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Global Hibakusha

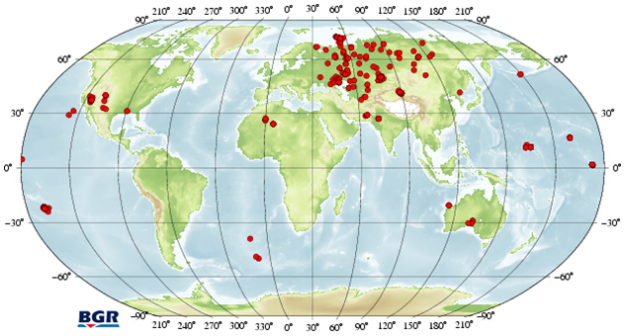
Robert Jacobs

Abstract: My book Nuclear Bodies: The Global Hibakusha has just been released by Yale University Press. The book is based on more than 10 years of research on the Global Hibakusha Project with my research collaborator Mick Broderick. This article provides a short overview of the book; you can learn more and watch some lectures at the book's website: Nuclear Bodies: The Global Hibakusha.

Keywords: global hibakusha, atomic bomb, Hiroshima, Nagasaki, Cold War, radioactivity, black rain

Who are the "global hibakusha"? As many of us know, hibakusha is the Japanese word used to refer to those who survived the two nuclear attacks conducted by the United States against the people living in Hiroshima and Nagasaki in 1945. Those attacks killed between 100,000 and 200,000 human beings instantly, and wounded as many. Hundreds of thousands of survivors were exposed to radiation from the attacks. In the face of this horror, we calm ourselves with the reassuring thought that nuclear weapons have not been used since 1945. However, there have been over 2,000 nuclear weapon detonations since then, and because of the size of the weapons and the scale of their effects, millions of people have been exposed to radiation under their fallout clouds, even as the detonations are called "tests." Millions more have been exposed from nuclear production and nuclear accidents. **These millions are the global hibakusha.**

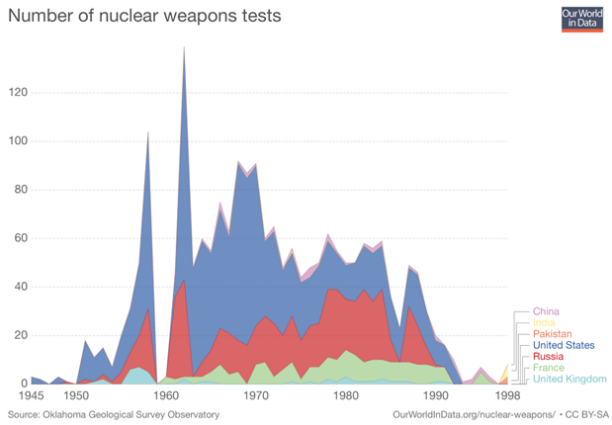
Many think of the Cold War as a period in which nuclear weapons were never used. However, statistically, a nuclear weapon was detonated every 8.6 days between 1946 and 1989. In reality nuclear weapons were exploding constantly throughout the Cold War. Nuclear Bodies assesses the consequences for those living close to the locations of those detonations.



Global nuclear weapon test sites.

Nuclear weapons have been tested on every continent except South America and Antarctica. The site with the most nuclear weapon tests on Earth is the Nevada Test Site in the United States with over 900 nuclear weapon detonations. The primary nuclear testing site of the former Soviet Union was in modern day

Kazakhstan, with almost 500 nuclear explosions. The people living near test sites have had profound experiences with radioactive fallout. Several nuclear weapon states have conducted tests in the Pacific, the U.S. in the Marshall Islands, the French in French Polynesia and the British in Kiribati. There were more than 200 tests in the Russian Arctic near Scandinavia, including the largest thermonuclear weapon ever detonated.



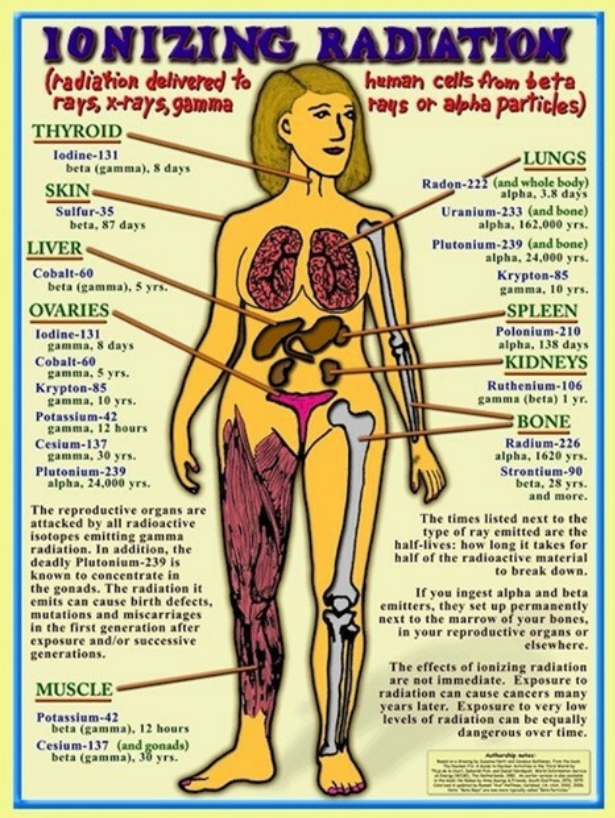
Distribution of nuclear tests by year.

Testing numbers rose quickly in the early Cold War when most detonations were conducted in the atmosphere, many distributing significant amounts of radioactive fallout far from the test sites. In 1962 there were 178 nuclear weapon tests—statistically, a nuclear detonation virtually every other day throughout that year, including massive hydrogen bomb tests.

While no population was directly attacked with nuclear weapons after Hiroshima and Nagasaki, exposure to radioactive fallout can be understood as an attack. To understand this, it is necessary to grasp how exposure to radioactive waves and radioactive particles differ. When a nuclear weapon is detonated, living creatures are exposed to radiation in two distinct ways. The detonation itself produces a burst of gamma and neutron waves that radiate out from the epicenter. This burst is only one form of the energies that radiate outward from the detonation; the other primary forms being blast and heat. These energies radiate from the epicenter and dissipate as they spread outward. The radioactive waves pass right through most matter they encounter, including buildings and bodies. In Hiroshima, for everyone within 3 kilometers of the detonation, large amounts of radioactive waves passed through your entire body, damaging cells and organs. This happened even if you were inside of a building, since they also passed through the structures. Beyond 3 km the energy of the waves dissipated to a less harmful level. The burst of radioactive waves lasts less than a minute: similar to an x-ray, it is turned on and then off, leaving no radiation behind. Those closest to ground zero may have died in hours, days or weeks. Others slowly developed diseases over the subsequent years and decades, and many experienced early mortality.

Many people were also exposed to radioactive fallout. This is radioactive material in the form of particles: stuff that sticks around. Some is unfissioned material (uranium-235 or plutonium) from the weapon, some are fission products produced by the detonation, and some are particles that are ionized (made radioactive) by the detonation. These particles rise up into the mushroom cloud, and as the cloud spreads downwind they “fall-out” of the cloud to the surface of the Earth. Unlike gamma waves these particles remain radioactive. Some are dangerous only for days or weeks, and some are dangerous for hundreds, or even hundreds of thousands of years. Once they deposit from the cloud to the ground, they can be internalized inside of and often retained by the body. Being chemicals, the body reacts to them as chemicals—it uses them. The body uses iodine in the thyroid gland, so if it internalizes iodine-131, the

radioactive isotope of iodine, it puts that in the thyroid too. Strontium-90, produced in significant amounts by nuclear weapon explosions, is chemically similar to calcium, so once internalized the body uses it in the bones and teeth. In 1957, U.S. AEC Commissioner Willard Libby referred to strontium-90 as a "bone seeker."[1] These particles don't give off large amounts of radiation, but once internalized into the body they emit this energy to the cells immediately around them 24 hours a day.



Where in the body common fallout from radionuclides tends to be retained.

In Hiroshima the mushroom cloud drifted to the northwest and large amounts of fallout came down with rain (precipitation strips particles from the atmosphere) and when combined with the soot from the burning city fell as "Black Rain." Those who lived in the areas where the black rain fell also began to develop sickness from their exposure to radiation. Most Black Rain sufferers were too far from the city center to have experienced exposure to any of the energetic wave effects of the nuclear attack, blast, heat or radioactive waves. It took a long time for doctors to understand that those exposed to Black Rain were hibakusha—that they were suffering from exposure to radiation. It was just last year, 2021, that these sufferers had their legal rights as hibakusha in Japan recognized by a court decision after decades of litigation.

Why did it take more than 70 years to legally recognize those exposed to radioactive fallout as hibakusha in a country where the legal recognition of harm from radiation (designated status as a hibakusha) had been established 64 years earlier? Much of the invisibility of the Black Rain hibakusha, and of the global hibakusha, is rooted in medical models of harm from radiation.

Soon after the nuclear attacks on Hiroshima and Nagasaki it was recognized that the existence of more than 100,000 hibakusha presented an unprecedented research opportunity. Beforehand, the number of people who had been understood to have been exposed to radiation numbered in the hundreds and were spread out over several decades. Medical information about the consequences to human health and mortality from radiation exposure had been extrapolated from these cases, animal studies, and probability models. Because of the use of nuclear weapons on human beings, there was now a massive cohort of radiation-exposed individuals who could be studied collectively to build a much more comprehensive model of what radiation does to human health. The United States established the Atomic Bomb Casualty Commission (ABCC) in 1946 in both Nagasaki and Hiroshima to begin research on the effects of their exposure

to radiation on the hibakusha and their descendants. The most consequential of their studies was the Life Span Study (LSS), begun in 1950 and continuing today by the Radiation Effects Research Foundation (RERF), the successor laboratory to the ABCC.

The LSS sought to establish a robust database which correlated radiation exposure to subsequent health outcomes. This database was built on two data points, determining how much radiation each participant was exposed to, and tracking their disease history and age of mortality. Building a database on this information for more than 200,000 people was intended to yield a powerful statistical tool to assess risk for anyone exposed to radiation in the future: if an exposure dose is known, the statistical probability for various health effects can be predicted. There are various problems in the design of the study, for example the fact that participants' dose reconstruction was done based partly on memory and interviews (less than ideal sources for statistical data components). Nevertheless, it is a widely respected and globally cited study. It is often referred to as the "gold standard" of radiation health effects data.

For my work, the most important thing about the LSS is that it only considered external exposure. Participants' dose is reconstructed wholly based on their estimated exposure to the burst of radioactive waves in the minute of the detonation. There is no information about harm from internalizing radionuclides. There are very good reasons for this parameter. In the 1950s it was not possible to determine whether someone had internalized a radioactive particle; whole body counters, which can make that assessment, each weighing 60 tons, only became available in 1964. Additionally, hundreds of thousands of people had been in the area affected by the massive burst of gamma rays, so working to compile information about their exposures and health outcomes was a massive research endeavor.

As Susan Lindee has pointed out, many imagined the future would be one in which many nuclear weapons would be used in warfare, feeling that "[A]ll conjectures about the nature of the imagined post-war world must be drawn on the experiences at Hiroshima and Nagasaki."[2] But this was not what occurred. Nuclear weapons have never again been used directly in military conflict. The experiences of the hibakusha in Hiroshima and Nagasaki did not become common. What did happen is that 520 nuclear weapons would be tested in the atmosphere and create fallout clouds that spread radionuclides downwind. What became common was the experiences of the people who endured the Black Rain—the people it has taken 76 years to recognize as victims of exposure to radiation in the country most legally accepting of such status. Internal exposures, not external exposures, is what the Cold War wrought.

When communities downwind from nuclear test sites claimed to be suffering from health problems because of their exposures, invariably the nation that irradiated them, and their local government (if separate), would cite the LSS to dismiss their claims. With rare exceptions, local externally measurable levels of radiation were not high enough to correlate with expected health problems when using the database. This was the wrong tool for the job. The LSS predicted health outcomes after exposures to a single massive exposure to external radiation. However, the people downwind from the test sites were internalizing particles, as had those in the areas of Black Rain. Measurable levels of radioactive rays may have been low, but the presence of radioactive particles in their ecosystems put them at risk, and for many, affected their health. The LSS tells us nothing

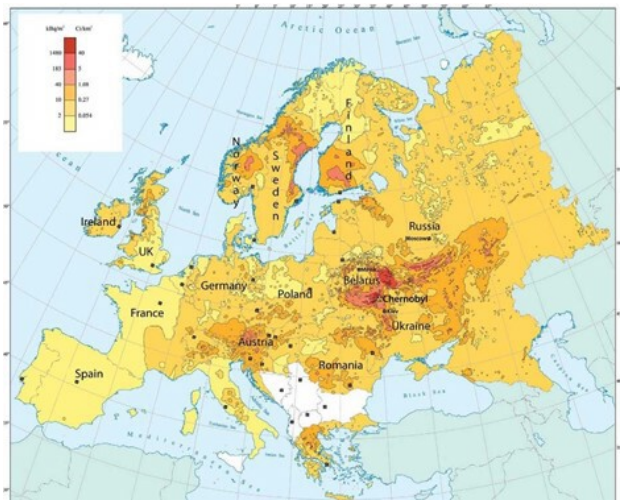
about the risks to health from internalizing radiation. It was not useful for assessing or maintaining community health, but it was useful for dismissing the claims of fallout victims and deflecting monetary and political liability. This has been the screen behind which the nuclear weapon states maintained the brutality of their nuclear testing programs, and the invisibility of the harm caused to those beneath the fallout clouds.

Other cohorts of global hibakusha have experienced different modes of contamination, but the routes of exposure are similar: internalizing radioactive particles. Many uranium miners have inhaled uranium particles and it has long been known that there is a high incidence of lung cancer among them. The presence of immense piles of uranium tailings alongside mines, left behind by operators when mines are abandoned, have long polluted the water, food and homes of those living in the area. A 2019 study determined that more than 25% of mothers and infants born in the Navajo Nation had extremely high levels of uranium in their bodies, even though active mining had ceased there by the mid-1980s.

Those who live near plutonium production facilities (nuclear reactors and chemical separation plants) as at Hanford, Washington, or uranium processing facilities that play a role in the enrichment of uranium, find high levels of radionuclides in the water, food and soil of their ecosystems. The "Green Run" experiment at Hanford in 1949, in which nuclear fuel was processed to extract plutonium when it was "green," (without waiting for short-lived radionuclides to decay) so that intelligence might be gathered that could help assessments of the plutonium production capacity of the Mayak facility (the Soviet Union's Hanford site) led to a massive release of iodine-131 that contaminated most of Eastern Washington and Central Oregon (seriously, click the link and read about this). This radioiodine surely made it into the milk consumed by the majority of the children living in the region. A plume of radioactive water leaking from the Hanford Tank Farm has been migrating towards the Columbia River for decades. People live, farm and raise families in the area. Radioactive waste from the Mallinckrodt Company which operated uranium processing facilities in and around St. Louis during the Manhattan Project and the Cold War, was buried and abandoned in several locations. Several tons ended up in the West Lake Landfill in Coldwater Creek, Missouri. A 2014 report by the state of Missouri found that the presence of the waste had caused a significant increase in cancers to those living nearby, something which they had become viscerally aware of before the study. Even more concerning is that an underground fire has been burning in the landfill for years, moving steadily closer to the radioactive waste. If the waste was to catch fire, the risk for residents, and anyone downwind of the fire, would be catastrophic. This is not the first fire to have burned in the landfill. These are just two of more than 100 weapon production sites in the United States that require remediation from radiation and toxic chemicals, and that have harmed nearby populations.

Nuclear reactors were invented by the Manhattan Project to produce plutonium for nuclear weapons: they were developed before nuclear weapons. I have argued elsewhere that nuclear power was "born violent." Since their invention, nuclear fuel melting has occurred roughly once per decade. There were two major nuclear accidents within 11 days in 1957 at military reactors used to manufacture plutonium (Mayak in the former Soviet Union and Windscale in the UK). In 1986, unit #4 exploded at the Chernobyl Nuclear Power Plant in Ukraine, in the former Soviet Union. A fire burned in the melted reactor core for over two weeks, belching radioactive fallout over vast sections of Europe. You can view a reconstruction of the spread of the fallout from the 1957 Windscale Fire over much of the UK and Northern Europe utilizing weather data

and modern computer modeling here.



A map showing the distribution of cesium-137 from that fallout plume that remains measurable on the ground in Europe 30 years after the disaster.

This cesium-137 continues to show up in food products throughout Europe every year, especially jams, mushrooms and wild boar (who eat the mushrooms). While we think of Chernobyl as a disaster that occurred in the past, it continues to present risk to people living far from the site who were not yet born. The triple meltdowns at Fukushima spread radioactive clouds throughout the region, with the primary deposition of fallout being to the northwest of the plants. There too, cesium-137 continues to spread through the ecosystem. As a chemical, cesium-137 is very adept at migrating in nature. It easily passes from air to soil to water to plants to biota. It remains radioactively dangerous for about 300 years, meaning that once it has deposited and embedded into an ecosystem, centuries of risk will follow. In towns affected by the fallout in Northern Japan from the 3.11 Fukushima nuclear meltdown, the government engages in "decontamination." However, the towns being decontaminated are surrounded by contaminated mountains and forests. It cannot be separated from the larger ecosystem, so although soil can be placed in plastic bags and moved "somewhere else," the particles embedded in the ecosystem surrounding the town will migrate back in with rain and wind and the natural dynamics of life. I argued last year in this journal that you cannot draw a circle in nature which allows you to successfully isolate the inner circle from the natural world that envelopes it. We must understand such contaminations as holistic events that will affect a large ecosystem over a broad period of time. Human beings are a part of those ecosystems, we are also embedded in them.

Because the dangers from these radionuclides are widely dispersed in both space and time, we can have no certainty whether we or our loved ones will suffer, or will navigate between the raindrops of risk. This uncertainty can itself be destabilizing even if sickness never comes. For those who lived here in Hiroshima and in Nagasaki after the nuclear attacks, no one knew who might develop cancer or other radiogenic diseases, and who would live to old age: many who never got sick spent lifetimes worrying. Those living where the fallout deposited from Chernobyl, from Fukushima, and from the dozens of nuclear test sites can't be certain what their risks are, and where dangers lie. Living in a particle rich environment can bring deep stress and anxiety, separate from illness. Everyone in such a situation worries about the health of their loved ones, especially children.

Defenders of nuclear technologies have pathologized such anxieties, calling them "radiophobia." This they define as an "irrational" fear of radiation, and present it as a mental health diagnosis. I argue that when long-lived radioactive particles deposit into the ecosystem where you live, and from where your

food is obtained, anxiety is a rational response. Chastising those living through such events as irrational because they are worried is cruel. It is victim blaming. People who find themselves downwind from nuclear fallout clouds, whether from weapon detonations or reactor accidents need support, not disdain.

This inclination to focus on public perceptions and relations in response to radiological contamination has been endemic throughout and since the Cold War. When former contaminated sites of U.S. nuclear weapons production are shut down, they are not simply remediated, they get a toxic make-over and are presented as pristine nature preserves. The Rocky Flats Plant outside Denver is where the U.S. deposited the plutonium produced at Hanford and Savannah River into pits—the fissile cores of nuclear weapons. It was the site of multiple fires that dispersed aerosolized plutonium across wide areas. In 1989, a task force made up of officials from the FBI and the EPA conducted an unprecedented raid on the DOE facility and found mind boggling violations of environmental regulations in the routine practices at Rocky Flats. The raid led to the end of pit production and the closure of the site. At the time operations ceased at the plant, there were 3 metric tons of plutonium onsite. Early estimates outlined a 65-year remediation process that would cost almost $40 billion, yet, just twenty years later the Rocky Flats National Wildlife Refuge opened to the public, sporting 18 km of hiking trails. Why this cosplay? Wasn't it enough to simply close down the site and keep the public out? The Colorado Front Range, where the Refuge is located, is laden with beautiful and accessible nature reserves and hiking trails. The Rocky Flats National Wildlife Refuge offered nothing specifically new or valuable to the community. This was not just done at Rocky Flats, multiple former nuclear weapon production facilities experienced rhinoplasty to be returned to society as access points to the natural world in a spectacular effort at nuclear greenwashing. Nuclear weapon sites across the globe have also been greenwashed. Apparently, following the remediation of the sites is the remediation of our memories.

Writing in a 2018 report intended for internal distribution only, Roger and Linda Meade described how, "When Trinity's radioactive debris contaminated the grain fields of the Midwest, the response was to move testing to the Marshall Islands, where the seemingly empty ocean that [sic] would swallow any radioactive fallout. This scheme worked until Bravo demonstrated that the world was not big enough to hide the radioactive fallout from thermonuclear detonations."[3] Throughout the history of nuclear weapon testing there has always been a careful selecting of the irradiated. As pointed out above, once it was understood that the Trinity Test had spread fallout inside the United States, the U.S. moved its nuclear testing program outside of the continental United States when testing resumed one year later. Not wanting to expose Americans to radioactive fallout, they selected the Marshallese as acceptable to irradiate.

All nations that tested nuclear weapons in the atmosphere made similar calculations. The Soviets chose Kazakhstan as their test site, a place that First Deputy Premier Beria claimed was "uninhabited." The Kazakhs were both ethnically and religiously different than the dominant Russian population. Both the British and the French never tested one of their nuclear weapons inside their own countries; they conducted all of their weapons tests in former or current colonial spaces. The British first tested in Australia, far from the cities populated with white Australians, on the lands of several indigenous communities. Because of the scale of the fallout clouds from thermonuclear weapons, the Aussies refused to let them be tested in Australia, so the British conducted their H-bomb tests on Christmas Island in Kiribati. The French first tested in Algeria while it was still a colony, and during

the Algerian War of Independence. Knowing that they were losing the war, even as they tested in Algeria they began to build a second site in a second colony, French Polynesia. The Chinese tested in the far western Xinjiang Province, the traditional home of the Uyghur people, again, both ethnically and religiously distinct from the Han Chinese population. Chinese hostility towards the Uyghur people continues today.

No nation tested nuclear weapons upwind from their own economically powerful and politically resourced populations. When the U.S. built a second test site in the continental United States it was placed amidst Native American and Hispanic communities, and just upwind from majority Mormon populations in Southern Utah. There was a protocol at the Nevada Test Site to not test when the wind was forecasted to blow to the south, which would carry the fallout clouds to Las Vegas and Los Angeles, but to test when the winds were forecast to blow to the east: again, selecting the irradiated.[4]

These decisions were made because it was clear that exposure to radioactive fallout was dangerous. This was understood militarily even before the Trinity Test. Both the U.S. and the Soviet military discussed dropping sand laden with uranium particles from airplanes to kill enemy troops and contaminate enemy territory during World War Two. When the Allied forces came ashore on Normandy Beach on D-Day in 1944, personnel carried Geiger Counters because of fears that the Nazis might have salted the beaches with uranium to contaminate and sicken the attackers.

The first postwar tests conducted in 1946 by the U.S. at Bikini Atoll in Operation Crossroads were an unmitigated radiological disaster. The second test, the Baker Test, was detonated underwater which meant that all of the radionuclides that would normally rise up into a cloud and be dispersed downwind simply remained in the water of the lagoon. As U.S. military personnel continued to work in the lagoon their exposure to radiation rose day after day until the Joint Task Force conducting the tests had to evacuate the 40,000 troops and scuttle the planned third test. This setback still enabled a detailed and extensive study of how radionuclides move through an ecosystem on the part of marine biologists working for the Atomic Energy Commission. Here is a film that they produced about their work in which they refer to Bikini Atoll as a "radiobiological laboratory."

The top-secret 1947 report on Operation Crossroads included a chilling and clear understanding of the use of radioactive fallout as a weapon, and as a means of inducing terror in a population:

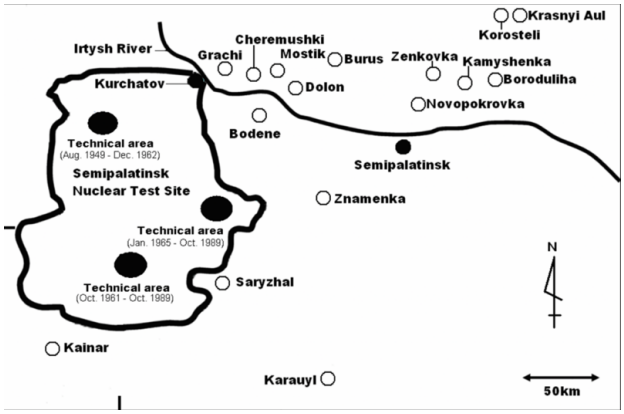
1. Test Baker gave evidence that the detonation of a bomb in a body of water contiguous to a city would vastly enhance its radiation effects by the creation of a base surge whose mist, contaminated with fission products, and dispersed by wind over great areas, would have not only an immediately lethal effect, but would establish a long-term hazard through the contamination of structures by the deposition of radiological particles.
2. We can form no adequate mental picture of the multiple disasters which would befall a modern city, blasted by one or more atomic bombs and enveloped with radioactive mists. Of the survivors in contaminated areas, some would be doomed to die of radiation sickness in hours, some in days, and others in years. But, these areas, irregular in size and

> shape, as wind and topography might form them, would have no visible boundaries. No survivor could be certain he was not among the doomed and so, added to every terror of the moment, thousands would be stricken with a fear of death and the uncertainty of the time of its arrival.[5]

There is no ambiguity in the understanding that the U.S. military had of the effects, and the military utility, of radioactive fallout immediately after the third of what would be more than 2,000 nuclear tests. Communities of people affected by the radioactive fallout from U.S. (and other nations') nuclear tests would understand precisely what was being described in this report, even as the militaries that irradiated them dismissed their claims and concerns.

This is a question posed in the book: when is a test an attack? The massive cloud from the Bravo Test at Bikini Atoll in 1954 killed a Japanese fisherman located over 100 miles away from the hypocenter, and sickened hundreds on other fishing boats and multiple downwind atolls. American and Soviet nuclear war planners both recognized and integrated the capacity of large fallout clouds to kill both combatants and "laborers" downwind from detonation points into nuclear targeting strategies. This understanding of fallout clouds led President Kennedy to warn Americans in the fall of 1961 that the most damaging aspect of a potential Soviet nuclear attack on the U.S. would be deadly fallout clouds that extended for hundreds of miles. Yet, Kennedy approved 96 nuclear weapon tests for the following year, including those involving thermonuclear weapons. The thermonuclear tests were all kept in the Pacific to spare Americans from the deadly clouds Kennedy warned about. By selecting who would not be subjected to those clouds he was also selecting who would be.

The Cold War was a limited nuclear war. Since no population was attacked directly with the weapons, and no one was subjected to the blast and heat of the detonations, it was never classified as a nuclear war. However, millions of people were subjected to radioactive fallout and had their bodies, their land and seas contaminated with radionuclides. The Cold War nuclear war was limited—limited to this one effect, the fallout radiation—the effect that President Kennedy said "could account for the major part of the casualties."[6] But residents of the Kazakh villages located 30 km from the Polygon where more than one hundred atmospheric nuclear tests were conducted, including several H-bombs (and more than 300 underground tests) endured ongoing attacks from the effects of nuclear weapons.



Map of villages downwind of the Polygon in Kazakhstan.

The book concludes with some reframing of our understanding of nuclear waste. I make several arguments, the first being that we need to recognize that the deadliest of our high-level

nuclear waste, the spent fuel from operating reactors or making weapons, is the most consequential thing ever produced by the human species. Long after our cities have crumbled, long after our languages are incomprehensible, long after our gods are dead, our spent nuclear fuel will still be here. Several hundred thousand metric tons (currently) of spent nuclear fuel, laden with uranium and plutonium, will still be intact and dangerous to living creatures for thousands of generations. It may be how our descendants know us: the people who made the nuclear waste that they have to live with.

We plan to build deep geological repositories (DGRs) to store this waste. This means making vast containment structures half a kilometer underground that must remain intact and dry for 100,000 years. A great deal of scientific planning and testing is going into this effort, and using the KBS-3 method developed in Sweden, the Onkalo site in Finland will soon be placing the first spent fuel in human history into "permanent" storage. Work has been done on the geological nature of the site itself, the construction of the copper canisters that will hold the spent fuel rods, and bentonite clay that will backfill the site upon completion, and multiple additional segments of the plan. This is all very solid and reliable research. However, what we can grasp in a few decades of research and what eventuates over 100,000 years are unlikely to line up perfectly. As for all human technological endeavors, we will probably get it a little bit right and a little bit wrong. Tremendous research has gone into the design and operation of nuclear reactors, and for the most part they have operated as intended. But not always. Even when we get it mostly right, and a little bit wrong, with technologies of this scale, and bearing risks of this magnitude, the little bit wrong part remains catastrophic.

When we approach problems of this magnitude, we remain embedded in our current moment, no matter the degree to which we think we are planning long-term. Firstly, we made this waste with no capacity to dispose of it. Now that we are proceeding with plans for disposal, they continue to reflect this limited perspective. Multiple countries that have begun construction of DGRs, and others in advanced planning stages, searched for the best locations for these millennia long repositories, and just happened to have found that the most ideal sites are already existing nuclear power plant sites, or military sites. Onkalo in Finland is located alongside one of Finland's two nuclear complexes. Sweden plans to build its DGR at one of its existing nuclear complexes. In both cases, the land is already owned and the local population largely employed or dependent on the industry. Local political approval was far less contentious in such locales as they were far from industrial areas. What divine providence that the optimum sites are so convenient for local 21st century politics.

Many nations have operated nuclear reactors, and accrued spent fuel that it must dispose of, yet not every nation is anticipated to be geologically stable for millennia. A clear example is Japan, which operated 54 commercial nuclear reactors before most were powered down after the Fukushima meltdowns of March 2011. Japan has thousands of tons of spent nuclear fuel and is geologically unstable. It was an earthquake that sparked the Fukushima meltdowns. Geologically, Japan is a spiderweb of fault lines and volcanic zones. There is no good place to build a deep geological repository inside Japan. Yet, Japan will build one because the waste was generated by "Japan," a construct that is likely to be meaningless to people sharing an ecosystem with buried Japanese waste in 40,000 years. Will we make choices with those people in mind? Or will we make choices based on the "necessities" of the politics of our current time? We all know the answer to that: we will bury

our nuclear waste within the lines of our current political maps, all the while claiming we are focused on protecting future generations.

Another key site where we can see the dysfunction of our strategies for protecting future generations from harm from our radioactive waste is in the marking of our waste sites. Nuclear semiotics is a field drawing expertise from multiple disciplines to strategize how to warn future generations of the dangers of our nuclear waste being buried under their communities. Since the waste will remain dangerous beyond 100,000-years we are aware that language is not likely to be sufficient. All of our plans position us as teachers and future generations as minds and feelings that need to be shaped by us from our place of wisdom. We either have to sufficiently inform them about the waste using language or images, or scare them using monumental sculpture or barriers. We cannot grasp the most fundamental fact: that the presence of our radioactive and toxic waste in their world is the message. We had so little consideration for their ecosystem that we buried hundreds of thousands of tons of the most toxic material we could make there; material that only provided benefits to us. We think the information we give them about this act somehow makes the act acceptable. I argue that any message must begin with an apology. Without an apology from us for putting them in this position, why would they listen to anything else we say?

When we released massive amounts of radionuclides into the ecosystem during Cold War nuclear testing scientists used them as radioactive tracers to study the dynamics of global systems. This helped us to grasp atmospheric dynamics and global ocean flows. Once in the ecosystem these particles embed and migrate as do all other materials. We observed the Earth function as a single ecosystem. A 2021 study found cesium-137 from nuclear testing in Nevada in multiple samples of honey gathered on the East Coast of the U.S. 58 years after atmospheric testing there concluded. The global distribution and ubiquitous presence of these radionuclides help us to determine forgeries in the sale of paintings and vintage wines. The spread of radioactive fallout around the world is not something that happened, it is something that is still happening.

All of these issues, and many more are explored in detail in my new book, Nuclear Bodies.

You can visit this website for the book, and find links to order it from numerous online booksellers: Nuclear Bodies: The Global Hibakusha.

Robert (Bo) Jacobs is a historian of science and technology at the Hiroshima Peace Institute and Graduate School of Peace Studies at Hiroshima City University. He has published widely on the interface of nuclear technologies with human beings and communities. His book, *Nuclear Bodies: The Global Hibakusha*, was published by Yale University Press in 2022.

Notes

[1] Willard K. Libby, "Radioactive Fallout," *Proceedings of the National Academy of Sciences* 43 (1957): 765.
[2] M. Susan Lindee, *Suffering Made Real: American Science and Survivors at Hiroshima* (Chicago: University of Chicago Press, 1994): 4.
[3] Roger A. Meade and Linda S. Meade, *"The World, We Think She Start Over Again": Nuclear Testing and the Marshall Islands, 1946–1958,* internal distribution report no. LA-UR-18-30848 (Los Alamos, NM: LANL, 2018): 116.
[4] James Rice, "Downwind of the Atomic State: US Continental Atmospheric Testing, Radioactive Fallout, and Organizational Deviance, 1951–1962," *Social Science History* 39 (Winter 2015): 656.
[5] "The Evaluation of the Atomic Bomb as a Military Weapon," *The Final Report of the Joint Chiefs of Staff Evaluation Board for Operation Crossroads,* Enclosure "A," JCS 1691/3 (30 June 1947): 57–89.
[6] John F. Kennedy, "Letter to the Members of the Committee on Civil Defense of the Governors' Conference," 6 October 1961 (accessed 10 March 2022).