

**M. SUSAN LINDEE\***

## **First Peoples of the Atomic Age: Finding New Kinds of Data in the Biobanks of the Radiation Effects Research Foundation**

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### **ABSTRACT**

In this article, I explore the history of biological materials that scientists and physicians collected from those who survived the atomic bombings at Hiroshima and Nagasaki. Originally acquired beginning in 1946 to track the genetic effects of radiation in the offspring of atomic bomb survivors, these materials gradually became relevant to other kinds of biological and biomedical research. Many of the samples still held at the Radiation Effects Research Foundation are from individuals (approximately 65 percent) who are no longer alive. To scientists and others engaged with their management and use, these samples are uniquely valuable, timeless, a legacy for “all mankind.” Like materials taken from isolated populations around the world, the atomic bomb samples are both unique and universalized. They join other forms of Big Data in their seamless transition from dramatic specificity to general relevance. My paper explores what such legacies mean, and what they might teach us about the history of biology, the practices of biobanking, and the post-1945 Pacific world.

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KEY WORDS: radiation genetics, Radiation Effects Research Foundation, Hiroshima, survivors, Hibakusha, atomic bomb

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\*Janice and Julian Bers Professor of the History and Sociology of Science, Department of the History and Sociology of Science, University of Pennsylvania, Cohen Hall Suite 303, 249 South 36<sup>th</sup> Street, Philadelphia, PA 19104, [mlindee@sas.upenn.edu](mailto:mlindee@sas.upenn.edu).

The following abbreviations are used: ABCC, Atomic Bomb Casualty Commission; AEC, Atomic Energy Commission; AFIP, Armed Forces Institute of Pathology; DOE, U.S. Department of Energy; ESR, electron spin resonance; NAS, National Academy of Sciences; RERF, Radiation Effects Research Foundation.

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The blood samples are very precious, not only for RERF and the survivors, but for all mankind.<sup>1</sup>

After more than seventy years, we can observe with anguished dispassion how the use of the atomic bombs fractured time. In this paper, I explore this world-changing, existential fracture through a consideration of irradiated biological objects.

These objects are held in the Biosample Research Center of the Radiation Effects Research Foundation (RERF) in Hiroshima and Nagasaki, Japan. Established in 2013, the Biosample Research Center holds consented materials from about 25,000 participants in the Adult Health Study of atomic bomb survivors, and about 12,000 participants in the study of the offspring of survivors. The 1.8 million tubes of biosamples (750,000 of serum, 370,000 of plasma, 500,000 of blood cells, and 210,000 of urine) are stored in a robotic biorepository system ( $-80^{\circ}\text{C}$ ) installed in the Hiroshima Laboratory on Hijiya Hill in 2015, and in 83 conventional deep freezers ( $-80^{\circ}\text{C}$ ) (51 freezers in Hiroshima and 32 in Nagasaki). In addition, 230,000 tubes of peripheral blood mononuclear cells are stored in a living state in 39 liquid nitrogen tanks ( $-150$  to  $-196^{\circ}\text{C}$ ) (32 tanks in Hiroshima and seven in Nagasaki).<sup>2</sup> The RERF also holds autopsy materials collected as early as August 1945, preserved in formalin rather than frozen and taken from atomic bomb victims, and from stillbirths, spontaneous abortions, and neonatal deaths in the next generation, the offspring of the survivors, in the postwar period roughly 1946–1976. Finally, the RERF collection includes about 300 survivor teeth, donated voluntarily over the years since 1986 as survivors had normal dental work. All these materials are now held indefinitely by the RERF, which has laboratories, clinics, and specimen centers in both Hiroshima and Nagasaki, Japan.

Collectively, this constitutes a large and complicated biobank that has posed logistical and ethical challenges for RERF, which is in the twenty-first century an outward-facing institution. The RERF today routinely welcomes school children, tourists, and journalists to its facilities on Hijiya Hill, where visitors can see the robotic biobank and huge freezers. Leadership is

1. Hiroaki Katayama, “RERF Databases and Implications for Future Studies,” *Radiation Protection Dosimetry* 151, no. 4 (2012): 677–81, on 681.

2. These numbers are taken from the website of the Biosamples Database at the Radiation Effects Research Foundation, [https://www.ref.or.jp/en/about/organization-en/chart-e/bio\\_e/](https://www.ref.or.jp/en/about/organization-en/chart-e/bio_e/) (accessed 1 Jul 2020).

straightforward about the institution's history and its complex past—the hallways feature displays of historical images and data, and the website provides online access freely to many key documents and images. The Biosample Research Center is presented as benefitting survivors, in the sense that it facilitates new research on the materials they have donated.

There are many larger biobanks, and newer DNA biobanks can contain many millions of individual samples. But the historical complexity in this case is unusual. The new sample center established in 2013 was expected to facilitate “the centralized preservation and maintenance of all of our important biosamples” and create “biosample databases to enable us to share such information with researchers both inside and outside of Japan.”<sup>3</sup> It was thus intended to convert the materials into global resources legible to the scientific community at large. It joined an estimated thirty-five other biobanks, including the Chernobyl Tissue Bank, holding materials relevant to radiation risk and collected from people exposed to radiation in various ways.<sup>4</sup>

The survivors of the atomic bombings are the first true residents of the atomic age—the first group exposed to the bomb as a weapon, and the first people who had to live with long-term consequences that might, eventually, befall many others. To highlight the comparison to Indigenous groups, I here call them the first peoples of the atomic age. I do not mean to suggest that their actual historical experiences of military and scientific violence are perfectly analogous with those of groups exposed to colonial violence. Rather, I mean to call attention to the shared qualities that the scientific community has attributed to both Indigenous and survivor biological materials, as derived from groups that are disappearing, rare, “precious,” and uniquely informative not only about the past but about the future.<sup>5</sup> One director of the Atomic

3. “Biosample Center Newly Established at RERF,” *RERF Update* 24, no. 1 (2013): 5; <https://www.rerf.or.jp/uploads/2017/07/2013vol24.pdf> (accessed Aug 2020).

4. According to its website, the Chernobyl Tissue Bank is “an international project and research resource that collects, stores and distributes biomaterials from patients who have developed thyroid lesions as a direct consequence of exposure to radioactive iodine in fallout from the Chernobyl accident.” This bank has 4,086 frozen samples available (of 5,228 total samples); <https://www.chernobyltissuebank.com/index.htm>, and <https://www.chernobyltissuebank.com/material-available.htm> (accessed Sep 2020).

5. Comparisons of suffering are often generally suspicious today: for example, the common use of the Holocaust to frame other kinds of oppression and genocide, including national policies toward Indigenous groups in the US, Canada, or Australia. Indigenous activists rightly balk at simplistic equivalence. I hope what I am doing here is non-reductive and respectful to both survivors and Indigenous people. Certainly I am not claiming that their experiences are the same,

Bomb Casualty Commission (ABCC), the predecessor to the RERF, called the survivors “the most important people living.”<sup>6</sup> I explore here how their meanings to science resonate with those assigned to other groups having special properties—groups valued for their isolation, uniqueness, or primitiveness, and seen also, despite their unusual qualities, as embodied evidence relevant to the general human future and to modernity in general. While Indigenous groups could be seen in the nineteenth century as relics of human evolution unspoiled by modernity, the survivors have functioned in a somewhat different register for the scientific community. They represent modernity in its worst potentiality: the atomic bomb survivors experienced a feared future that has at times seemed more or less likely week-by-week (witness the *Bulletin of the Atomic Scientists* Doomsday Clock).<sup>7</sup>

The core similarities between these groups of scientific subjects include the labor of abstraction and distancing that is central to so many other kinds of work with biological materials collected around the world.<sup>8</sup> This labor involves purging the materials of their specificity and uniqueness. For instance, in the

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only that their meanings to the scientific community have a certain revealing resonance that illuminates how technical knowledge systems work. On this debate in very contemporary terms, see, for example, Jonathan M. Katz, “Call immigrant detention centers what they really are: concentration camps,” *Los Angeles Times*, 9 Jun 2019; and David MacDonald, “First Nations, Residential Schools, and the Americanization of the Holocaust: Rewriting Indigenous History in the United States and Canada,” *Canadian Journal of Political Science* 40, no. 4 (2007): 995–1015. MacDonald says that comparisons between the Holocaust and the treatment of Indigenous groups produces “twin dangers”: “At one level the Holocaust is subjected to a process of trivialization. At another level, framing history through the Holocaust decontextualizes group histories by re-reading past victimization through a distinctive and different series of events. While comparing historical atrocities can be academically fruitful, activists will do better to highlight the traumatic effects of atrocities on individuals and families, noting their intergenerational legacies. This may be a better way of representing history, and of building bridges between diverse groups.” (995).

6. Ex-director of the Atomic Bomb Casualty Commission, Robert Holmes, quoted in Robert Trumbull, *Nine who survived Hiroshima and Nagasaki: Personal experiences of nine men who lived through both atomic bombings* (New York: E. P. Dutton and Co. (1957): 132–33.

7. On the changing status of Indigenous groups as timelessly biological and uniquely historical, see Joanna Radin and Emma Kowal, “Indigenous blood and ethical regimes in the United States and Australia since the 1960s,” *American Ethnologist* 42, no. 4 (2015): 749–65, esp. 763–65.

8. Warwick Anderson, *The Collectors of Lost Souls: Turning Kuru Scientists into Whitemen* (Baltimore: Johns Hopkins University Press, 2008); Emma Kowal, Joanna Radin, and Jennifer Reardon, “Indigenous Body Parts, Mutating Temporalities, and the Half-lives of Postcolonial Technoscience,” *Social Studies of Science* 43, no. 4 (2013): 465–83; Joanna Radin, *Life on Ice: A History of New Uses for Cold Blood* (Chicago: University of Chicago Press, 2017); Joanna Radin, “Unfolding Epidemiological Stories: How the WHO made Frozen Blood into a Flexible

fall of 2016, the COSMIC Cell Line Project, (Catalogue Of Somatic Mutations In Cancer), an online scientific database maintained by the Wellcome Sanger Institute in the UK, listed five RERF cell lines available for scientific research, including four relating to lung cancer and one to stomach cancer. These five cell lines contain more than 4,000 mutations; for each cell line, the online database presented mutations visualized in circular, interactive images that highlight anomalies on a beautiful, almost artistic, molecular map.<sup>9</sup> Nothing in the notation or the descriptions of these lines refers to the atomic bombs, the survivors, the Cold War, the Allied Occupation of Japan, or radiation risk, though their geographical origins in Japan are stated. They are instead abstracted, neutral, molecular resources for understanding cancer in general. Their complex history, in the context of biobanked cell lines, is more than irrelevant here. It is necessarily erased, in service to a project of generalized, de-historicized knowledge that privileges the strictly biological properties of biological things, even when those things are thoroughly historical, embedded in time in an unforgettable way.<sup>10</sup>

Joanna Radin has tracked a similar process involving the Gila River Indian Community in the Southwestern United States, a group of people known as Pima Indians, or by their own name, Akimel O’odham. This group was originally the focus of biomedical research oriented around the epidemiology of diabetes, but the data collected gradually became a resource for projects unrelated to diabetes or even, as she demonstrates, to biomedicine. Radin proposes that the Pima data story exemplifies “Big Data” and that what makes data “big” is not so much its size as “its ability to radically transcend the circumstances and locality of its production.”<sup>11</sup> The atomic bomb materials have become resources for precisely this kind of transcendence.<sup>12</sup>

The Biospecimen Center at the RERF, which I explore here, is thus consistent with an emerging style of twenty-first-century biobanks. Materials that

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Resource for the Future,” *Studies in the History and Philosophy of Biological and Biomedical Sciences* 47 (2014): 62–73.

9. COSMIC, Catalogue of Somatic Mutations in Cancer, [http://cancer.sanger.ac.uk/cell\\_lines/search?q=RERF](http://cancer.sanger.ac.uk/cell_lines/search?q=RERF) (accessed Aug 2020).

10. My use of the word “unforgettable” is a reference to the title of a striking compilation of survivor paintings published in 1981. See Japan Broadcasting Corporation, ed., *Unforgettable Fire: Pictures drawn by atomic bomb survivors*, trans. World Friendship Center, Hiroshima (New York: Pantheon Books, 1981).

11. Joanna Radin, “Digital Natives’: How Medical and Indigenous Histories Matter for Big Data,” *Osiris* 32 (2017): 43–64, on 45.

12. *Ibid.*

the ABCC-RERF—originally collected in a haphazard manner, across many decades, from survivors and controls, through autopsies, clinical care, and dental treatments—are now being rationalized and modernized into a cohesive, more general frame, relevant in an unstated elsewhere. The specimen center reimagines the samples to build new kinds of knowledge, indefinitely.<sup>13</sup> New interest among historians of science in “How Collections End,” the title of a 2019 special issue of the *British Journal for the History of Science*, reflects ironically on this property of endlessness: many collections persist and change, becoming something new in the process.<sup>14</sup> No longer revealing only radiation risk, the biological materials taken from the survivors become enduring resources for all kinds of biomedical exploration, including an endless epidemiology unmoored from the vexed circumstances of their production.

#### **“THE FEELING THAT THE ASSAILANTS ARE INVESTIGATING THE VICTIMS”**

On August 10, 1945, Major Y. Kiyoshi, of the Bureau of Medical Affairs of the Japanese Imperial Army, conducted what is believed to be the first full autopsy of a victim of the atomic bombing at Hiroshima, a young boy who must have died in the immediate aftermath of the bombings.<sup>15</sup> The autopsy was carried out under emergency conditions, as pathologists and physicians in the two cities began to realize that patients were dying in strange and unexpected ways.<sup>16</sup> In August and September 1945, Japanese pathologists conducted about

13. For a discussion of this idea, see RERF, *Report of the 41st Scientific Advisory Committee Meeting*, 3–5 Mar 2014; [https://www.rerf.or.jp/uploads/2017/09/5\\_Meeting-Reports-1.pdf](https://www.rerf.or.jp/uploads/2017/09/5_Meeting-Reports-1.pdf) (accessed Aug 2020).

14. Boris Jardine, Emma Kowal, and Jenny Bangham, “Introduction, How Collections End: Objects, Meaning and Loss in Laboratories and Museums,” *British Journal of the History of Science*, no. 4 (2019): 1–27; <https://doi.org/10.1017/bjt.2019.8>.

15. My earlier account of these events is Susan Lindee, “The repatriation of atomic bomb victim body parts to Japan, 1967–1973: Natural objects and diplomacy,” in “Beyond Joseph Needham: Science, Technology and Medicine in East and Southeast Asia,” ed. Morris Low, special issue, *Osiris* 13 (1999): 376–409. Other relevant sources include Lindee, *Suffering Made Real: American Science and the Survivors at Hiroshima* (Chicago: University of Chicago Press, 1994); Lindee, “Survivors and scientists: Hiroshima, Fukushima, and the Radiation Effects Research Foundation, 1975–2014,” *Social Studies of Science* 46, no. 2 (2016): 184–209; and Lindee, “Human genetics after the bomb: Archives, clinics, proving grounds and board rooms,” *Studies in History and Philosophy of Biological and Biomedical Sciences* 55 (2016): 45–53.

16. For a technical picture of life in the two cities in mid- to late August 1945, see Committee for the Compilation of Materials on Damage Caused by the Atomic Bombs in Hiroshima and

300 autopsies of victims of the atomic bombs.<sup>17</sup> They preserved slides, organs, and texts that instantiated the embodied experiences of those who died, and they wrote down the stories that victims told them.<sup>18</sup>

As the war ended, and Allied forces gradually took control of Japan, a US Joint Army–Navy commission arrived in Hiroshima and Nagasaki to begin a preliminary assessment of the biomedical consequences of the bombings. The commission collected materials from at least 218 autopsies from Japanese pathologists and confiscated about 1,400 other slides and tissue samples, including skin biopsies, bone marrows, and blood smears.<sup>19</sup> Later, one pathologist, Tamagawa Chuta of Hiroshima University, described his decision to turn over these autopsy materials to the Americans in the fall of 1945 as motivated by fear of occupying forces as Allied troops took over Japan: “Deceased bodies and autopsy materials are not spoils of war.”<sup>20</sup> Japanese scientists were also offended when Allied authorities confiscated their scientific manuscripts relating to the bomb and the biological effects of radiation. These were collected in 1945 and 1946 by Occupation authorities, supposedly for

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Nagasaki, *Hiroshima and Nagasaki: The Physical, Medical, and Social Effects of the Atomic Bombings*, trans. Eisei Ishikawa and David L. Swain (New York: Basic Books, 1981).

17. My account of this event was drawn years ago for my 1999 *Osiris* paper from translations of Japanese newspaper articles held in the Otis Historical Archives of the National Museum of Health and Medicine, and then at the AFIP in Washington, DC. In 2011, the AFIP was closed as a result of defense spending cuts. See Alison McCook, “Death of a pathology centre: shelved,” *Nature* 476 (2011): 270–72; doi:10.1038/476270a. The Otis Historical Archive is now housed at the National Museum of Health and Medicine at Silver Spring, MD.

18. Their later scientific papers, most of which were censored during the early Occupation, included studies of the “relation between atomic bomb effects and menstruation,” the “bacteriological and serological researches for diarrhea of atomic bomb disease,” and the “investigation of oral disease of the atomic bomb patients at Hiroshima.” See the listing of Japanese papers in Austin M. Brues and Paul S. Henshaw, “General Report, Atomic Bomb Casualty Commission, January 1947,” generally referred to as the Brues-Henshaw Report, which is now available in PDF form online at [http://www.nasonline.org/about-nas/history/archives/collections/organized-collections/atomic-bomb-casualty-commission-series/abccrpt\\_toc.pdf](http://www.nasonline.org/about-nas/history/archives/collections/organized-collections/atomic-bomb-casualty-commission-series/abccrpt_toc.pdf). Copies of this crucial report are also held in multiple files at the ABCC Collection, NAS, in Washington, DC.

19. Ashley W. Oughterson and Shields Warren, eds., *Medical Effects of the Atomic Bomb in Japan* (New York: McGraw-Hill, 1956); Averill A. Liebow, *Encounter with Disaster: A Medical Diary of Hiroshima, 1945* (New York: Norton, 1971).

20. Tamagawa is quoted in “Returned A-Bomb Disaster Materials Now at Origin,” *Chugoku Shimbum* (17 May 1973). A translation of the article is in Otis Historical Archives (formerly at the AFIP, now at the National Museum of Health and Medicine in Silver Spring, MD), A-Bomb MSS, Box 19.

security review, but never returned.<sup>21</sup> The new occupiers thus took both scientific texts and bodily materials. Autopsy materials were packed up and sent to Washington, DC, to be stored in the Armed Forces Institute of Pathology (AFIP). There they stayed until 1973, when US officials returned them to Japan as part of a diplomatic exchange.<sup>22</sup>

In 1947, the Atomic Energy Commission (AEC), with guidance from the National Academy of Sciences (NAS), created a new agency to study the biomedical problems in the atomic bomb survivors. The ABCC, which set up clinics in both Hiroshima and Nagasaki in the spring of 1947, and collected autopsy materials from atomic bomb survivors. This required establishing a system of trust relationships in the communities to encourage the survivors to agree to donate their remains for long-term scientific studies of radiation risk. Physicians and scientists at the ABCC persuaded many survivors that contributing to scientific knowledge was important, and for some years, particularly before 1965, rates of donation were relatively high. These autopsies, often conducted by Japanese pathologists with ABCC cooperation, produced wet tissue, slides, and materials preserved in wax. These materials were at first shipped to Washington, DC, for permanent storage at the AFIP, where biological materials from the US Civil War and World War I were also stored.

The apparent lack of any debate about the decision to ship biological materials from Japan to the United States contrasts sharply with a debate happening inside the AEC around the same time over other materials collected to assess radioactive fallout. In 1949, the AEC began building a worldwide network to study how radioactive fallout from atomic testing was contaminating soil, water, and air. In 1953, the program, now called Project Sunshine, expanded to include secret studies of human bone samples collected by physicians around the world. Hydrogen bomb testing was generating more fallout, and many AEC experts feared health consequences. Those involved with Project Sunshine worried about the legal and public relations issues raised by “body snatching.” The AEC collected the bones of infants who died in Houston, New York, Vancouver, and other cities, and misled families who contributed bodily materials about the nature of the research. Willard Libby,

21. For a full and compelling discussion of the censorship of scientific materials in Occupied Japan, see Monica Braw, *The Atomic Bomb Suppressed: American Censorship in Japan, 1945–1949*. (Malmö: Liber Förlag, 1986).

22. Lindee, “The repatriation of atomic bomb victim body parts” (ref. 15).

Project Sunshine planner, explicitly used the term “body snatching” in his 1953 Rand Foundation study of plans for the project.<sup>23</sup> The President’s Advisory Committee on Human Radiation Experiments in 1995 released documents showing that those involved were aware of the dubious legal and ethical grounds for the research.<sup>24</sup> The important point is that collecting bodily materials linked to radiation from domestic sources could and did provoke internal consternation. But the materials from the atomic bomb victims and survivors seemed transparently to belong to the United States, and the practices involved in their management were neither secret nor internally controversial in the inner circles at NAS and AEC. The pathologist who complained that bodily remains were being treated as “spoils of war” saw what US officials perhaps could not.

In 1957, ABCC Director George Darling first proposed that the agency stop sending new materials to Washington. Stored in the AFIP’s atomic bomb-proofed building in Washington, DC, they were inaccessible to many researchers, and all sides worried about how they might be used, or not. At the same time, Japanese physicians and scientists who had participated in the early autopsy program, or who were interested in studying the health effects of the atomic bomb on the survivors, began to express their dissatisfaction with the arrangement and their sense that US scientists had taken important scientific data from them improperly. Japanese materials should be held in Japan, they argued, where those who had originally collected them could study them.

In the list of the Japanese scientific community’s grievances against the United States when the debate began, the removal and storage of biological materials taken from atomic bomb victims would probably not be at the very top. However, the disposition of these materials had implications for US and Japanese scientists’ relationships. Many US scientists based in Japan began to think that returning the atomic bomb victim autopsy materials to Japan would facilitate greater cooperation with the local medical and scientific community, demonstrating respect for their legitimate interest in participating in relevant research.

In 1962, leadership at the NAS, which oversaw the ABCC, and the AEC, which funded it, began to support the complete return to Japan of all the

23. For an overview of Project Sunshine, which involved collecting human remains around the world in order to assess fallout, see Advisory Committee on Human Radiation Experiments, *Final Report* (Washington, DC: U.S. Government Printing Office, 1996), 402–06.

24. Warren E. Leary, “In 1950’s, U.S. Collected Human Tissue to Monitor Atomic Tests,” *New York Times*, 21 Jun 1995.

biological materials then stored in Washington (then about 700 autopsies). This solution was partly a response to the precarious status of the ABCC itself. The ABCC was under constant budget pressure. Every year it seemed as if the AEC might cancel or drastically cut funding. If it were to close, those managing the program wondered, what would happen to the autopsy materials? While keeping the materials in the United States could be justified if they were the focus of ongoing, active research, it would be different if the ABCC closed down. Then, the United States would be holding human remains produced by a US weapon, with no scientific agenda to justify keeping them. The proposed repatriation of the atomic bomb victim autopsy materials, in other words, at least partly reflected concerns about the long-term survival of the ABCC.

Other commentators hammered home the unseemliness of the United States holding on to such special materials no matter what. Journalists said that the materials preserved from the autopsies of the survivors “constitute the one and only legacy left to this world by the A-bomb survivors, demanding literally with their life and blood that such a disaster be not repeated.” It was “improper” for any one institution to control access to these materials because of their value to all of humanity.<sup>25</sup> A story in the *Asahi Weekly* described a seemingly sinister “mortality detection network” at Hiroshima in which “pathology contactors—as such persons are called—make the round of the City Office and its branch offices twice a day to ‘catch’ death reports . . . it is said that the contactors are paid an allowance of 60 yen per body.”<sup>26</sup> One survivor, who had refused to work with the ABCC, told the newspaper, “I cannot rid myself of the feeling that the assailants are investigating the victims.”<sup>27</sup>

In the fall of 1969, Darling arranged for the immediate return of all ABCC autopsy and clinical materials to Japan.<sup>28</sup>

25. Ibid.

26. Cited and described by Kenji Joji in a letter to George Darling, Memo, 9 Aug 1967, ABCC Collection, NAS Archives, Washington, DC.

27. “21st A-bomb anniversary record: What has ABCC done to date, visceral organs of survivors sent to United States,” trans. ABCC, featured article in *Asahi Shimbun*, 12 Aug 1966, Otis Historical Collection (formerly at the AFIP), ABCC collection, Box 20.

28. This was also in the midst of a debate in the popular press in Japan, including newspapers like the *Asahi Shimbun*, in which some activists and survivors said that the ABCC employed “vulture-like autopsy contactors” and the organization should immediately return not only the autopsy materials, but also all the buildings and land that the agency was using. Kenji Joji to George Darling, “Prof. Shimizu’s article on ABCC appearing Kagaku Asahi,” 9

In 1975, the Atomic Bomb Casualty Commission was renamed and reorganized as the Radiation Effects Research Foundation. Neither the facilities nor the staff changed, but the organization itself changed in important ways, because funding and scientific control became truly joint, with the United States and Japan working together on equal terms. The new RERF established much closer ties to the Japanese scientific community and worked to improve relationships in general with the communities in the two bombed cities. It was a turning point in the history of the institution.

In 2013, the RERF created a new Biosample Center aimed at “the integrated management in a systematic and accessible manner of RERF’s blood, urine, and other biosamples obtained from A-bomb survivors.”<sup>29</sup> Many of the samples had been previously cryopreserved and managed at individual research departments, either in various departments at Hiroshima University, Nagasaki University, or at the RERF. Henceforth, the RERF would keep all these biosamples together under centralized management. This would allow the agency to sort the materials more accurately into categories that would make it easier to respond to requests for data. The new biosample center would form databases of individual epidemiological categories such as age, sex, radiation exposure, conditions at the time of the bombings, and subsequent health status.

This was a practical plan to make sense of (at the time) almost a million biological samples that had been used only sparingly outside the RERF. Center facilities were established in both Hiroshima and Nagasaki, with Dr. Kazunori Kodama named director of seven staff at Hiroshima and eight at Nagasaki. In 2018, Dr. Osamu Tanabe took over as director.<sup>30</sup>

The size of the collection by 2013 reflected the size of the ABCC-RERF project. All of the research programs at the ABCC collected tissue samples from the beginning for example the tumor registries that began in 1957 in Hiroshima and 1958 in Nagasaki. The Adult Health Study annual exams begun in 1958 also generated tissue samples, though consenting for those samples began only in 1969. These examinations continue to generate new biological samples.

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Aug 1967, in Papers of the Atomic Bomb Casualty Commission, National Academy of Sciences, Washington DC.

29. “Biosample Center Newly Established at RERF,” *RERF Update* 24, no. 1 (Spring 2013): 5.

30. RERF Research Scientists, [https://www.rerf.or.jp/en/about/organization-en/chart-e/staff/tanabe\\_e/](https://www.rerf.or.jp/en/about/organization-en/chart-e/staff/tanabe_e/) (accessed Aug 2020).

One of the most important programs for collecting human tissue and bodily remains was the ABCC's Genetics Program, which began under the direction of University of Michigan human geneticist (and physician) James V. Neel in 1947 and which has persisted in various forms into the present with new genomics methods. The genetics studies of the offspring of bomb survivors, indeed, inspired the Department of Energy (formerly the AEC) in 1985 to begin developing a plan for a Human Genome Project. The first key meeting on this possibility was held at the in Hiroshima. Later the NIH took control, but the bomb and its potential genetic effects animated the first plan to map the entire human genome.<sup>31</sup>

For many observers, in the 1940s and 1950s, the potential genetic effects of radiation in the atomic bomb survivors constituted the single most frightening aspect of increasing radiation exposure. Predictions of monstrous births in the popular press in the fall of 1945 provoked significant public concern. As atmospheric weapons testing began, geneticist H.J. Muller, chemist Linus Pauling, and other scientists urged caution and predicted dramatic genetic consequences for the human species.<sup>32</sup> For survivor families in Japan, information about malformations and neonatal deaths was socially charged, relevant to future arranged marriages.

Collecting data about these pregnancy outcomes required a network of cooperative midwives and physicians who would collaborate with the ABCC genetics team and help them negotiate the donation of bodies from stillbirths or neonatal deaths. (Elective abortions very early in pregnancy, before twenty weeks, were common and well accepted in Japan, but were of less interest to the ABCC genetics team at the time because researchers presumed such fetuses to be healthy and unlikely to be malformed. In retrospect, tissues from such abortions might have eventually yielded genomic information as well)

31. In his chapter about the origins of the DOE's interest in mapping the complete human genome, "Genes and the Bomb," Robert Cook-Deegan provides an excellent explanation of how the genome seemed to be a resource for documenting genetic effects of radiation, by demonstrating at a molecular level both normal and abnormal variations in DNA. One key player at the DOE was the new head of the Office of Health and Environmental Research, Charles DeLisi, and in March 1984, DeLisi participated in a special genetics conference in Hiroshima, at RERF, on possible gene mapping to detect mutations. Robert Cook-Deegan *The Gene Wars: Science, Politics and the Human Genome* (New York: WW Norton, 1996).

32. Susan Lindee, "Performing anger: H. J. Muller, James V. Neel, and radiation risk," in *Human Heredity in the Twentieth Century*, ed. Bernd Gausemeier, Staffan Muller-Wille, and Edmund Ramsden (London: Pickering and Chatto, 2013), 205–15.

In what might constitute the first biobank of the atomic age, Neel in the summer of 1949 negotiated an agreement with Nagasaki University for the “construction of a shelf to be used for storage of specimens” that might be of interest to ABCC.<sup>33</sup> His group asked midwives to help with the collection of spontaneous abortions, stillbirths, and neonatal deaths, and told them that the ABCC would pay for cremation of the remains. Eventually tissue specimens taken from the infants and fetuses were stored in formalin in several locations, including laboratories at universities in Hiroshima and Nagasaki. Neel and his colleagues expected to be able to collect about two hundred infants per year, but in most years they collected significantly fewer, perhaps under a hundred.<sup>34</sup>

A detailed system for notification, processing, payment to families and to physicians or midwives who referred the cases, and so on, was in place by 1952. Those visiting the family would ask permission to conduct an autopsy and ask parents to sign an Autopsy Permit Form and a Cremation Permit. Parents could choose a crematorium; ABCC would provide an ashbox, urn, wrapper cloth, bouquet, and letter of condolence, sending the ashes to the bereaved family after the autopsy was complete.<sup>35</sup>

The RERF today therefore holds materials collected in at least six ways. First, there were the early autopsies conducted in the fall of 1945, by both Japanese and US pathologists. These were generally preserved in paraffin or formalin—not frozen—and documented in the autopsy reports collected by the first medical teams in 1945 and 1946. Second, beginning in 1957, the Tumor Registry collected materials from patients being treated for cancer, with a paper trail associated with each patient as a part of clinical care. Again, these materials were not frozen but preserved as slides. Third, there were tissues collected for the Genetics Program focused on the FI, the offspring of survivors, some of which were frozen. These were documented in the family case files of the genetics program. After 2002, consented materials from the offspring of survivors were added to the collection. Fourth, there were autopsy materials voluntarily donated by participants in the ABCC-RERF’s long-term Adult Health

33. Memorandum for the Record, “Autopsy Program in Nagasaki,” 6 Jun 1949, in Notebook 1, “Genetics Program,” Papers of William J. Schull, Houston Academy of Medicine, Texas Medical Center.

34. *Ibid.*

35. Memorandum for the Record, D. J. McDonald and S. Matsumoto, “Genetics Autopsy Program: A Complete Review of the Methods of the Genetics and Contacting Department,” 5 Nov 1952, in Notebook 4, “Genetics: Autopsy,” Papers of William J. Schull, Houston Academy of Medicine, Texas Medical Center.

Study, which began in 1958. Fifth, blood and urine collected during routine examinations for this Adult Health Study were added to the biobank after a consent protocol was introduced in 1969. Finally, survivors began donating teeth removed as a result of routine dental care.

As this list suggests, the samples vary in terms of how they were collected, recorded, preserved, and stored. Some involved informed consent, others did not. Some were in formalin, some in paraffin, some frozen, some slides; some from exposed persons, but some from controls and others from the children of survivors and therefore not exposed. All are relevant to radiation risk, but not in the same ways.

Most of those who work with these samples, even at RERF, do not have access to information about the individual people from whom they were taken. The details about individuals are a closely held secret, anonymized behind network firewalls. Most records are digitized in text formats but some are apparently still on actual paper, many on the very thin “onion paper” commonly used in the 1950s, stored in cabinets at the RERF in Hiroshima and vulnerable today to loss via fire or water. As Katayama suggests in his essay on these materials, over the history of their collection reagents have changed, analyzing techniques have changed, measured values have been modified, and old values have to be converted to new values with a consistent formula. A new dosimetry system in 1986 clarified key questions without dramatically changing estimated radiation exposures. The samples have also been stored in different ways, with different paper trails. The databases outlined in Katayama’s Figure 2, “Studies Conducted in Hiroshima by ABCC\RERF,” includes references to 118,300 autopsy pathologic materials, 38,000 genetic samples, 103,700 sex-ratio samples, 20,400 shielding histories, 112,000 cancer and tissue registry samples, and 9,800 samples from chromosome studies.<sup>36</sup>

If earlier natural history collectors brought materials together without quite knowing exactly what kinds of knowledge they could be expected to yield, those collecting materials from survivors of the atomic bombings had a well-developed sense of what they contained: a record of nuclear risk. Rather than collecting “nature”—like an unknown insect or bird—those involved in collecting materials from the survivors were explicitly collecting “culture” or history—a record of things that happened, written in human bodies.<sup>37</sup>

36. Katayama, “RERF Databases” (ref. 1), 681.

37. On early natural history collecting, see Janet Browne, *The Secular Ark: Studies in the History of Biogeography* (New Haven, CT: Yale University Press, 1983); Paula Findlen, *Possessing*

### “DISTINCTIVE NATURAL DOSIMETERS”

Every specimen at RERF has a story, a history: “I was standing near the school,” or “I was in my kitchen.” This history may be invisible to those analyzing cancer rates, but it is central even to the technical meanings of the samples. Indeed, the difficulties of assessing the accuracy and legitimacy of personal histories taken from survivors has animated some of the most intriguing work on the biosamples. This is the effort to develop independent biological measures that could reinforce the authority of personal stories. While the personal histories were important to dosimetry systems, the bodily remains were understood to provide a different kind of compelling evidence of human experience. There has been a calibration, still unfolding, between the two kinds of data, the written testimonials of the survivors and the biosamples in which exposures are presumably recorded. The biological materials cannot be fully interpreted without the recollections of their donors, and the donor’s recollections cannot necessarily be fully trusted unless they are backed up by results from laboratory studies of biological materials that reveal radiation exposure. My anonymous referee called this a “dance,” between story and tissue, and I think the image is apt.

In October 1952, Japanese investigators began to take personal histories from survivors, asking them to explain where they had been at the moment of the bomb’s detonation. Survivors would answer a few relatively straightforward questions about their location, clothing, and experience; what they heard; whether they felt a blast or heat; and whether they had experienced black rain (potentially radioactive rain that fell in Hiroshima on the day of the bombing). The team then asked survivors to tell the complete story of what had happened to them, including any symptoms of radiation sickness. Survivors also often took the group to see where they had been at the moment of the bomb’s detonation, demonstrating their exact position and location: they re-enacted the moment in physical and embodied terms. Often, a draftsman accompanying the group would draw their recollection,

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*Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley: University of California Press, 1994); Londa L. Schiebinger and Claudia Swan, eds., *Colonial Botany: Science, Commerce, and Politics in the Early Modern World* (Philadelphia: University of Pennsylvania Press, 2005); Londa L. Schiebinger, *Plants and Empire: Colonial Bioprospecting in the Atlantic World* (Cambridge, MA: Harvard University Press, 2004); and Beth Fowkes Tobin, *The Duchesses Shells: Natural History Collecting in the Age of Cook’s Voyages* (New Haven, CT: Yale University Press, 2014).

showing roofing, walls, a tree, a body crouched on the floor. By the end of 1954, more than nine years after the bombings, 2,000 histories were completed at Nagasaki and 650 in Hiroshima.<sup>38</sup>

These histories could provide information for one side of the dose problem: each survivor's experience of the bomb. They could not, however, answer the question of how much and what kinds of radiation the bombs had produced, and in the crucial early years of the scientific program, the levels and types of radiation released by the bomb were considered a state secret that could not be shared with the biomedical scientists studying the bomb's effects.

In 1950, the Washington oversight committee for the ABCC asked Cornell physicist Robert R. Wilson to examine published reports (most importantly, the 1950 report of Glasstone and Hirschfelder) about atomic weapons (both those used in Japan and those tested in the Pacific and at the Nevada Test Site) to make some estimates about probable radiation doses.<sup>39</sup> There was more information available about the implosion-type bomb used at Nagasaki because it had been test-fired, at Alamogordo on July 16, 1945, and at the Bikini test site in the Pacific in the summer of 1946, but the radiation estimates from the tests were not made available to the ABCC. The Hiroshima "gun-type" bomb was of an entirely different design that had been used only once.

In any case, the AEC did not provide any of the estimates of radiation calculated by scientists at Los Alamos to the ABCC in the early years. Despite being funded by the AEC, this biomedical agency had to make do with gleanings and assumptions based on publicly available information. The ABCC's earliest publications, for example on leukemia, used distance from the hypocenter instead of dose to categorize survivors.

In 1956, the Health Physics Division of Oak Ridge National Laboratory established a field-testing program, called Ichiban ("first," often connoting "best"), to stage reenactments of the bombings in the Nevada desert to mea-

38. John A. Auxier, *ICHIBAN: Toxic Agents Dosimetry for the Survivors of the Bombings of Hiroshima and Nagasaki* (Washington, DC: ERDA Prestige Series, 1976): 19–25; John A. Auxier, "Ichiban: The Dosimetry Program for Nuclear Bomb Survivors of Hiroshima and Nagasaki," in *Proceedings of the Symposium on Protective Structures for Civilian Populations* (Washington, DC: NAS-NRC, 1965), 121–26.

39. Samuel Glasstone and J. O. Hirschfelder, eds. *The Effects of Atomic Weapons: Prepared for and in Cooperation with the U.S. Department of Defense and the U.S. Atomic Energy Commission* (Washington, DC: US government Printing Office 1 Sep 1950).

sure the bombs' radiation.<sup>40</sup> The Oak Ridge group worked with the ABCC to develop specifications and drawings for a "typical" Japanese house as a part of its planned surrogate bombing of what the group called a "phantom" Japanese community at the Nevada Test Site. Teams measured dimensions and densities of commonly used building materials in Japan—mud plaster walls, slate, wood siding, tatami mats—and built experimental houses on this desolate landscape. Inside the houses were radiation sensors, not people. A test detonation completed the experiment.

Interviews of survivors and staged analogue desert bombings were part of the development of dosimetry systems for the survivors.<sup>41</sup> Every survivor had to be placed in an exposure category, which depended on what forms of radiation the bomb had released and where the person had been standing, how shielded, how positioned. But several historical factors have long rendered these doses opaque. Many early records, including a crucial survey of residual radiation conducted by Japanese physicists in August 1945, were lost and recovered only in the 1980s. The delays in interviewing survivors; the failure to retest the once-used design of the Hiroshima bomb; the impact of atmospheric weapons testing, which left residues of radioactive materials that persist around the world; the social meanings of survivor status and its meanings in Japan—all of these had an impact on how much RERF and DOE scientists trusted the dose estimates.

Through the 1960s and 1970s, the calculations of physicists and others involved in the dose assessments continued to shift based on new quantitative estimates and new interpretations of blast effects. "The problem of estimating the amount of radiation received by persons exposed to the atomic bombs in Hiroshima and Nagasaki is still troublesome today, after twenty years of study of the question," Kato, Neel, and Schull wrote in 1966, and "for the present we must be content with this range of uncertainty."<sup>42</sup> In 1983, RERF's William J. Schull lamented to a colleague that the genetics

40. John A. Auxier, "Ichiban: The Dosimetry Program for Nuclear Bomb Survivors of Hiroshima and Nagasaki—A Status Report as of April 1, 1964," Atomic Energy Commission, CEX-64.3 (1964).

41. My PhD student Sumiko Hatakeyama's dissertation, currently in process, is exploring the complex development of these dosimetry systems and their meanings for survivors and for scientists in Japan.

42. Hiroo Kato, William J. Schull, and James V. Neel, "A Cohort-Type Study of Survival in the Children of Parents Exposed to Atomic Bombings," *American Journal of Human Genetics* 18, no. 4 (1966): 339–73; Lindee, "Performing anger" (ref. 32).

program was on the brink of being able to “demonstrate that man is not mouse-like in his genetic response to radiation.” This demonstration would “make all the work (and the expense) of the past thirty-five years worthwhile! Unfortunately—just when I thought we were close to pinning this down, along comes the dosage reevaluation. We’re in ‘hold’ until we have the new doses.”<sup>43</sup> Dosimetry did not hold still, and this had an impact on all of the scientific conclusions about medical risk.

For those who continue to study the survivors, the perfect dosimetry system—the perfect reading of dose for each survivor—has acquired an almost grail-like quality over the decades. Although the most recent iteration, DS-02 (dosimetry system 2002), which corrected calculations of neutron radiation, is considered the “final” word on radiation release by the bombs, questions about individual doses continue to be explored in ever more baroque configurations of reconstruction and imagination.<sup>44</sup> Some veterans of calculating dosimetry have proposed that the next step (unlikely to ever happen) would be a complete digital reconstruction of the two cities (their roads, rivers, buildings, and people) in the first sixty seconds of the bombs’ detonations. Such an exercise would build in data on every building, every wave of energy, every bit of flying debris, every movement of every survivor, to be played and replayed in Monte Carlo simulations, until a statistically likely distribution could be identified.<sup>45</sup> They trust DS-02, but they know that there are some missing elements, including all that flying debris. The search for doses is a continuing, capacious search for something that can free the research from the vexing uncertainties of disaster, history, memory, and complexity—from time itself.

Realistically, survivors themselves might not have been able to describe where they were standing or what happened to them, as many scientific papers note. Interviews to collect survivor accounts did not begin until almost ten years after the bombings. Many survivors of trauma of all kinds

43. Schull to Howard Hamilton at the RERF, 11 May 1983, in “Howard B. Hamilton I:1:8,” April 1983, MC No. 66, Papers of Howard B. Hamilton, Series I, Box I, Houston Academy of Medicine–Texas Medical Center.

44. Committee on Dosimetry for the Radiation Effects Research Foundation et al., *Status of the Dosimetry for the Radiation Effects Research Foundation (DS 86)* (Washington, DC: National Academy Press, 2001).

45. The desirability of such a simulation was described to me in a telephone conversation with four of the leading developers of DS-86, who proposed that it would be the only way to resolve some remaining uncertainties. Phone interview, Bob Young, George Kerr, Dean Kaul, and Steven Egbert, 26 Oct 2016.

have difficulty remembering events related to the trauma. Discrimination against survivors might have led some to underreport their potential exposure; “indeed some survivors had written in their personal histories that they intentionally under-reported the exposure conditions or even hid the fact.”<sup>46</sup> Still others could have over-reported exposure because of benefits available through the Atomic Bomb Survivors Medical Treatment Law, which became effective in 1957 and provided free health examinations.<sup>47</sup> Questions of the survivors’ authenticity have been raised repeatedly, but what had happened to them was also written in their bodies. Radiation left characteristic signs of its presence, and biomedical researchers could not know “how well they [the histories] represent true conditions until the authors evaluate individual doses by a biologic approach.”<sup>48</sup>

In the 1980s, RERF dentists from the Department of Dental Radiology proposed that molars extracted from survivors might preserve a record of radiation exposure. Teeth might provide insight into the “true” dose for each survivor, and might be taken to be more reliable than the most recent assigned dosimetry system, DS-86.<sup>49</sup> Tooth enamel is a “unique inorganic body structure” in which radicals induced by radiation exposure are relatively stable and can be measured many decades later.<sup>50</sup> “Human teeth may be distinctive natural dosimeters,” a team at Hiroshima RERF proposed, “not

46. Kiyohiro Hamatani et al., “Improved Method for Analysis of RNA Present in Long-Term Preserved Thyroid Cancer Tissue of Atomic Bomb Survivors,” *Thyroid* 20 (2010): 1.

47. Kauanui notes that Indigenous peoples have been subject to standards of authenticity based on a colonial logic of biological and cultural purity— notions undergirded by succeeding schools of physical and cultural anthropology. Kēhaulani Kauanui, “Indigenous” in *Keywords for American Cultural Studies*, 2nd ed., ed. Bruce Burgett and Glenn Hendler (New York: New York University Press, 2014) 134.

48. Nori Nakamura, Yuko Hirai, and Yoshiaki Kodama, “Gamma-ray and Neutron Dosimetry by EPR and AMS using Tooth Enamel from Atomic Bomb Survivors: A Mini Review,” *Radiation Protection Dosimetry* 149, no. 1 (2012): 79–83.

49. William C. Roesch, ed., “US-Japan Joint Reassessment of Atomic Bomb Radiation Dosimetry in Hiroshima and Nagasaki: DS86, Dosimetry system 1986; Final report,” Appendix to vol. 1 (Hiroshima: Radiation Effects Research Foundation, 1987).

50. Motoji Ikeya, Toshikatsu Miki, Ayako Kai, and Masaharu Hoshi, “ESR Dosimetry of A-Bomb Radiation Using Tooth Enamel and Granite Rocks,” *Radiation Protection Dosimetry* 17 (1986): 181–84; Motoji Ikeya, Junko Miyajima, and Shunzo Okajima, “ESR dosimetry for atomic bomb survivors using shell buttons and tooth enamel,” *Japan Journal of Applied Physics* 23 (1984): 697–99; and Yuko Hirai, Yoshiaki Kodama, Harry M. Cullings, Chuzou Miyazawa, and Nori Nakamura, “Electron Spin Resonance Analysis of Tooth Enamel Does not Indicate Exposures to Large Radiation Doses in a Large Proportion of Distally-exposed A-bomb Survivors,” *Journal of Radiation Research* 52 (2011): 600–08.

only for acute radiation exposures but also for repeated small exposures or chronic gamma-ray exposures of radiation workers and people residing in contaminated environments.”<sup>51</sup> The use of electron spin resonance (ESR) to detect exposures in teeth from Nagasaki survivors was reported in 1988. Molars, particularly the inside of molars, turned out to be more suitable for enamel separation and ESR measurement. The outside of a tooth, the RERF group concluded, could have radiation signals from dental x-rays.<sup>52</sup> In a later study in 2012, three geneticists at RERF compared gamma ray and neutron results from tooth enamel and shell buttons worn by survivors with cytogenetic assessments of chromosomal anomalies.<sup>53</sup>

As this account suggests, RERF researchers have understood preserved biological materials (chromosomes and teeth) as a biological corrective to the uncertainties of survivor memory and the complexities of reconstructing an exploding city.

### **CONCLUSION? “TWENTY YEARS FROM NOW, THERE WILL BE ALMOST NO SURVIVORS LEFT”**

For most of its history, the ABCC-RERF has been approximately twenty years away from being closed down. In the 1950s, it was expected to terminate sometime in the 1970s. In the 1970s, it seemed like it would end in the 1990s. Today, a similar twenty-year future stretches ahead—a horizon just far enough away to require no action at the moment, by anyone. The survivors are all older than seventy, and many are much older. Will the institution established to study them outlive them? Do they “live on” in the Biosample Center, in their usefulness to science and medicine?

At various times in the history of the studies of the atomic bomb survivors, different parties have claimed a right to make scientific statements about their bodies, their health, and their experiences. Often these claims played with time (future and past) as a political or social resource. University of Michigan

51. Explanation of the RERF donor tooth program is Nakamura et al., “Gamma Ray and Neutron Dosimetry” (ref. 48).

52. Nakamura et al., “Gamma Ray and Neutron Dosimetry” (ref. 48).

53. Nori Nakamura, Chuzou Miyazawa, Shozo Sawada, Mitoshi Akiyama, and Akio A. Awa, “A Close Correlation Between Electron Spin Resonance (ESR) Dosimetry from Tooth Enamel and Cytogenetic Dosimetry from lymphocytes of Hiroshima Atomic-bomb Survivors,” *International Journal of Radiation Biology* 73, no. 6 (1998): 619–27.

geneticist Neel, who played a key role in the genetics project of the ABCC in Japan, also later worked with isolated groups in Latin America. When Neel went to Venezuela in the 1960s to study the Yanomamo, an isolated group living on the Orinoco River, he hoped his work there could leverage evolutionary history to chart a new human future: What should society look like, he asked, if society matched the evolutionary signs written in human biology?<sup>54</sup> Just as isolated groups could illuminate a human future drawn from their biology, so too were the survivors scientifically constructed as a resource for imagining survival after a nuclear war. The emphasis on the collection and long-term storage of blood, tumors, and urine that we see in studies of Indigenous groups throughout the Pacific and in other places around the world is also present in studies of the survivors and in the materials held in the biobank of the RERF. And if studying primitive isolates often constituted a kind of salvage project—the preservation of materials from people who would soon disappear—so too did the studies of the survivors. There would never be another population like them.

Bo Jacobs has suggested that radiation makes people invisible.<sup>55</sup> This invisibility too has a resonance with the ways that Indigenous groups are invisible, powerless, stripped of political autonomy. The survivors do not control lands, territories, or resources; but they do have a biological identity that they share with others exposed to radiation at Chernobyl, Fukushima, and other disaster sites. They are not “primitive” in the classic sense of the term—indeed, they are utterly modern and technoscientific. Brutalized by history, disempowered by the circumstances of war and military control, they have become a universalized resource for making new knowledge unrelated to radiation.

In a thoughtful 2012 report on biospecimens and biorepositories, three National Cancer Institute scientists noted that:

Biospecimens (blood, urine, tissue—fresh, frozen, paraffin-embedded, saliva, various cells) have been organized into formal collections in the U.S. for over 150 years, starting in the Civil War era with the pathology specimens that resulted in the largest collection in the United States at the

54. Susan Lindee, “Representing James V. Neel: Voices of the dead in the Yanomami controversy,” in *Lost Paradises and the Ethics of Research and Publication*, ed. Francisco Salzano and Magdalena Hurtado (Oxford: Oxford University Press, 2003), 27–48.

55. Robert Jacobs, “The Radiation That Makes People Invisible: A Global Hibakusha Perspective,” *Asia-Pacific Journal* 12, no. 31 (2014), <http://japanfocus.org/-Robert-Jacobs/4157>.

Armed Forces Institute of Pathology. Many smaller collections exist in pathology laboratories and clinics. And larger population-based collections are managed at multiple academic and clinical centers and at the National Institutes of Health.<sup>56</sup>

Yet there had long been, they pointed out, “a serious lack of attention to controlling the quality and consistency of collection, processing and storage of biospecimens.”<sup>57</sup> Inconsistent handling and record keeping undermined the value of the samples, and in many cases ethical and regulatory requirements were poorly understood or applied. Biospecimen management, they noted, is expensive. A large biorepository cost millions of dollars to construct and operate. Such facilities require sophisticated equipment monitoring and alarm systems, back-up generators for power failures, quality management protocols, and well-developed procedures for processing, storing, and shipping. Many collections are used across national boundaries as well, and protocols and practices acceptable in one location may not be acceptable in another. Most scientists received no training in the management of biospecimens, though in 2012, there was a movement to develop new degree programs built around a professionalized vision of biospecimen management. “The field of biobanking has evolved from the earlier view that simply embedding or freezing biospecimens with no consideration of preanalytical variables was sufficient, into a true scientific discipline. But it’s still a tricky endeavor,” they concluded.<sup>58</sup>

Many biosamples, like those held by the RERF, have been collected in different ways and with different intentions and protocols over the decades. While they seem to be future-oriented, intended to facilitate new discovery, they are also deeply historical. Biological materials drawn from the survivors are biodosimeters, having recorded the bombs’ detonations in scrambled chromosomes and CO<sub>2</sub> radicals in tooth enamel. They are also signals of future planetary risk. Experts in Japan saved atomic bomb survivor teeth, blood, and tumors for what seemed at times to have been almost spiritual and philosophical reasons. The biological samples were a kind of Rosetta Stone for interpreting the future. Produced at the very moment of fracture and collected in

56. Jimmie B. Vaught, Marianne K. Henderson, and Carolyn C. Compton, “Biospecimens and Biorepositories: From Afterthought to Science,” *Cancer Epidemiol, Biomarkers & Prevention* 21, no. 2 (2012): 253–55.

57. *Ibid.*

58. *Ibid.*, 255.

the course of biomedical research at the nuclear Pacific's ground zero, the samples are permanently marked by a form of energy that threatens humanity. The marks could be deployed to solve problems of dosimetry, of cancer risk, or to evaluate the risks of escalating energy demands around the world. They could also be applied to broader goals of biomedical research. The flat technical accounts of florescence in situ hybridization (FISH) and polymerase chain reaction (PCR) and cytogenetic data can barely hold in check the sense that these materials somehow represent the "destiny of mankind." Death, judgment, heaven, and hell are entangled with tooth enamel electron paramagnetic resonance.

Some intriguing work in science studies has suggested that ritual practices may be a critical part of the process that turns biological materials into the bearers of generalized knowledge.<sup>59</sup> Michael Lynch makes the role of "sacrifice" in experimental biology explicit, proposing that "the violence done to the animal victim is part of a systematic consecration of its body to transform it into a bearer of transcendental significances."<sup>60</sup> Anthropological work has also explored how relics, remains, bones, and native arts can and do acquire more general value as those from whom they came are about to disappear. Indigenous inhabitants whose presence was a challenge to settlement, agriculture, economic growth, or land tenure have often become the focus of sacralized memory at the very moment they were officially "vanishing." Such sacralization may be historically necessary to the prosperity and social order of those who have taken over their land: things become sacred when those from whom they were taken can no longer challenge systems of power. The romance of human remains depends on the disappearance of those from whom they came.

I would propose that the RERF biobank raises similar questions of mobility, value, circulation, destruction, memory, and political organization. Samples can gain increased scientific value as they become embedded in different scientific explanations, and they are both destroyed and perpetually renewed, as they are stored in freezers, enhanced with PCR, and circulated in transnational knowledge networks. The biological samples involve an act of sacrifice—the willingness to contribute one's bodily materials to science—and they

59. Michael E. Lynch, "Sacrifice and the Transformation of the Animal Body into a Scientific Object: Laboratory Culture and Ritual Practice in the Neurosciences," *Social Studies of Science* 18, no. 2 (1988): 265–89.

60. *Ibid.*, 265.

testify to the passage of time, both past and future. By analogy, the first peoples of the atomic age—the “most important people living”—can become precious, priceless, and highly valued, because they have been vanquished, subjected to the violence of the atomic bomb, to the Allied occupation of Japan, and to scientific control that constructs their bodily materials as general resources for knowledge production.

That the remains of the survivors are uniquely precious is a common theme in the scientific construction of their meanings. “Understanding the effect of radiation on the human genome remains an important challenge and RERF has precious biosamples to help mankind learn how sensitive the genome is to radiation and how much genomic variation affects the transport of radiation risk to other populations,”<sup>61</sup> said a 2012 report on the RERF biobank. The precious biosamples promise an epidemiology without end—the chance to study the survivors *forever*. Indeed, the RERF continues to look forward to another twenty years of research: “Twenty years from now, there will be almost no survivors left. So does that mean no RERF?” RERF Scientific Director Ohtsura Niwa told a journalist in 2015, “No. We intend to keep on going, to do something for the next generation.”<sup>62</sup>

Both the institution and the data are imagined as endless.

61. Evan Duple and Roy E. Shore, “Future Plans and Structure for Research in the Basic Sciences at RERF: A Summary of a Workshop Held at the Radiation Effects Research Foundation,” *RERF Update* 23, no. 2 (2012): 11–14.

62. Julie Makinen, “US Scientists have been quietly working in Hiroshima for decades,” *LA Times*, 26 May 2016.