



This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 662287.



EJP-CONCERT

European Joint Programme for the Integration of Radiation Protection Research

H2020 – 662287

D6.5– Report on integration of archive materials in STORE/ Radioecology databases

Lead Author: Laure Sabatier (CEA)

Author: Paul Schofield (UCam)

With contributions from: Bernd Grosche (BfS, Retired), Ulrike Kulka (BfS), Soile Tapio (HMGU), Almudena Real-Gallego (CIEMAT), Mandy Birschwilks (BfS)

And collaboration of WP6 members: Ainsbury L., Benotmane R., Bohnstedt A., Bottollier-Depois J.-F., Chobanova N., Dekkers F., Dolo J.-M., Duranova T., Fiserova A., V. Hadjidekova V., Haghdoost S., Hanusovsky L., Laurent O., Lumniczky K., Madas B. G., Muikku M., Ottolenghi A., Oughton D., Pajuste E., Panagiotopoulou M., Raskob W., Ritter S., Sáfrány G., Salbu B., Salomaa S., Smyth V., Tabocchini A., Teien H. C., Tkaczyk A., Wojcik A.

Reviewer(s): CONCERT coordination team

Deliverable nature:	Report
Dissemination level:(Confidentiality)	Public
Contractual delivery date:	31 st May 2019 (M48)
Actual delivery date:	M48
Version:	1
Total number of pages:	20
Keywords:	archive materials, databases, STORE
Approved by the coordinator:	M48
Submitted to EC by the coordinator:	M48

Disclaimer:

The information and views set out in this report are those of the author(s). The European Commission may not be held responsible for the use that may be made of the information contained therein.

Abstract

The scope of this report is the integration of archive materials in the STORE/Radioecology databases and specifically covers the collections of biotic and abiotic resources gathered to record the effects of radiation exposure on humans and non-human biota (animals and plants) following individual events, accidental and clinical exposures, experimental exposures, environmental monitoring including abiotic materials, and historic archives. Many of these collections are associated with large databases, but the majority of materials we discovered are small collections associated with publications and specific studies as opposed to large organised biobanks. Identification of resources comes from investigator-lead resource deposition into STORE, contacting MELODI and ALLIANCE platform members, and from the literature. As this report reflects the inclusion of resources into STORE it does not represent a comprehensive overview of material resources in radiation biology and ecology, but a sample of what is available. We consider that this report might be the precursor of a comprehensive review, which is outside the remit of this report.

Content

1	<i>Overview of material collections</i>	5
2	<i>Collections of materials in STORE</i>	7
3	<i>Human exposure and experimental animal samples</i>	7
3.1	The Chernobyl Tissue Bank, UK	7
3.2	WISMUT archive, Germany	7
3.3	Radiation Effects Research Foundation (RERF), Japan	7
3.4	Southern Urals Biophysical Institute (SUBI), Russia	8
3.5	Radiobiological Archive of Large-scale Animal Experiments at QST-NIRS: J-SHARE, Japan	8
3.6	Institute of Environmental sciences – IES, Rokkasho, Japan.....	9
3.7	Sample bank of Fukushima animals, Japan	9
3.8	The National Human Radiobiology Tissue Repository, USTUR, USA	9
3.9	The Nagasaki Atomic Bomb Survivors' Tumor Tissue Bank, Japan.....	9
3.10	Northwestern University Radiation Archives (NURA), USA	9
3.11	FFPE blocks from Thorotrast® animal experiments, German Centre for Cancer Research	10
4	<i>Radioecological and environmental samples</i>	10
4.1	Radioecology Exchange samples register	10
5	<i>References</i>	11
6	<i>Annex</i>	13

1 Overview of material collections

The collection of biological and abiotic materials in radiobiological, epidemiological and radioecological contexts presents many of the same challenges and benefits as similar materials in other domains. There are, however, some features of motivation and logistics which require a different treatment and set of priorities. The collection of materials following radiological disasters, such as the dropping of the thermonuclear bombs over Hiroshima and Nagasaki, the Chernobyl and Fukushima accidents and significant radioactive leaks such as the Techa River discharge, fall into a discrete category because of the one-off catastrophic nature of the event and the unique lessons that might be learned from follow-up and use of the material. A strong argument could also be made for the importance of the very large animal exposure experiments carried out between the 1950s and 1990s which are never likely to be carried out again due to ethical and financial considerations, together with other examples of accidental human medical and occupational contamination. However, much of the material collected is for studies such as those involving ecological monitoring or in the pursuit of specific hypothesis-driven research. Consequent on this are the issues of reuse, secondary use and reference utility, all of which impact on the financial sustainability of the resource, its longevity and its utility as a public good¹; i.e. the benefit to society that might be realised by its retention and reuse.

Most of the repositories of materials curated for STORE, both biological and non-biological, are associated with large-scale data collection exercises (Schofield et al. 2019). In many cases the materials were collected to permit measurement of levels of contamination, but also for histopathological and molecular investigation. In some cases, material can be utilised for purposes that were not foreseen at their collection, particularly molecular analyses (Tapio and Atkinson 2008) and there are examples of these from the Mayak tissue bank (Azimzadeh et al. 2017), the USA Northwestern University Radiation Archives (NURA) (Haley et al. 2015, Paunesku et al. 2008) and the Chernobyl Thyroid Tissue bank (Abend et al. 2013).

In our survey of available materials it has been striking how variable are the scale, purpose and sustainability of the resource collections and biobanks. These range from the actively curated biobanks of human tissue, many of which continue to accumulate samples and are well funded with commitment to continue over the long term, to small collections of inorganic materials gathered as part of surveys and regulatory activities, effectively retained as reference samples.

We provide details in STORE of some of the better established collections and records have been created for these individually as they are generally linked to data resources and have significant funding which is likely to be sustained over time, such as the United States Transuranium and Uranium Registries (USTUR), the LSS (Life Span Study) Adult Health Survey, and the Nagasaki atomic bomb survivors tumour bank. Other large resources do not have the same degree of funding commitment, such as the NURA archive, but have significant institutional support and the cost of maintaining samples is not high; for example no requirement for refrigeration. There are then a wide range of collections, particularly of non-human biota and inorganic materials where it has been very difficult to establish the current source of funding, other than assuming Institutional core funding, and the likely sustainability of the collections themselves, as they are generally represented in institutional reports and in publications made close to the time of collection for a particular purpose. Where some of these resources are clearly open for sample access, others are only available as part of collaborations with the host institution, and in many cases there is no explicit public information on the conditions of availability.

¹ Commissioned report for the Ethics and Governance Council of UK Biobank/Wellcome Trust. Submitted June 2007. pp. 32. Available at: <http://www.egcukbiobank.org.uk/meetingsandreports>. Peer reviewed.

We have been struck by three general observations:

- Firstly there is no standardisation of the governance, structure or intellectual property arrangements across resources. In many cases the information is not available, but where it is available this differs greatly from resource to resource.
- Secondly we have found no instance of resources cooperating or integrating their collections outside their own institutions, with the exception of the NURA archive; itself an integrative initiative, but for legacy materials.
- Thirdly we have been able to identify few international collaborative funding efforts for major archives with the exception of US and European Commission funding from the US Department of Energy (DoE) to resources in Russia (SUBI) and Japan (RERF).

All three issues have already been identified in other biorepositories. Governance, standardisation of metadata and quality control (Vaught et al. 2012) and consequent ability to integrate and disseminate resources are a well characterised but unresolved set of problems. While clinical biobanks are currently the subject of ongoing Commission policy discussion² the kind of biobanks relevant to radiation science, even those of human samples, have eluded wider discussion, even in large H2020 funded biobank policy projects (Kinkorová and Topolčan 2018).

Retention of ecological samples has major implications for longitudinal environmental analysis over decades as well as regulatory activity and again there is no coordinated policy investigation concerning sustainability of these resources which are largely isolated and where supported are often only sustained by the local Institution. There exists no systematic study of such collections.

Archives struggle to secure long-term funding (Chandras et al. 2009, Schofield et al. 2010, Watson et al. 2014) which is impacted by the recognition of the ongoing importance of bioresources. Short-term funding cycles, geared to shorter project lives, and shifts in national and institutional funding priorities threaten development and retention of material, and funding applications are greatly compromised by a lack of metrics for utility (Mabile et al. 2013) and sustainability, and the difficulties in comparing the scientific value of maintaining sample banks to funding experimental science; the issue of distribution of limited financial resources.

There has been little focussed research on the distribution and sustainability of biobanks and sample archives relevant to radiation biology and epidemiology and we are aware that the data collected in STORE is not a complete reflection of the range of material available, much of which may be retained in individual laboratories and whose existence is not reflected in the public literature. We recommend that a focussed study be carried out internationally to better capture the current state of resources worldwide with the intention of making recommendations for coordination, standardisation and funding vehicles in order to protect and sustain critical biological and environmental collections.

² Biobanks in Europe: Prospects for Harmonisation and Networking <http://publications.jrc.ec.europa.eu/repository/handle/JRC57831>

2 Collections of materials in STORE

In this report we discuss both human and non-human biobanks, together with material collected as part of ecological studies which includes biotic and abiotic material. We report 39 studies currently in STORE with materials available. The STAR radioecology archives³ represent a further 126 collections and are summarised in STORE entries STOREDB STUDY:1143-1147. Below we comment on 12 major resources in detail.

The internationally distributed nature of studies, their details, and how to access data currently lacks a coherent or common platform or clearing house to allow investigators and regulators to discover datasets and material that may often, especially in the case of environmental samples, be completely unique. The motivation for gathering information about biological resources into STORE therefore is to provide a platform for discovery and sharing of resources with the principle that if investigators can locate resources that might be of use in pursuing their research this will lead to better resource use and improve on the value of collecting the materials in the first place. We hope that as dissemination activities of STORE progress that owners of material resources will advertise their existence by entering them into STORE themselves, but there is certainly scope for an active acquisition strategy on the part of the STORE database.

3 Human exposure and experimental animal samples

The main resources studied are included in the commentary below. The remainder of resources with material available are listed in Table 1 (Annex).

3.1 The Chernobyl Tissue Bank, UK

The Chernobyl Tissue Bank (CTB) is an international cooperation which was established in 1998 and which is coordinated by Imperial College London, UK (Thomas 2012). It collects, stores and distributes biological samples from patients with thyroid carcinomas and cellular adenomas who were exposed as children or juveniles by fallout from the Chernobyl accident and resident in contaminated regions of Ukraine and Russia. In addition to the biobanks the CTB keeps information on the patients. It also houses research data derived by researchers using the CTB biomaterials. Data and biomaterial can be accessed once the request is approved in a standard application process.

(STOREDB:STUDY1092 *Chernobyl Tissue Bank* [[DOI:10.20348/STOREDB/1092](https://doi.org/10.20348/STOREDB/1092)])

3.2 WISMUT archive, Germany

Along with data from The German Uranium Miners Cohort Study, a bank with biological samples from former uranium miners and healthy controls was established as a part of an international project (Rosenberger et al. 2018). Information on The German Uranium Miners is kept in STORE and can be accessed on request.

(STOREDB:STUDY1034 *Wismut Uranium Miners - Biobank* [[DOI:10.20348/STOREDB/1034](https://doi.org/10.20348/STOREDB/1034)])

3.3 Radiation Effects Research Foundation (RERF), Japan

A sub-cohort of 15,000 individuals of the LSS of atomic bomb survivors, the Adult Health Survey, has used biennial health surveys to follow up on all morbidities in addition to cancer. Biological samples have been collected including serum, plasma, paraffin embedded tissue blocks, prepared slides, and teeth. In 2013, the Biosample Center (RP3-15) was established at RERF with the aim of archiving and curating these biological samples. One of the aims of the project is to consider how to make the samples available to the wider community through collaborations. This involves many complex ethical, legal, and political considerations but it is clear that

³ The STAR (Strategy for Allied Radioecology) Project was co-funded by the European Commission under the VII Euratom Framework Programme for Nuclear Research & Training Activities (2007-2011) (Contract Number: Fission-2010-3.5.1-269672).

this is an invaluable resource, which will soon be exploited to improve our understanding of radiation-associated disease mechanisms using new technologies through collaborative studies.

(STOREDB:STUDY1137 *Adult Health Survey of Japan LSS* [[DOI:10.20348/STOREDB/1137](https://doi.org/10.20348/STOREDB/1137)])

The RERF coordinated study of TEPCO emergency workers from Fukushima (Kitamura et al. 2018) is collecting blood and urine from subjects from each of the local medical institutions. Frozen biomaterial exists and plans how to use the samples or make them available in the future are under development.

3.4 Southern Urals Biophysical Institute (SUBI), Russia

The animal experiments at SUBI, conducted between 1949 to 1996, included studies of alpha- ($^{234,235}\text{U}$, ^{237}Np , $^{238,239}\text{Pu}$, ^{241}Am) and beta- (^3H , ^{90}Sr , ^{137}Cs , ^{144}Ce) emitters delivered via different routes into a range of species including rodents (mice, rats) and rabbits, and other mammals (dog, pig, monkey). Biological material was obtained from more than 23,000 animals; much of it preserved in the SUBI Radiobiological Archive (Abbott 2012). A large amount of the biomaterial is still uncurated and difficult to attribute to the individual animal, but at least for six selected experiments with rodents (mostly Wistar rats) the biomaterial was catalogued and the experiments were described in detail. Information about the experiments with more than 6,000 animals, corresponding to the amount of available samples, and ways of how to get access to these are described in the STORE entry.

Human material is also archived in SUBI. The Russian Radiobiological Human Tissue Repository (RHTR) was established to collect and store biological samples relevant to human health effects of chronic, low-dose radiation exposure (Loffredo et al. 2017). The RHTR enrolled two cohorts between 1951 and 2017: exposed workers at the Mayak facilities and, as controls, local residents who were never occupationally exposed to ionizing radiation. Overall the cohort of Mayak workers comprises 22,377 individuals employed at one of the main Mayak facilities between 1948 and 1982. These samples are annotated with demographic, occupational, dosimetric and medical information. The repository consists of surgical tissues from 900 individuals, autopsy samples from an additional 1000, together with blood samples and DNA from family trios. Both specimens and data are available to the community.

(STOREDB:STUDY1149 *Russian Radiobiological Human Tissue Repository* [[DOI:10.20348/STOREDB/1149](https://doi.org/10.20348/STOREDB/1149)])

(STOREDB:STUDY1056 *Biomaterial from 6 animal experiments conducted at SUBI* [[DOI:10.20348/STOREDB/1056](https://doi.org/10.20348/STOREDB/1056)])

3.5 Radiobiological Archive of Large-scale Animal Experiments at QST-NIRS: J-SHARE, Japan

The J-SHARE project includes an extensive archive of biological specimens. To date these consist of material from:

- Lifespan studies of 10,220 B6C3F1 male and female mice at different life stages, irradiated with gamma rays, carbon ions and neutrons.
- Studies on mammary gland and lung carcinogenesis with 2,200 Sprague Dawley female rats and 1,429 Wistar female rats, respectively.
- Studies on brain, digestive tract and renal tumorigenesis utilizing genetically-modified animals.
- Studies on the combined effect of radiation and chemicals.
- Studies for anticarcinogenic properties of caloric restriction and specific antioxidant nutrients and phytochemicals.

Frozen samples are retained along with experimental protocols, paraffin blocks, and histopathological slides. Digitisation of slides is being carried out to produce an archive of zoomable images using the Hamamatsu NanoZoomer. Embedded and frozen tissues are available for molecular analysis. See (Morioka et al. 2019).

(STOREDB:STUDY1138 *Radiobiological Archive of Large-scale Animal Experiments at QST-NIRS: J-SHARE* [[DOI:10.20348/STOREDB/1138](https://doi.org/10.20348/STOREDB/1138)])

3.6 Institute of Environmental sciences – IES, Rokkasho, Japan

The IES has been conducting studies especially on low-dose chronic irradiation for the last 21 years. Much of the material from these experiments has been archived, mainly as formalin fixed paraffin embedded materials but also frozen (Braga-Tanaka et al. 2018). This constitutes a major resource of well-preserved and characterised materials from low dose irradiation experiments.

(STOREDB:STUDY1139 *Institute of Environmental Studies database* [[DOI:10.20348/STOREDB/1139](https://doi.org/10.20348/STOREDB/1139)])

3.7 Sample bank of Fukushima animals, Japan

Following the Fukushima Daiichi Nuclear Power Plant accident, a sample bank of animals affected was established. Domestic livestock were collected from the evacuation zone of August 29, 2011 and organs were sampled, and either stored as formalin fixed, paraffin embedded blocks or frozen at -80C (Takahashi et al. 2015). As of the end of March 2015, organs (1,270) and peripheral blood samples (200) from 302 exposed cows had been archived, and analysis on radionuclide content carried out (Fukuda et al. 2013). More recently the sample bank has been augmented by the collection of organs from more than 400 Japanese macaques ((Urushihara et al. 2018) and M. Fukumoto. Pers. Comm.). Detailed environmental dosimetry, geographical distribution and other data are available on request.

(STOREDB:STUDY1141 *Sample bank of Fukushima animals* [[DOI:10.20348/STOREDB/1141](https://doi.org/10.20348/STOREDB/1141)])

3.8 The National Human Radiobiology Tissue Repository, USTUR, USA

The National Human Radiobiology Tissue Repository (NHRTR) within the United States Transuranium and Uranium Registries (USTUR) holds around 9,000 frozen and formalin-fixed tissue samples from 40 whole- and 92 partial-body USTUR donors, and around 10,000 acid-digested tissue samples for radioactivity determination (Tolmachev et al. 2011). The role of USTUR, a US federally funded institution, is to study the biokinetics and internal dosimetry of actinides in occupationally exposed individuals who volunteer their post-mortem tissues for scientific use. NHRTR also houses historical frozen, ashed, dried, and plastic-embedded bone samples from the radium studies carried out by Argonne National Laboratory, the Massachusetts Institute of Technology, and the New Jersey Radium Research Project. It also houses the materials from the historic Radium dial painters studies (see <https://ustur.wsu.edu/nhrtr/>). Materials are freely available subject to ethical and legal permissions.

(STOREDB:STUDY1140 *The National Human Radiobiology Tissue Repository, USTUR, USA* [[DOI:10.20348/STOREDB/1140](https://doi.org/10.20348/STOREDB/1140)])

3.9 The Nagasaki Atomic Bomb Survivors' Tumor Tissue Bank, Japan

Beginning in April, 2008, a cohort study has been initiated at Nagasaki University —the Global Strategic Center for Radiation Health Risk Control—to analyse solid cancers and haemopoietic malignancies, radiation exposure information, and clinical data collected from atomic bomb survivors in Nagasaki (Miura et al. 2015). Tumour and surrounding normal tissue are removed at surgery and archived together with personal, historical dose and demographic data. Between 2008 and 2015 around 600 samples were archived, and DNA and RNA prepared.

(STOREDB:STUDY1142 *The Nagasaki Atomic Bomb Survivors' Tumor Tissue Bank, Japan* [[DOI:10.20348/STOREDB/1142](https://doi.org/10.20348/STOREDB/1142)])

3.10 Northwestern University Radiation Archives (NURA), USA

Much of the data from the Argonne experiments on beagles and the JANUS rodent irradiation studies has now been archived and curated at the Northwestern University Radiation Archive (NURA). Along with this data paraffin-embedded material is archived both for the beagle experiments (janus.northwestern.edu/dog_tissues)

and Janus mouse experiments (selected tissues; lung, liver, spleen, kidney, heart and gross lesions) along with detailed primary histopathological pathological data from 19,000 animals (Haley et al. 2011, Wang et al. 2010). Many of the paraffin embedded tissue samples and original source data are available upon request.

(STOREDB:STUDY1094 *JANUS database* [[DOI:10.20348/STOREDB/1094](https://doi.org/10.20348/STOREDB/1094)])

3.11 FFPE blocks from Thorotrast® animal experiments, German Centre for Cancer Research

In parallel to the German Thorotrast® cohort study (Grosche et al. 2016) animal experiments were conducted at the German Centre for Cancer Research, Heidelberg. There are data available from all four Thorotrast-related experiments with rats carried out in the years 1975 - 1989. The purpose was to determine the respective roles of the radioactive and chemical component in Thorotrast gel-induced tumours of the lung, liver or spleen. All information is included into STORE (STOREDB:STUDY1082 Liver and Spleen Tumours in Rats After Injection of Th-230 Enriched Thorotrast [[DOI:10.20348/STOREDB/1082](https://doi.org/10.20348/STOREDB/1082)]; STOREDB:STUDY1083 Lung Tumours in Rats After Injection of Normal and Th-228 Enriched Thorotrast and Inhalation of Quartz Dusts [[DOI:10.20348/STOREDB/1083](https://doi.org/10.20348/STOREDB/1083)]; STOREDB:STUDY1084 Liver Tumours and Diseases in Rats After Fractionated Neutron Exposure or Injection of Non-radioactive Zirconotrast [[DOI:10.20348/STOREDB/1084](https://doi.org/10.20348/STOREDB/1084)]; STOREDB:STUDY1085 Liver and Spleen Tumours in Rats After Injection of Zirconotrast to Which Different Amounts of Th-228/Th-230 Were Added. [[DOI:10.20348/STOREDB/1085](https://doi.org/10.20348/STOREDB/1085)]). FFPE tissue blocks from these experiments are stored at HMGU, Munich, and access can be granted through BFS (store@bfs.de).

4 Radioecological and environmental samples

The STAR (Strategy for Allied Radioecology) project has collated unique data on sample archives throughout Europe, which include samples derived from air (mainly filters), water, soil and building materials, as well as biological material. The data records for these archives may be found on <https://radioecology-exchange.org/content/sample-archives> along with the appropriate contact details.

4.1 Radioecology Exchange samples register

Biomaterials from non-human biota and inorganic matter including water and air are generally archived as part of specific data gathering, often over protracted periods of time with the aim of gathering longitudinal data from the same site. This means that samples are scattered across the community and discovery of relevant material depends on familiarity with published studies. In an attempt to produce a clearing house for such sample collections the European Radioecology Alliance has collected lists of available samples on its website (The Radioecology Exchange), mainly derived from European studies. These include samples derived from air (mainly filters) [[DOI:10.20348/STOREDB/1143](https://doi.org/10.20348/STOREDB/1143)], water [[DOI:10.20348/STOREDB/1144](https://doi.org/10.20348/STOREDB/1144)], soil [[DOI:10.20348/STOREDB/1148](https://doi.org/10.20348/STOREDB/1148)] and building materials [[DOI:10.20348/STOREDB/1147](https://doi.org/10.20348/STOREDB/1147)], as well as biological materials [[DOI:10.20348/STOREDB/1144](https://doi.org/10.20348/STOREDB/1144); [DOI:10.20348/STOREDB/1145](https://doi.org/10.20348/STOREDB/1145); [DOI:10.20348/STOREDB/1146](https://doi.org/10.20348/STOREDB/1146); [DOI:10.20348/STOREDB/1148](https://doi.org/10.20348/STOREDB/1148)]. Work is underway to curate these collections for the STORE database in order to improve accessibility and discovery for other investigators. Work is underway to curate these collections for the STORE database in order to improve accessibility and discovery for other investigators.

5 References

- Abbott A. 2012. Radiation risks: Raiders of the lost archive. *Nature*.485:162-163.
- Abend M, Pfeiffer RM, Ruf C, Hatch M, Bogdanova TI, Tronko MD, Hartmann J, Meineke V, Mabuchi K, Brenner AV. 2013. Iodine-131 dose-dependent gene expression: alterations in both normal and tumour thyroid tissues of post-Chernobyl thyroid cancers. *British journal of cancer*.109:2286-2294. Epub 2013/09/17.
- Azimzadeh O, Azizova T, Merl-Pham J, Subramanian V, Bakshi MV, Moseeva M, Zubkova O, Hauck SM, Anastasov N, Atkinson MJ, et al. 2017. A dose-dependent perturbation in cardiac energy metabolism is linked to radiation-induced ischemic heart disease in Mayak nuclear workers. *Oncotarget*.8:9067-9078. Epub 2016/07/09.
- Braga-Tanaka I, Tanaka S, Kohda A, Takai D, Nakamura S, Ono T, Tanaka K, Komura J. 2018. Experimental studies on the biological effects of chronic low dose-rate radiation exposure in mice: overview of the studies at the Institute for Environmental Sciences. *International journal of radiation biology*.94:423-433.
- Chandras C, Weaver T, Zouberakis M, Smedley D, Schughart K, Rosenthal N, Hancock JM, Kollias G, Schofield PN, Aidinis V. 2009. Models for financial sustainability of biological databases and resources. *Database : the journal of biological databases and curation*.2009:bap017.
- Fukuda T, Kino Y, Abe Y, Yamashiro H, Kuwahara Y, Nihei H, Sano Y, Irisawa A, Shimura T, Fukumoto M, et al. 2013. Distribution of artificial radionuclides in abandoned cattle in the evacuation zone of the Fukushima Daiichi nuclear power plant. *PloS one*.8:e54312. Epub 2013/02/02.
- Grosche B, Birschwilks M, Wesch H, Kaul A, van Kaick G. 2016. The German Thorotrast Cohort Study: a review and how to get access to the data. *Radiation and environmental biophysics*.55:281-289. Epub 2016/05/08.
- Haley B, Wang Q, Wanzer B, Vogt S, Finney L, Yang PL, Paunesku T, Woloschak G. 2011. Past and future work on radiobiology mega-studies: a case study at Argonne National Laboratory. *Health physics*.100:613-621.
- Haley BM, Paunesku T, Grdina DJ, Woloschak GE. 2015. The Increase in Animal Mortality Risk following Exposure to Sparsely Ionizing Radiation Is Not Linear Quadratic with Dose. *PloS one*.10:e0140989. Epub 2015/12/10.
- Kinkorová J, Topolčan O. 2018. Biobanks in Horizon 2020: sustainability and attractive perspectives. *The EPMA journal*.9:345-353.
- Kitamura H, Okubo T, Kodama K. 2018. EPIDEMIOLOGICAL STUDY OF HEALTH EFFECTS IN FUKUSHIMA NUCLEAR EMERGENCY WORKERS-STUDY DESIGN AND PROGRESS REPORT. *Radiation protection dosimetry*. Epub 2018/08/24.
- Loffredo C, Goerlitz D, Sokolova S, Leondaridis L, Zakharova M, Revina V, Kirillova E. 2017. The Russian Human Radiobiological Tissue Repository: A Unique Resource for Studies of Plutonium-Exposed Workers. *Radiation protection dosimetry*.173:10-15. Epub 2016/11/26.
- Mabile L, Dalglish R, Thorisson GA, Deschenes M, Hewitt R, Carpenter J, Bravo E, Filocamo M, Gourraud PA, Harris JR, et al. 2013. Quantifying the use of bioresources for promoting their sharing in scientific research. *GigaScience*.2:7.
- Miura S, Akazawa Y, Kurashige T, Tukasaki K, Kondo H, Yokota K, Mine M, Miyazaki Y, Sekine I, Nakashima M. 2015. The Nagasaki Atomic Bomb Survivors' Tumor Tissue Bank. *Lancet*.386:1738. Epub 2015/11/08.

Morioka T, Blyth B, Imaoka T, Nishimura M, Takeshita H, Shimomura T, Ohtake J, Nishida K, Schofield P, Grosche B, et al. 2019. Establishing the Japan-Store House of Animal Radiobiology Experiments (J-SHARE), a large-scale necropsy and

histopathology archive providing international access to important radiobiology data. *International journal of radiation biology*. In Press.

Paunesku D, Paunesku T, Wahl A, Kataoka Y, Murley J, Grdina DJ, Woloschak GE. 2008. Incidence of tissue toxicities in gamma ray and fission neutron-exposed mice treated with Amifostine. *International journal of radiation biology*.84:623-634.

Rosenberger A, Hung RJ, Christiani DC, Caporaso NE, Liu G, Bojesen SE, Le Marchand L, Haiman CA, Albanes D, Aldrich MC, et al. 2018. Genetic modifiers of radon-induced lung cancer risk: a genome-wide interaction study in former uranium miners. *Int Arch Occup Environ Health*.91:937-950. Epub 2018/07/05.

Schofield PN, Eppig J, Huala E, de Angelis MH, Harvey M, Davidson D, Weaver T, Brown S, Smedley D, Rosenthal N, et al. 2010. Research funding. Sustaining the data and bioresource commons. *Science*.330:592-593.

Schofield PN, Kulka U, Tapio S, Grosche B. 2019. Big data in radiation biology and epidemiology; an overview of the historical and contemporary landscape of data and biomaterial archives. *International journal of radiation biology*.1-18. Epub 2019/03/20.

Takahashi S, Inoue K, Suzuki M, Urushihara Y, Kuwahara Y, Hayashi G, Shiga S, Fukumoto M, Kino Y, Sekine T, et al. 2015. A comprehensive dose evaluation project concerning animals affected by the Fukushima Daiichi Nuclear Power Plant accident: its set-up and progress. *Journal of radiation research*.56 Suppl 1:i36-i41. Epub 2015/12/18.

Tapio S, Atkinson MJ. 2008. Molecular information obtained from radiobiological tissue archives: achievements of the past and visions of the future. *Radiation and environmental biophysics*.47:183-187.

Thomas GA. 2012. The Chernobyl Tissue Bank: integrating research on radiation-induced thyroid cancer. *J Radiol Prot*.32:N77-80. Epub 2012/03/08.

Tolmachev SY, Ketterer ME, Hare D, Doble P, James AC. 2011. The US Transuranium and Uranium Registries: forty years' experience and new directions in the analysis of actinides in human tissues. *Radiochimica Acta*.1:173-181.

Urushihara Y, Suzuki T, Shimizu Y, Ohtaki M, Kuwahara Y, Suzuki M, Uno T, Fujita S, Saito A, Yamashiro H, et al. 2018. Haematological analysis of Japanese macaques (*Macaca fuscata*) in the area affected by the Fukushima Daiichi Nuclear Power Plant accident. *Scientific reports*.8:16748.

Vaught JB, Henderson MK, Compton CC. 2012. Biospecimens and biorepositories: from afterthought to science. *Cancer epidemiology, biomarkers & prevention : a publication of the American Association for Cancer Research, cosponsored by the American Society of Preventive Oncology*.21:253-255.

Wang Q, Paunesku T, Woloschak G. 2010. Tissue and data archives from irradiation experiments conducted at Argonne National Laboratory over a period of four decades. *Radiation and environmental biophysics*.49:317-324.

Watson PH, Nussbeck SY, Carter C, O'Donoghue S, Cheah S, Matzke LAM, Barnes RO, Bartlett J, Carpenter J, Grizzle WE, et al. 2014. A framework for biobank sustainability. *Biopreservation and biobanking*.12:60-68.

6 Annex

TABLE 1 : STUDIES WITH BIOLOGICAL AND NON-BIOLOGICAL MATERIALS IN STORE

STUDY NAME	ECOLOGICAL DATA	STUDY DESCRIPTION	COUNTRY	SPECIES	ENDPOINT	EXPOSURE PATTERN
STOREDB:STUDY1001 Local high-dose cardiac irradiation induces disturbed energy metabolism associated with impaired PPAR alpha activity in C57BL/6 mice		Radiation exposure is associated with a markedly increased risk of cardiac morbidity and mortality with a latency period of several decades. Although different studies have confirmed the damaging effe ...	Germany	Mus musculus		
STOREDB:STUDY1005 Lung tumour induction after Pu or Np inhalation		Data on ERA	France	Rattus norvegicus	Cancer	Protracted
STOREDB:STUDY1007 Osteosarcoma in rats after intravenous plutonium citrate injection (ANE)		Induction osteosarcomas following iv plutonium citrate in the rat	France	Rattus norvegicus		
STOREDB:STUDY1008 Lung tumours in rats after inhalation of MOX (ASTI)			France	Rattus norvegicus	Cancer	Acute
STOREDB:STUDY1011 CEREBRAD hippocampus cortex NMRI			Germany	Mus musculus	Cognitive effects	Acute
STOREDB:STUDY1014 Comparative Toxicity and Retention of Am-241, Pu-239, and U-233 in Mice		Aim: To determine the long-term risks from contamination by different alpha emitters Treatment: Nine i.p. injections of Am-241 citrate, Pu-239 citrate or U-233 citrate (the activity was given as 9 inj ...	United Kingdom	Mus musculus		

STOREDB:STUDY1015 GENRISK-T (FP6-36495) Iodine131-induced Thyroid Tumours in Mice	To determine the extend to which individual genetic differences influence the risk of developing thyroid cancer after exposure to radiation.Genetic factors can modify susceptibility to the carcinogeni ...	Germany	Mus musculus		
STOREDB:STUDY1019 Effects of In-utero low dose irradiation on long-term cardiac proteome		Germany	Mus musculus	Cardiovascul ar	Acute
STOREDB:STUDY1022 Wound contamination by actinides in the rat	Biokinetics and biodistribution of actinides after contamination of wound in the rat	France	Rattus norvegicus		
STOREDB:STUDY1026 Radiobiology studies at SCK-CEN (samples)		Belgium	Mus musculus		Acute
STOREDB:STUDY1034 Wismut Uranium Miners - Biobank	The German uranium miners cohort study (Wismut cohort) is the largest single cohort study worldwide of miners exposed to radon and its progeny and is being conducted by the Federal Office for Radiatio ...	Germany	Homo sapiens		
STOREDB:STUDY1037 Semipalatink Nuclear Test Site 3-generation study	A description of the study is given here: http://www.concert-h2020.eu/~media/Files/Concert/AIR2/Infrastructures_AIR2_Bulletin_5_March_2016.pdf?la=en , page 3 Examples from the EXCEL spreadsheets w ...	Kazakhstan	Homo sapiens		

STOREDB:STUDY1038 Mayak Nuclear Workers; proteomics on left ventricle	A Dose-dependent Perturbation in Cardiac Energy Metabolism is Linked to Radiation-induced Ischemic Heart Disease in Mayak Nuclear Workers Background - Epidemiological studies show a significant inc ...	Germany	Homo sapiens	Cardiovascular	Protracted
STOREDB:STUDY1041 SUBI tritium exposed Wistar rats	Information on data and biological material from 224 Wistar rats held at Southern Urals Biophysics Institute of the Federal Medical Biological Agency Ozyersk, Russian Federation Responsible scie ...	Russia	Rattus norvegicus		Protracted
STOREDB:STUDY1056 Biomaterial from 6 animal experiments conducted at SUBI	An overview is given on biomaterial from six selected animal experiments carried out at SUBI, Russia. These experiments were, ordered by SUBIÖs contract numbers: - Contract 75311: ÖTritium oxide effe ...	Russia			
STOREDB:STUDY1063 Proteome analysis of irradiated endothelial cells reveals persistent alteration of RhoGDI and NO signalling pathways	Background: Recent epidemiological studies indicate that radiation doses as low as 0.5 Gy may increase the risk of cardiovascular disease. The aim of the present study was to investigate whether this ...	Germany	Homo sapiens	Cardiovascular	Acute
STOREDB:STUDY1082 Liver and Spleen Tumours in Rats After Injection of Th-230 Enriched Thorotrast	Purpose: To determine the respective roles of the radioactive and chemical component in Thorotrast gel-induced tumours, alpha radioactivity in Thorotrast was enriched about 50 times by addition of Th- ...	Germany	Rattus		

<p>STOREDB:STUDY1083</p> <p>Lung Tumours in Rats After Injection of Normal and Th-228 Enriched Thorotrast and Inhalation of Quartz Dusts</p>	<p>Purpose: To determine whether thoron exhaled from incorporated Thorotrast whose alpha radioactivity was enriched about 25 times in some groups by an addition of Th-228 would cause lung tumours if comb ...</p>	<p>Germany</p>	<p>Rattus</p>	
<p>STOREDB:STUDY1084</p> <p>Liver Tumours and Diseases in Rats After Fractionated Neutron Exposure or Injection of Non-radioactive Zirconotrast</p>	<p>Purpose: To determine the respective roles of the radioactive and chemical component in Thorotrast induced liver damage. The fractionated neutron exposure was to simulate the radioactive, the Zirkonot ...</p>	<p>Germany</p>	<p>Rattus</p>	
<p>STOREDB:STUDY1085</p> <p>Liver and Spleen Tumours in Rats After Injection of Zirconotrast to Which Different Amounts of Th-228/Th-230 Were Added.</p>	<p>Purpose: To determine the respective roles of the radioactive and chemical component in Thorotrast induced liver and spleen damage. The radioactive Th-228/Th-230 was added to the Zirconotrast Zr-dioxi ...</p>	<p>Germany</p>	<p>Rattus</p>	
<p>STOREDB:STUDY1086</p> <p>Single Dose Fe Ion Irradiation Highlights the Radiation Quality Dependent Nature of the Endothelial Cell Response to Ionizing Radiation Exposure</p>	<p>Background and Purpose. Radiotherapy is an essential tool for cancer treatment. In order to spare normal tissue and to reduce the risk of normal tissue complications, particle therapy is a method of c ...</p>	<p>Germany</p>	<p>Homo sapiens</p>	<p>Cardiovascul ar Acute</p>

STOREDB:STUDY1091 3-generation Exposure Study	The Semipalatinsk nuclear test site (STS) is located approximately 150 km west of the city of Semipalatinsk (now called Semey), and was a major site for nuclear weapons testing by the former Soviet Un ...	Kazakhstan	Homo sapiens	Transgenerational effects	
STOREDB:STUDY1092 Chernobyl Tissue Bank	The Chernobyl Tissue Bank (CTB) was established in 1998 to collect, store and distribute biological samples from patients born on or after 26th April 1967, and resident in the regions of Ukraine and R ...	Ukraine	Homo sapiens	Cancer	Transitory
STOREDB:STUDY1094 JANUS database	JANUS is a collection of data and tissue samples from materials made at different US National Laboratories during animal studies done between 1950s and 1990s. The Janus experiments, carried out at A ...	United States	Multiple Animal	Multiple	
STOREDB:STUDY1095 Radiation alters the cargo of exosomes released from squamous head and neck cancer cells to promote migration of recipient cells	Radiation is a highly efficient therapy in squamous head and neck carcinoma (HNSCC) treatment. However, local recurrence and metastasis are common complications. Recent evidence shows that cancer-cell ...	Germany	Homo sapiens	Cancer	Acute
STOREDB:STUDY1100 The role of PPAR alpha in radiation induced heart disease	The PPAR alpha, important regulator of fatty acid metabolism in heart shown to be involved in development of cardiovascular disease. The radiation induced impairment of fatty acid metabolism was obser ...	Germany	Mus musculus	Cardiovascular	Acute

STOREDB:STUDY1106						
Acute and chronic TBI irradiation APOE null mice				Mus musculus		Acute
STOREDB:STUDY1137						
Adult Health Survey of Japan LSS		A sub-cohort of 15, 000 individuals of the LSS of atomic bomb survivors, the Adult Health Survey, has used biennial health surveys to follow up on all morbidities in addition to cancer. Biological sam ...	Japan		Homo sapiens	
STOREDB:STUDY1138						
Radiobiological Archive of Large-scale Animal Experiments at QST-NIRS: J-SHARE		The Japanese Institutes for Quantum and Radiological Science and Technology (QST) and its National Institute of Radiological Sciences have had a program of large-scale external exposure of rodents to ...	Japan	Mus musculus	Cancer	Multiple
STOREDB:STUDY1139						
Institute of Environmental Studies database		For the past 22 years the Institute of Environmental studies (IES) in Rokkasho, Aomori prefecture, Japan has been studying the biological effects of long-term external exposure in mice (Braga-Tanaka e ...	Japan	Mus musculus	Cancer	Protracted
STOREDB:STUDY1140						
The National Human Radiobiology Tissue Repository, USTUR, USA		The National Human Radiobiology Tissue Repository (NHRTR) within the United States Transuranium and Uranium Registries (USTUR) holds around 9,000 frozen and formalin-fixed tissue samples from 40 whole ...	United States		Homo sapiens	Multiple
STOREDB:STUDY1141						
Sample bank of Fukushima animals	Yes	Following the Fukushima Daiichi Nuclear Power Plant accident, a sample bank of animals affected was established. Domestic livestock were collected from the evacuation zone of August 29, 2011 and organ ...	Japan		Multiple Animal	Protracted

STOREDB:STUDY1142						
The Nagasaki Atomic Bomb Survivors' Tumor Tissue Bank, Japan		Beginning in April, 2008, a cohort study has been initiated at Nagasaki University –the Global Strategic Center for Radiation Health Risk Control–to analyse solid cancers and haemopoietic malignancies ...	Japan	Homo sapiens	Cancer	Acute
STOREDB:STUDY1143						
Air sample archive from STAR Partners	Yes	The STAR Network of Excellence holds a variety of samples from the terrestrial and aquatic environment, and samples from a variety of air samplers collected by various methods. The linked table provi ...				Protracted
STOREDB:STUDY1144						
Aquatic sample archives held by STAR Network of Excellence Partners	Yes	The STAR NoE holds a variety of samples from the terrestrial and aquatic environment, and samples from a variety of air samplers collected by various methods. In the tables linked below you will find ...				Protracted
STOREDB:STUDY1145						
Food sample archives held by STAR Network of Excellence Partners	Yes	The STAR NoE holds a variety of samples from the terrestrial and aquatic environment, and samples from a variety of air samplers collected by various methods. In the tables linked below you will find ...				Protracted
STOREDB:STUDY1146						
Human samples collected by the Partners of the STAR Network of Excellence	Yes	The STAR NoE holds a variety of samples from the terrestrial and aquatic environment, and samples from a variety of air samplers collected by various methods. In the tables linked below you will find ...		Homo sapiens		Protracted

STOREDB:STUDY1147					
Information on industrial sample archives collected by the STAR Network of Excellence Partners	Yes	The STAR NoE holds a variety of samples from the terrestrial and aquatic environment, and samples from a variety of air samplers collected by various methods. In the tables linked below you will find ...			
STOREDB:STUDY1148					
Information on terrestrial biotic and abiotic samples collected by STAR network of Excellence	Yes	The STAR NoE holds a variety of samples from the terrestrial and aquatic environment, and samples from a variety of air samplers collected by various methods. In the tables linked below you will find ...			
STOREDB:STUDY1149					
Russian Radiobiological Human Tissue Repository (RHTR)	No	The Russian Radiobiological Human Tissue Repository (RHTR) was established to collect and store biological samples relevant to human health effects of chronic, low-dose radiation exposure (Loffredo ...	Russia	Homo sapiens	Protracted

STOREDB © Bundesamt fuer Strahlenschutz 2014-Present | Licensed under Creative Commons by Share Alike 4.0 International