Washington State University since 1992, the USTUR was designed as a research program to improve radiation protection of nuclear workers. It studies the biokinetics and internal dosimetry of incorporated actinide elements such as plutonium, americium, and uranium in occupationally exposed workers and individuals medically exposed to Thorotrast. Tissues are obtained from voluntary donors (Registrants) who have authorized the Registries to obtain their individual medical and radiation exposure records for research purposes and to collect tissue samples posthumously. More than 340 individuals have donated tissues to the program.

Is information available about the cases?

Information on each Registrant such as radiation exposure history, work history, bioassay and other dosimetry results, chemical exposures, smoking history, cause of death, and results of radiochemical analysis of tissues is available. Exposure and medical histories are available for the majority of the cases from whom tissues or related materials have been obtained. However, the identity of all cases is strictly protected and confidentiality is maintained in accordance with legal and ethical requirements.

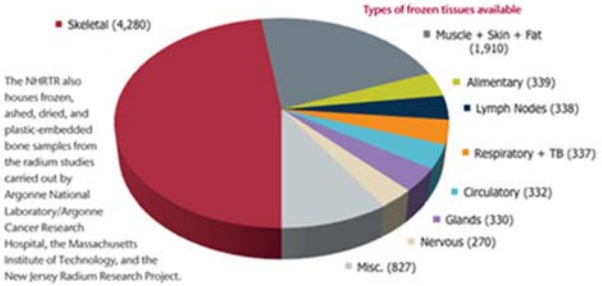
What kinds of human tissues have been collected?

The USTUR receives, preserves, and catalogs a portion of each organ and bone from whole-body donors as well as selected tissue and organ samples from partial-body autopsy donors. Additionally, the Registries receives tissue samples from surgical specimens from the Registrants and tissue-related materials, including histopathology slides from other radiation worker studies.

Currently, the NHRTR holds approximately 9,000 frozen and formalin-fixed tissue samples from 41 whole- and 103 partial-body USTUR donors (see figure below), and approximately 10,000 acid-digested tissue samples. A wide range of tissues is available including samples from the bone, lung, lymph node, liver, kidney, and brain.

The NHRTR

The National Human Radiobiology Tissue Repository (NHRTR) is a tissue collection associated with the Registries. The NHRTR is comprised primarily of tissues obtained at autopsy from USTUR Registrants. It includes frozen and acid-digested tissues, as well as histological slides and tissue blocks. The NHRTR also houses an existing collection of tissue materials obtained from the terminated Radium Worker study at Argonne National Laboratory and historical plutonium injection studies. These unique collections of tissues, records, and related materials are available to other researchers studying radiation effects, cancer, and other biological phenomena.



The NHRTR also houses frozen, ashed, dried, and plastic-embedded bone samples from the radium studies carried out by Argonne National Laboratory/Argonne Cancer Research Hospital, the Massachusetts Institute of Technology, and the New Jersey Radium Research Project.

Appendix C

USTUR-0366-14
NOVEMBER 2014 • ISSUE 20

USTUR NEWSLETTER

DIRECT FROM THE DIRECTOR

It is my pleasure to have this opportunity to provide updates on the USTUR research and operations in 2014. In the 2013 Newsletter, I happily stated that we had two radiochemists on board. I was full of "redoubled optimism", but a change in USTUR personnel occurred in December 2013 with the retirement of our senior radiochemist. However, we managed to keep radiochemistry operations running with minimal detriment. This year, I am excited to welcome Dr. George Tabatadze as a new member of our radiochemistry team. Thus, once again, I feel redoubled optimism about our radiochemistry.

We successfully renewed our DOE grant to manage and operate the Registries through March 31, 2015. The USTUR funding remains 'flat' at $900,000. In addition, the USTUR research team obtained external funding of $50,000. These extra resources bring a sense of stability to the Registries in 2014.

The Registries has continued to collaborate with scientists nationally and internationally. We work closely with a team of US and international scientists to study the behavior of soluble plutonium material in the human lungs. This year, the USTUR team provided unique radiochemical results on plutonium distribution in lung tissues, which were used by a team of British scientists to estimate the fraction of bound plutonium in the lung. These results will be implemented by the International Commission on Radiological Protection to improve the current lung model. The new model will be used worldwide in radiation dose assessment for better protection of nuclear workers. This would have not been possible without generous contributions from our Registrants.

The USTUR 2014 scientific and operational achievements were highly rated by the Scientific Advisory Committee in the annual program review.

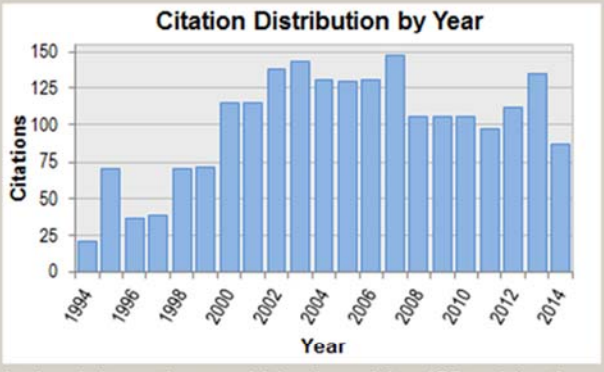
At the USTUR, we extend our greatest appreciation to those Registrants and their families, who have made the ultimate donation to the program, and to those Registrants who have remained with the program for many years. Thank you all.

~ Sergei Tolmachev

INSIDE THIS ISSUE

LEARNING FROM PLUTONIUM AND URANIUM WORKERS

IMPACTING SCIENCE: USTUR PUBLICATIONS WIDELY CITED

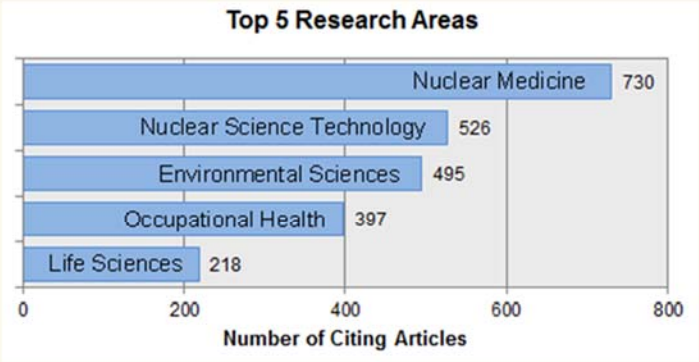


Late last year the USTUR's director asked an interesting question: how many times have other scientists cited the USTUR's research? This is an important question because the frequency with which the USTUR's publications are cited is a key indicator of the impact that the Registries is having on the world of science, and, consequently, on today's nuclear workers. The Registries has 272 publications in scientific journals and conference proceedings, and citation information could be found for 177 publications. Since 1980, these 177 articles have been cited 2,259 times. This means that USTUR publications are on average cited 66 times per year. That is quite an impact! The USTUR could not have done this without the generosity of our Registrants and their families. Thank you!

Want to learn more? Citation data was generated by the ResearcherID website. View a list of USTUR publications at: http://www.researcherid.com/rid/I-1056-2013

WHO IS CITING OUR ARTICLES?

ResearcherID also enables us to know in what fields of research our articles are cited. The top five research areas for publications where USTUR research has been cited are displayed on the right. Note that a single journal article may fall into multiple research areas, and, therefore, may be included in two or more of categories.



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HELPING FUTURE WORKERS THROUGH CURRENT RESEARCH

The USTUR is collaborating with scientists from the US, Russia, and the United Kingdom (the Mayak 2.4 project) to determine what fraction of inhaled plutonium is chemically "bound" to lung tissues for long periods of time. A larger fraction of "bound" plutonium would result in a higher dose to the worker, so this is an important question. The USTUR is measuring the amount of plutonium in different types of lung tissues from Registrant donations; the Mayak 2.4 research team will use these data to refine the mathematical model that describes the movement of plutonium through the lungs. Ultimately, the International Commission on Radiological Protection (ICRP) will incorporate these findings into their upcoming publication about occupational intakes of radionuclides. The ICRP's publications are internationally recognized as an authority on radiation protection, and its recommendations are used by professionals worldwide.

Through our collaboration with the Mayak 2.4 project, the USTUR's scientific staff were invited to attend one of their meetings, which was held locally in Richland. This was a valuable opportunity for the USTUR to work with, and learn more about, a program that is similar to our own.

MAYAK 2.4: WHAT IS IT?

The Mayak 2.4 project studies workers employed at the Mayak Production Association in Ozyorsk, Russia between 1948 and 1972.

COMPARE & CONTRAST

- → Both Mayak 2.4 and the USTUR study former nuclear workers.
- → Both analyze autopsied tissues for radionuclides such as plutonium.
- → Most USTUR donors were exposed to much smaller amounts of plutonium than typical plutonium workers at Mayak.

NEW FACES AT THE USTUR

This August, **George Tabatadze** began working as a research associate in radiation measurements. Dr. Tabatadze's Ph.D. research was conducted using data from a USTUR Registrant donation. As such, he is well-acquainted with the mission and operation of the Registries. He is enthusiastic about joining the USTUR research team, and we look forward to working with him.

Timothy Ledbetter (Tri-Cities Chaplaincy) has assumed the role of ethics advisor to the Scientific Advisory Committee. His experience as a hospital/hospice chaplain and representative on the Battelle/PNNL Institutional Review Board will benefit the USTUR and its Registrants as he offers advice on topics of ethical importance.

SCIENTIFIC ADVISORY COMMITTEE MEETING

Each year, the USTUR hosts a special meeting that allows the USTUR faculty to meet with our Scientific Advisory Committee and discuss the goals, achievements, and direction of USTUR research. The 2014 meeting was held in Richland, WA on September 5-6. Operational achievements and current research were presented. Featured topics included the distribution of uranium in humans due to environmental exposures, and testing of the National Council on Radiation Protection's recommendations for assessing intakes from radionuclide-contaminated wounds. Both studies used data from Registrant donations.

2014 SAC: Roger McClellan, Timothy Ledbetter, Robert Bistline, Richard Toohey, Herman Gibb, William Hayes.

A NOTE FROM OUR NEWEST SAC MEMBER

Being a community member of the USTUR advisory board is one of several hats that I wear in our greater Tri-Cities community. I also care for persons as a hospital and hospice chaplain for The Chaplaincy (a local agency that helps to ease suffering of those in medical and life crises). As a chaplain, I appreciate how important are gifts of body or tissue donation to the Registries. As you know, such foresighted gifts advance our knowledge about the effects of exposure to radiation. While society may not know much about this work, that does not diminish the value of your loved one's contributions.

I work with many persons and families in the frail and terminal stages of life and am very much aware it is often difficult to decide about matters related to the death of our bodies. In our western culture, such intentional conversations are frequently avoided. In light of this common reticence, I salute and commend your uncommon willingness to be intentional about donating. It is worth noting that in most religious and humanitarian traditions, one's sense of stewardship can be summarized by the phrase, "giving of one's time, talent, treasure…and tissue." This reinforces the Registries' deep gratitude and respect for the stewardship of your loved one's body that continues to benefit present and future workers, and society in general. Each donor contributes to a marvelous—albeit quiet—legacy! Thank you.

~ Tim Ledbetter

2014 SAC MEMBERS

Richard Toohey (chair) - *Health Physics*

Robert Bistline - *Occupational Health*

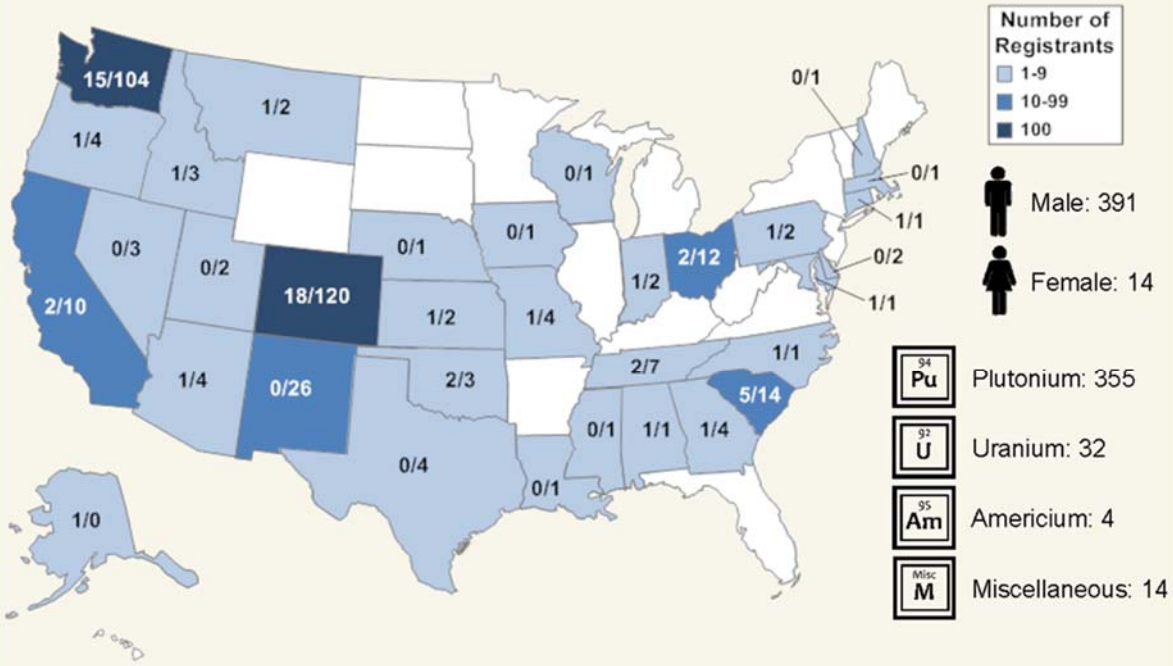
Herman Gibb - *Epidemiology*

William Hayes - *Radiochemistry*

Timothy Ledbetter - *Ethics*

Roger McClellan - *Toxicology*

REGISTRANT STATISTICS



The USTUR has **60 living** and **345 deceased** Registrants. On average, living Registrants are 79 years old (range: 43 to 90+), and deceased Registrants are 68 years old (range: 25 to 90+).The distribution of Registrants by US state is illustrated on the map. The first number for each state represents living Registrants, and the second represents deceased.

USTUR Registrants were exposed to a variety of radioactive elements such as americium, plutonium, uranium, thorium, and curium. Many were exposed to a combination of two or more of these during the course of their careers. When only primary intakes are considered, 355 Registrants were exposed to plutonium, 32 to uranium, 4 to americium, and 14 to other radioactive elements. Most Registrants received their intake(s) while working at Department of Energy (DOE) worksites such as Hanford; however, several of you worked in uranium mines/mills and a handful worked in private industry.

Back Row: George Tabatadze (USTUR), Danielle Gustin (WSU-Nursing), Margo Bedell-Parker (USTUR), Maia Avtandilashvili (USTUR), Stacey McComish (USTUR), Florencio Martinez (USTUR), Elizabeth Thomas (USTUR)
Front Row: Diana McGlynn (WSU-Nursing), Colette deVries (WSU-Nursing), Sergei Tolmachev (USTUR)

RENEWALS

Many thanks to those Registrants who signed renewal paperwork in the early months of 2014. I understand that there are several forms these days, and we appreciate your cooperation and dedication to the USTUR. As a reminder, Registrants are required to sign new permission forms every five years. Thirteen Registrants will be due for renewal in 2015. If you happen to be one of these Registrants, we will send the appropriate paperwork to you toward the beginning of the new year.

U.S. Transuranium and Uranium Registries
1845 Terminal Drive
Richland, WA 99354

Phone: 509-946-6870
Toll Free: 800-375-9317
Fax: 509-946-7972

www.ustur.wsu.edu

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Appendix D

UNITED STATES TRANSURANIUM AND URANIUM REGISTRIES

College of Pharmacy, Washington State University
2014 Scientific Advisory Committee Meeting
Courtyard Marriott Hotel, Richland, WA
September 5-6, 2014

Friday, September 5, 2014

07:45 – 08:30	Breakfast	
08:30 – 08:45	Executive Session (for SAC Members)	R. Toohey, *SAC Chair*
08:45 – 08:55	Welcome & Introductions	S. Tolmachev, *Director*
08:55 – 09:05	WSU/COP & USTUR	P. Lazarus, *COP Pharm Sciences Chair*
09:05 – 09:15	WSU/TC Research	A. Hossain, *Dep. of Civil & Env. Eng.*
09:15 – 09:20	Updates from DOE/HS-13. Guidance for FY2015	J. Zhou, *DOE Manager*
09:20 – 10:10	2013 SAC Recommendations & 2014 USTUR Overview	S. Tolmachev, *Director*
10:10 – 10:30	Administrative & Financial Developments	M. Parker, *Fiscal Specialist*
10:30 – 10:45	Coffee Break	
10:45 – 11:00	USTUR Registrant Statistic	S. McComish, *Asst. in Research*
11:00 – 11:15	Health Physics Database Progress Report	M. Avtandilashvili, *Research Asst.*
11:15 – 11:30	National Human Radiobiological Tissue Repository	S. McComish, *Asst. in Research*
11:30 – 11:50	Radiochemistry Progress Report	G. Tabatadze, *Research Asst.*
12:00 – 13:30	Lunch	
13:30 – 13:45	Application of Digital Autoradiography	B. Miller, *PNNL*
13:45 – 14:00	USTUR/ JCCRER Project 2.4 Collaboration	B. Napier, *PNNL*
14:00 – 14:15	Uranium Distribution in Humans	R. Kathren, *WSU Prof. Emeritus*
14:15 – 14:40	Case 0212: Testing NCRP Wound Model	M. Avtandilashvili, *Research Asst.*
14:40 – 15:00	Coffee Break	
15:00 – 15:15	WSU Grad Certificate Program in Radiation Protection	P. Stansbury, *WSU/Dade Moeller*
15:15 – 15:45	Research & Operation: Plan for FY2015	S. Tolmachev, *Director*
15:45 – 16:30	General Discussion: USTUR in 2014 and Beyond	USTUR, DOE, SAC, Guests
17:30 – 18:00	Appetizers and No-Host Reception, at Anthology Event Center, 608 Williams Blvd, Richland, WA	
18:00 – 21:00	Dinner -- at Anthology Event	

Meetings, Breakfast, and Lunch will be held in the Riverview Hall at the Courtyard Marriott at Columbia Point, Richland WA

UNITED STATES TRANSURANIUM AND URANIUM REGISTRIES

College of Pharmacy, Washington State University
2014 Scientific Advisory Committee Meeting
Courtyard Marriott Hotel, Richland, WA
September 5-6, 2014

Saturday, September 6, 2014 – SAC, DOE and USTUR Management

07:45 – 09:00	Breakfast	
09:00 – 09:10	SAC Membership	S. Tolmachev, *Director*
09:10 – 09:45	SAC Q & A	R. Toohey, *SAC Chair*
09:45 – 12:30	SAC Executive Session	R. Toohey, *SAC Chair*
12:30 – 13:45	Lunch	
13:45 – 15:45	SAC Debriefing	R. Toohey, *SAC Chair*
15:45 – 17:15	Tour to USTUR Laboratory Facility, Richland Airport Return to Marriott, Richland	

Saturday, September 6, 2014 – All

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

Appendix E

USTUR-0358-14

US Transuranium and Uranium Registries Case Study on Accidental Exposure to Uranium Hexafluoride

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

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

[2]*Centre for Radiation, Chemical and Environmental Hazards, Public Health England, Chilton, Didcot, UK.*

The United States Transuranium and Uranium Registries' (USTUR) whole-body donor (Case 1031) was exposed to an acute inhalation of uranium hexafluoride (UF_6) produced from an explosion at a uranium processing plant 65 years prior to his death. The USTUR measurements of tissue samples collected at the autopsy indicated long-term retention of inhaled slightly-enriched uranium material (0.85% ^{235}U) in the deep lungs and thoracic lymph nodes. In the present study, the authors combined the tissue measurement results with historical bioassay data, and analyzed them with International Commission on Radiological Protection (ICRP) respiratory tract models and the ICRP Publication 69 systemic model for uranium using maximum likelihood and Bayesian statistical methods. The purpose of the analysis was to estimate intakes and model parameter values that best describe the data, and evaluate their effect on dose assessment. The maximum likelihood analysis, which used the ICRP Publication 66 human respiratory tract model, resulted in a point estimate of 79 mg of uranium for the occupational intake composed of 86% soluble, Type F material and 14% insoluble, Type S material. For the Bayesian approach, the authors applied the Markov Chain Monte Carlo method, but this time used the revised human respiratory tract model, which is currently being used by ICRP to calculate new dose coefficients for workers. The Bayesian analysis estimated that the mean uranium intake was 160 mg, and calculated the case-specific lung dissolution parameters with their associated uncertainties. The parameters were consistent with the inhaled uranium material being predominantly soluble with a small but significant insoluble component. The 95% posterior range of the rapid dissolution fraction (the fraction of deposited material that is absorbed to blood rapidly) was 0.12 to 0.91 with a median of 0.37. The remaining fraction was absorbed slowly, with a 95% range of 0.00022 d^{-1} to 0.00036 d^{-1} and a median of 0.00031 d^{-1}. The effective dose per unit intake calculated using the dissolution parameters derived from the maximum likelihood and the Bayesian analyses was higher than the current ICRP dose coefficient for Type F uranium by a factor of 2 or 7, respectively; the higher value of the latter was due to use of the revised respiratory tract model. The dissolution parameter values obtained here may be more appropriate to use for radiation protection purposes when individuals are exposed to a UF_6 mixture that contains an insoluble uranium component.

Journal of Radiological Protection 2015, 35: 129-151.

USTUR-0370-14

Study of the distribution of actinides in human tissues using synchrotron radiation micro X-ray fluorescence spectrometry

E. Vergucht[1], B. De Samber[1], A. Izmer[1], B. Vekemans[1], K. Appel[2], S. Tolmachev[3], L. Vincze[1], F. Vanhaecke1

[1]Department of Analytical Chemistry, Ghent University, Ghent, Belgium;

[2]DESY-Photon Science, Hamburg, Germany;

[3]United States Transuranium & Uranium Registries, College of Pharmacy, Washington State University

This study aims at evaluating the capabilities of synchrotron radiation micro X-ray fluorescence spectrometry (SR micro-XRF) for qualitative and semi-quantitative elemental mapping of the distribution of actinides in human tissues originating from individuals with documented occupational exposure. The investigated lymph node tissues were provided by the United States Transuranium and Uranium Registries (USTUR) and were analyzed following appropriate sample pre-treatment. Semi-quantitative results were obtained via calibration by external standards and demonstrated that the uranium concentration level in the detected actinide hot spots reaches more than 100 µg/g. For the plutonium hot spots, concentration levels up to 31 µg/g were found. As illustrated by this case study on these unique samples, SR micro-XRF has a high potential for this type of elemental bio-imaging owing to its high sensitivity, high spatial resolution, and non-destructive character.

Analytical and Bioanalytical Chemistry 2015; 407 (6): 1559-1566.

USTUR-0365-14

Bias in the Proportionate Mortality Ratio Analysis of Small Study Populations: a Case on Analyses of Radiation and Mesothelioma

J. Zhou

US Department of Energy, Office of Health, Safety and Security, Washington, DC

Purpose: To quantify bias in the proportionate mortality ratio (PMR) analysis of small study populations and develop a bias correction methodology.

Materials and methods: Bias in the PMR analysis of small study populations is quantified through algebraic derivation. A simulation procedure is developed to evaluate the relationship between bias and study population size. A recently published PMR analysis of radiation and mesothelioma among 329 deceased registrants in the United States Transuranium and Uranium Registries (USTUR) is used as an illustrated example.

Results: The proportionate mortality ratios are biased and overestimated in small population studies; the smaller the study population, the larger the overestimation. As such, the average overestimation of PMR for mesothelioma in the analyses of radiation and mesothelioma in USTUR is 7.2% (95% confidence interval 5.1%,

9.7%); the PMR overestimation is 22.5% (95% confidence interval 16.8%, 29.1%) when stratified by quartiles of radiation doses.

Conclusions: The degree of PMR small sample bias is mainly determined by the sample size ratio, which is defined as the ratio of the sample size to the number of disease categories in the reference population. Correction for the bias is recommended when the sample size ratio is less than 5. The quantification and correction algorithm of the PMR small sample bias developed in this research supplements the PMR methodology.

International Journal of Radiation Biology 2014, 90 (11): 1075-1079.

USTUR-0361-14A

USTUR Whole-Body Case 0212: Testing NCRP Wound Model

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

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

The National Council of Radiation Protection and Measurements' (NCRP) wound model was applied to the data from a United States Transuranium and Uranium Registries' whole-body donor (Registrant). The Registrant (Case 0212) was exposed to plutonium nitrate as a result of occupational wound injury. Chelation treatment with intravenous injection of Ca-DTPA was administered on a bi-weekly basis over approximately six months. Two hundred and five urine samples were collected over approximately 3.5 years post-accident and analyzed for plutonium activity. A total of 916 Bq of plutonium was excreted in urine during the treatment period with maximum excretion rate of 73 Bq d^{-1} on the first day post-intake. The average post-treatment urinary excretion rate was 0.02 ± 0.01 Bq d^{-1}.

The individual died 17 years post-accident, at age 56, from severe pulmonary emphysema. At autopsy, all major soft tissues and bones were collected for radiochemical analyses of ^{238}Pu, $^{239/240}$Pu and ^{241}Am. From tissue radiochemical analyses, 239/240Pu retention in the liver, skeleton and wound was estimated at 80.3 Bq, 114.5 Bq and 2.3 Bq, respectively. Total systemic $^{239/240}$Pu activity at the time of death was calculated at a magnitude of 229.4 Bq.

Application of the NCRP wound model for strongly retained material resulted in a credible fit to the post-treatment ('baseline') urine data based on Chi-Square statistics (p = 0.246) and predicted plutonium liver and skeletal activity within 25% of the post-mortem activities. Using IMBA Professional Plus, the fraction of plutonium wound deposition not removed by DTPA therapy was estimated at 364 Bq. This resulted in the residual committed effective dose of 177 mSv. Accounting for plutonium eliminated with urine during the chelation therapy, a total 'untreated' intake of 1,280 Bq and the projected committed effective dose of 622 mSv were calculated...

(Abstract) *Health Physics* 2014, 107 (1 Suppl): S108.

USTUR-0362-14A

Incorrect Analyses of Radiation and Mesothelioma in the U.S. Transuranium and Uranium Registries

J. Zhou

US Department of Energy, Office of Health, Safety and Security, Washington, DC

A recently published study, "Analyses of Radiation and Mesothelioma in the U.S. Transuranium and Uranium Registries", by Gibb et al. (American Journal of Public Health 103: 710-716; 2013) examines seven mesothelioma deaths among a population of 329 deceased registrants in the United States Transuranium and Uranium Registries (USTUR). The study finds a proportionate mortality ratio (PMR) of 62.40 for mesothelioma and suggests that cumulative external radiation is associated with an increased risk of mesothelioma. The reported PMR of 62.4 for mesothelioma is strikingly large and does not add up by quick examination. A PMR is defined as the proportion of observed deaths from a given cause in a study population divided by the proportion of deaths expected from this cause in a standard population. The proportion of observed deaths from mesothelioma among all USTUR deaths is 2.1% (7/329), while the proportion of deaths from mesothelioma among all U.S. deaths is approximately 0.1%, as cited by the Gibb study. Therefore, a crude estimate of the PMR for mesothelioma is only 21.0 (2.1% / 0.1%). Furthermore, mesothelioma is primarily an occupational disease, and the USTUR registrants were overwhelmingly adult male Caucasians. Since mesothelioma accounts for over 0.16% of all deaths in the population of American male Caucasians over age 30, a better estimate of the PMR for mesothelioma is 13.1 (2.1% / 0.16%). This presentation reveals that the Gibb study failed to consider the disease coding change for mesothelioma over the timeframe of the study, resulting in flawed results on radiation and mesothelioma.

(Abstract) *Health Physics* 2014, 107 (1 Suppl): S47.

USTUR-0363-14A

Uranium Distribution and Concentrations in the Tissues of Whole-Body Donations to the USTUR

R.L.Kathren[1,2], S.Y. Tolmachev[1]

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

[2]*Retired*

This paper reports the distribution and concentration of measured uranium concentrations in the several hundred samples of soft tissues and bones from two whole-body donations to the United States Transuranium and Uranium Registries with no known occupational or other than natural chronic environmental (i.e. 'background') exposure to uranium. Both cases were Caucasian males aged 68 and 78 y, respectively, and long-time residents of the same geographic area, and thus likely to be representative of equilibrium levels of environmental uranium from chronic intake. The primary depot and highest concentrations of uranium were

in the skeleton with the remaining uranium widely distributed throughout the soft tissues as a whole. Measured concentrations in bone averaged about 4 ng U g^{-1} wet weight with considerable variation among individual bones and bone samples with indication that uranium was a bone volume seeker. Soft tissue concentrations ranged over about an order of magnitude and averaged about 0.5 ng g^{-1} wet weight with the exception of the thoracic lymph nodes, which showed concentrations more than an order of magnitude greater than most of the other soft tissues. Uranium concentrations in the thoracic lymph nodes of the case with a smoking history were somewhat lower than those of the nonsmoking cohort, possibly suggestive of impaired particle clearance. The latter case also showed a possible anomalously high concentration of uranium in thyroid. The tissue distributions of the two background cases were compared with those in a previously reported third USTUR whole body donation with a documented occupational intake of uranium; the relatively recent study of element content in adult Chinese males; and the more limited data from empirical measurements of a few tissues reported in the open peer reviewed literature. Implications of the results from these measured postmortem cases were also examined with respect to the validity and applicability of the ICRP models and other biokinetic models and Reference Man data, and indicated refinements and significant differences noted.

(Abstract) *Health Physics* 2014, 107 (1 Suppl): S107.