RADIATION reassessed

Lessons of Hiroshima and Chernobyl

The end of the Cold War may have eased the threat of atomic holocaust, but it didn't squelch the controversy about the health effects of ionizing radiation. Some scientists say there's no safe level, others **vehemently** disagree. Billions of dollars, and thousands of lives, hang in the balance. What do we know about the health effects of low doses of ionizing radiation?

About one hour after the bombing of Hiroshima on 6 August 1945. © U.S. Army.

51 years later, the study of radiation exposure in Japan continues.

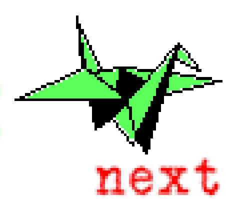
The explosion and fire at Chernobyl caused a colossal radiation release. Any lessons there?

A small dose of radiation couldn't hurt you, could it?

Maybe it's **actually healthy**. Excuse me???

Here's information on measuring this invisible energy.

Meet The Why Files team, and our experts for this issue.



A NISE Project funded by NSF TALK to us...

There are 1 2 3 4 5 6 7 8 9 10 11 12 documents. (Update: 6 Mar 2002 | Glossary | Bibliography)

RADIATION reassessed

A-bomb survivors continue suffering

The atomic bombings of Hiroshima and Nagasaki in August, 1945, ended World War II with a fiery blast of radiation and death, causing an estimated 140,000 deaths by the end of 1945. They also started the largest and longest study of the health effects of radiation, under the auspices of the Radiation Effects Research Foundation (RERF), headquartered in Hiroshima.

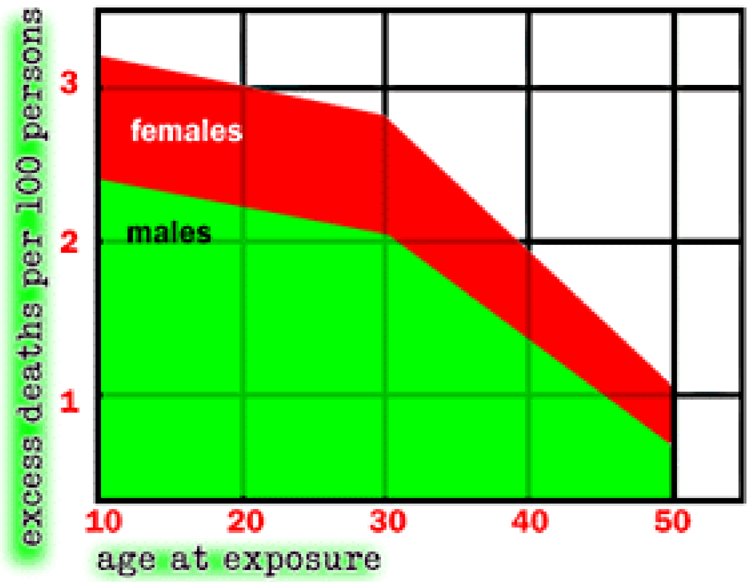
The hypocenter and the Atomic Bomb Dome. Formerly the Hiroshima Prefectural Building for the Promotion of Industry, the "Atomic Bomb Dome" can be seen from the ruins of the Shima Hospital at the hypocenter. The white structure is Honkawa Elementary School. The tombstones in the foreground are at Sairen-ji (temple). November 1945. Image © US Army. Source: A-Bomb WWW Museum.

The original investigations in Hiroshima and Nagasaki were performed by the Atomic Bomb Casualty Commission, which concentrated on looking for genetic abnormalities caused by the blasts. By the time RERF was formed, in 1975, the focus had shifted to cancer and other diseases. Every few years, the group sums up its research. And the latest report (covering data collected through 1990) contains disturbing news: the increased cancer risk faced by people who survived the bombs' heat, blast, gamma rays and neutrons is not disappearing.

If anything, the risk is increasing, says Donald Pierce, a RERF researcher. "For those exposed at ages less than 30 years, nearly half of the excess deaths during the entire 40 years of follow-up have occurred in the last five years." See "Studies of the Mortality..." (in the bibliography).

Furthermore, the younger you were at the time of the blast, the higher your risk of developing cancer, as we see in this graph. However, notes Preston, "This is largely because their background risks [of cancer] have so far been very small."

Projected Lifetime Risk for Solid Cancer Mortality at the Mean Dose 200 mSv (millisievert) for Exposed Subjects (here's help with radiation measurement lingo).



Women have a much higher relative risk than men, for the same radiation exposure. People who are younger at exposure have greater risk of radiation-induced cancer. The total number of cancers deaths that would be expected in the absence of radiation exposure ranges from 15 to 28 per 100 people (depending on sex and age at start of follow-up). Graph data courtesy of Dale Preston, RERF.

The increased risk of cancer **"continues throughout life,"** says Dale Preston, director of statistics at RERF, and another author of the study. However, it's worth noting that among about 52,000 survivors who received at least .005 sieverts (0.5 rem) of radiation, 420 excess cancer deaths have been blamed on radiation, while about 7,600 other cancer deaths were due to other causes. That's **hardly the kind of cancer epidemic** that many people associate with the word "radiation."

The large amount of data from Hiroshima and Nagasaki have played crucial roles in setting radiation exposure standards around the world, since, for many years, there was little alternative data. Still, however, scientists have wondered whether the effects of the instantaneous exposure to gamma rays and some neutrons in Japan were applicable to the typically lower-level, more diverse, and longer-term exposure faced by radiation workers and the public.

What does this mean to me?

There are 1 2 3 4 5 6 7 8 9 10 11 12 documents. (Update: 6 Mar 2002 | Glossary | Bibliography)

Chernobyl -- the largest open-air radiation experiment?

On April 26, 1986, one of the four reactors at the Chernobyl generating station in the Soviet Union, melted down, largely as a result of operator error. Their mistake -- running the plant with safety measures disconnected -- was compounded by the lack of a containment vessel (defined).

Chernobyl nuclear power station. © Greenpeace/Shirley.

Here's the detailed sequence of the accident. The result -- fire, chaos, fear, a gigantic plume of radioactive isotopes spreading across vast reaches of Eastern Europe, and the radioactive contamination of hundreds of thousands of people.

In other words, the disaster was exactly what the world has (sadly enough) long needed -- a **vast test** of the effects of low-level radiation on human health.

Unfortunately, this human tragedy is not being exploited as it should be, according to scientists who are trying to learn from it. "There's been a lack of resources that should have been available to look at cancer and non-cancer cases in the population," says Armin Weinberg, a cancer prevention specialist at Baylor College of Medicine who's helped set up a registry of Chernobyl survivors. "There's been a disappointing ability for Western scientists to obtain funding and capitalize on this opportunity to study low-level effects."

To date, most of the information about radiation and health came from studies of the aftermath of the bombings of Hiroshima and Nagasaki (rodent-click here if you missed our coverage).

But these thorough studies have examined the effects of a single, brief and relatively intense dose. In contrast, Chernobyl's exposure is mainly chronic, low-level, and long-term.

A better understanding of the health effects of low-level contamination would help in any future melt-down, Weinberg says. With about a dozen Chernobyl-type reactors in operation in the remains of the Soviet Union, and with 476 nuclear reactors operating or under construction around the world (1995 data), that is a real possibility.

The obstacles facing scientists who want to study the aftermath of Chernobyl include:

- The dissolution of the Soviet Union split administrative, record-keeping and medical responsibilities among Belarus, Ukraine, and Russia. (The plant is practically astride the present borders between Belarus, Russia and Ukraine.)
- The general decline in living standards has reduced the level of medical care in the area.
- Individual doses cannot be reconstructed accurately. In the atomic bomb studies, dose information was relatively accurate -- but even there, dose estimates have been overhauled over time. The Chernobyl estimates have been complicated by the fact that some of the dose was external, through exposure to radioactive dust, and part of it was internal, through eating contaminated food.
- Finally, there's little money for the kind of large studies that are needed to extract the best data from the disaster. Says Weinberg. "My frustration is that it's been difficult to organize and fund these studies."

Here's are some of the facts, as best we know them, about the Chernobyl melt-down.

- The accident released 1.85 x 10 to the 18th bequerel (1,850,000,000,000,000,000) of radioactive material. Each bequerel represents one radioactive decay event per second.

- The releases contaminated an estimated 17 million people to some degree. The exact amount of exposure depended on location, wind, length of exposure, eating habits, and whether the person was a "liquidator." These unfortunate heroes were pressed into service in a crude clean-up effort after the accident.

- 134 people showed signs of acute radiation sickness immediately after the accident. Many of the 28 people who died from acute radiation sickness many had skin lesions covering 50 percent of more of the body.

- After the fire, 135,000 people evacuated the area around the reactor, and 800,000 "liquidators" moved in to try to decontaminate the area. Between 17 and 45 percent of these folks received doses between 10 and 25 centigrays (10 to 25 rads). (For comparison, in the United States the annual dose permitted general public is 0.1 rads; nuclear workers are permitted 5 rads.)

Now, with the preamble out of the way, let's find out what Chernobyl has taught us so far about cancer and low-level radiation.

The Why? files back home radio-active facts next

There are 1 2 3 4 5 6 7 8 9 10 11 12 documents. (Update: 6 Mar 2002 | Glossary | Bibliography)

RADIATION reassessed

How much is too much?

How dangerous is ionizing radiation? You'd think, after 100 years of working with this elusive stuff that scientists could be able to give a straight answer to this simple question.

Fuhgeddabowdit (translated).

They can't, and for some disappointingly good reasons -- such as their unwillingness (with some notable exceptions) to experiment on people, and the fact that radiation comes in many flavors, doses, and exposures. And the fact that its effects tend to be stochastic -- a fancy way of saying that their effects are governed by probability.

There is no question that sufficiently large dosages of radiation can be deadly-- some people at Hiroshima, for example, who survived the blast and fires died of acute radiation sickness (defined).

And there's no doubt that somewhat lower doses can damage dividing cells and cause cancer (though it can also kill cancer, too, which explains the popularity of radiotherapy).

Chest X-ray courtesy of Tokai University School of Medicine Biomedical Engineering.

But what are the effects of even lower exposures, say a few additional chest X-rays, or a basement with some radon (defined) gas in it? Before you tell me it's going to **kill** you, remember that just because something is dangerous in large doses, doesn't prove that a lower level isn't innocuous or even helpful (think oxygen, vitamin A or television).

The best studies of radiation and health have compared the health of residents of Hiroshima and Nagasaki who were exposed to a lot of radiation (based on their location at the time of the blast) to neighbors who got less radiation since they were further from the explosion. But scientists have long wondered how much this brief, relatively intense exposure adequately could tell us about the low-dose exposures that could result from medical X-rays, uranium mining, or nuclear waste storage.

In the past few months, that dispute has become more bitter, with some scientists saying that legitimate fear of high-dose radiation has become an insane "radiophobia" of low doses.

But before we plunge into this morass, how 'bout we step back for a hyper-speed history of ionizing radiation?

The Why? files back home radio-active facts next

A NISE Project funded by NSF TALK to us...

There are 1 2 3 4 5 6 7 8 9 10 11 12 documents. (Update: 6 Mar 2002 | Glossary | Bibliography)

RADIATION reassessed

One astonishing notion

is that low doses of radiation are not only not harmful (are you counting the negatives here?) but they're helpful. Right. **Healthy**. Where did this strange notion come from, and is there any evidence for it?

It came from results of some of the larger radiation studies, but before we get to that, understand that people who believe in radiation hormesis (defined) agree that large doses of radiation are harmful. It's in the low-dose area where they argue -- passionately -- that the benefits outweigh the dangers.

One proponent of radiation hormesis is John Cameron, professor emeritus of medical physics at University of Wisconsin-Madison. Cameron once believed so strongly in the dangers of low-dose radiation that he founded a company to make instruments for calibrating medical X-ray machines. His idea was that if the machines ran reliably, they could be tuned to minimize exposure to the patient.

But he's changed his tune slightly, as evidence has convinced him, at least, of the validity of "radiation hormesis." Hormesis is the theory that something that's harmful in large doses -- say table salt, magnesium, or oxygen itself -- can be beneficial in low doses. "All these trace elements -- fluorine, cobalt, iron -- are absolutely necessary in small amounts, but poisonous in larger amounts." Toxicologists have long known that "the dose makes the poison," he points out, and "it's highly likely that this is true of radiation as well.

For example, he cites a large study of more than 70,000 male shipyard workers who serviced nuclear-powered ships. The findings were comforting -- or bizarre -- depending on your point of view. Let's quote an official summary of that work:

Image courtesy of the United States Navy.

"While total mortality was lower than expected when compared to the general population, it was highest for the shipyard workers **not exposed to radiation** [emphasis added]. The death rates from leukemia and other blood-related cancers for both the radiation exposed and non-exposed workers were similar to those for U.S. men."

"The death rate for cancer among the radiation exposed workers was slightly lower than that for the U.S. population, but this decrease was not statistically significant. The corresponding death rate among workers not exposed to radiation was slightly higher (12 percent) due to a small increase of lung cancer."

"If somebody makes an assumption and you find a blatant case contradicting that assumption, you have to question it," Cameron says. His point is not that we should go out and expose ourselves deliberately to ionizing radiation (as was done earlier in the century), but that we should stop fearing it so much, and stop spending so much money controlling it.

For more information, see "The Good News About Radiation" in the bibliography.

An attractive idea?

Certainly, particularly to those who must spend money to control radiation exposures, in defense, medical, nuclear power, and other industries. But how much support does it get?

Suffice it to say that radiation hormesis remains a heretical notion, supported by some data, but not exactly a mainstream proposition, let alone a proven theory. Remember, many scientists are unconvinced that low-level radiation is harmless, let alone beneficial. If you just joined us, we quoted them back here.

Want to read our bylines and sources for this edition?

The Why? files back home radio-active facts next

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RADIATION reassessed

The measurement morass

A casual observer might figure that there are just too many ways to measure ionizing radiation, and that casual observer might well be right. As usual, there's an explanation, since various units measure the radiation, the absorbed dose, or the duration and intensity of the dose.

Image of Geiger counter courtesy of The University of Maryland Physics Lecture-Demonstration Facility. Make your own noise at The Virtual Geiger Counter.

Here are a few of the more common units, deciphered as best we can:

SI (international standard) units:
Sievert (Sv): used to derive equivalent dose, similar to Rem, often expressed in millionths of a sievert (micro-sieverts) or thousandths of a sievert (millisieverts). Equivalent dose in Sv = absorbed dose in Gy x (Q) (see rem, below). One sievert is equivalent to 100 rem; one millisievert (0.001 Sv = 0.1 rem).

Gray (Gy): measures the absorbed dose. One gray is equivalent to 100 rads; one rad = 0.01 gray, also called "one centi-gray."

Q: a factor reflecting our notion of how harmful the particular type of radiation. A given dose of radiation with a higher Q is more damaging than the same dose with a smaller Q.

U.S. units:
Rad (radiation absorbed dose): measures the absorbed dose of radiation, and can be used for any type of radiation or material. One rad is the absorption of 100 ergs per gram of material. The unit does not describe the biological effects of different form of radiation.

Rem (roentgen equivalent man): used to derive "equivalent dose" and compare the effective biological damage of radiation. The dose is often expressed in terms of thousandths of a rem (millirem, or mrem). Equivalent dose in rem = absorbed dose (rad) x Q (see above).

Confused? Check out more definitions here.

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RADIATION reassessed

Interview subjects

Here's who we talked to for this story.
* indicates a factchecker for this edition.

- * **John Cameron**
  professor emeritus of medical physics
  University of Wisconsin-Madison
- * **Kenneth Mossman**
  professor of health physics
  Arizona State University
- * **Dale Preston**
  chief of statistics
  Radiation Effects Research Foundation, Hiroshima, Japan
- * **Armin Weinberg**
  associate professor of medicine, Baylor College of Medicine
  director, Center for Cancer Control Research, and investigator, USA Chernobyl Immigrant Registry

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Amy Toburen, creative team member
Susan Trebach, team leader

back home radio-active facts

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THE UNIVERSITY of WISCONSIN MADISON

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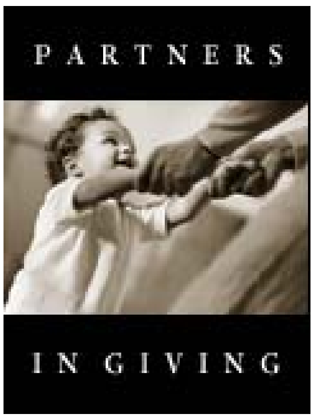

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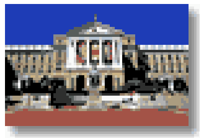

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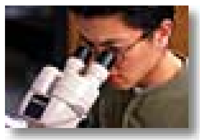

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Arizona State University is a major research university located in metropolitan Phoenix, the economic, cultural, and governmental center of Arizona. In addition to the Main Campus located in Tempe, the University features two newer campuses with more specialized missions: ASU West (in Northwest Phoenix adjacent to Glendale) and ASU East (in Mesa). The University also operates the Extended Campus, which is administered out of its center located in downtown Phoenix. The University, in all of its aspects, is a place where students participate with faculty in the creation of new knowledge and where numerous programs enhance the quality of life in metropolitan Phoenix.

ASU is an internationally recognized research institution and center for the promotion of cultural and performing arts. It is a leading center for research and technological advancement, in partnership with the private sector to advance the economic competitiveness and quality of life in Arizona.

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- Microelectronics Teaching Factory opens at ASU East
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Microelectronics Teaching Factory

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Â


Gary Smith

Armin D Weinberg, PhD and Amelie G Ramirez, DrPH, Baylor College of Medicine; Charles Coltman, MD, San Antonio Cancer Institute; Harold P. Freeman, MD, National Cancer Institute (NCI); Roland Garcia, PhD, NCI; and Jennifer Reseck-Segall, Susan G. Komen Breast Cancer Foundation.

Harold P. Freeman, MD, Associate Director of the National Cancer Institute, Participates in Annual *Redes En AcciÃ³n* National Steering Committee Meeting

August 21, 2002
San Antonio, Texas

More than 60 scientists, physicians, educators and other leading authorities on issues related to cancer among the country's 35 million Latinos gathered in San Antonio August 21-23 to discuss the efforts of *Redes En AcciÃ³n: The* National Hispanic/Latino Cancer Network in promoting Latino cancer research, training and awareness. At the meeting's introductory session Thursday morning (August 22), keynote speaker Harold P. Freeman, MD, Director of the National Cancer Institute's recently created Center to Reduce Cancer Health Disparities, presented a report on the Center's efforts and other NCI minority cancer health activities. Dr. Freeman is also Associate Director of NCI as well as former chairman and present member of the President's Cancer Panel.


Gary Smith

"Dr. Freeman has long been recognized nationally as a champion of cancer prevention and control among minority populations," said Amelie G. Ramirez, DrPH, Principal Investigator of *Redes En AcciÃ³n* (Networks in Action). "His participation in our National Steering Committee meeting will certainly focus our efforts as we chart the course for future *Redes En AcciÃ³n* Latino cancer health action." Dr. Ramirez is Deputy Director of Baylor College of Medicine's Chronic Disease Prevention and Control Research Center.

version 5.7 (July 10, 2000)

Japanese version

Call for your peace messages!!

Hiroshima, Japan Based Group Asks For Peace Messages

HIROSHIMA, JAPAN - July 6, 2000 - Every year, in Hiroshima, Japan, people float lanterns with prayers, thoughts, and messages of peace down the rivers in commemoration of the atomic bombing of Hiroshima. Until this year, the only way to join this celebration was to go to Hiroshima personally, but now a group of volunteers have started a website that will allow people from around the world to join in. The site, URL, allows visitors to both write in messages and view messages that others have left from across the planet. On August 6th, during the Lantern Floating Festival, the messages will be printed out and assembled into a series of lanterns that will be floated down the rivers. This will be shown live on the same website:

- Hiroshima Peace Message 2000***New***

"The website is neither meant to condemn nor condone the bombing, but is meant as a way for people to express their views on how to achieve peace, on what peace is, and other thoughts about peace. We hope that everyone will write in their thoughts," said Prof. Mitsuru Ohba.

Contacts:
Mitsuru Ohba
Project Leader
ohba@cs.hiroshima-cu.ac.jp

Cem Karan
Student Volunteer
cfkaran@eos.ncsu.edu

Call for Opinions!!

We are soliciting your opinions and comments on the recent nuclear tests in Asia. A new forum has been opened for exchanging different views of peoples with the issue of the new age. Miyoko Matsubara is the editor of the forum page.

- Nuclear Tests: Are they necessary?***Updated!***

Thank you,

Mitsuru Ohba
Producer, A-Bomb WWW Project

Sorry!!

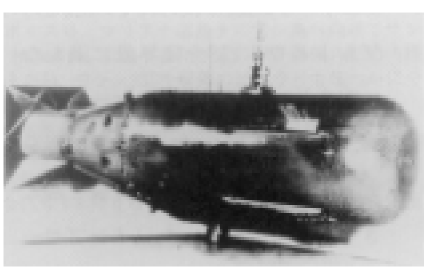
We have received so many comments, questions and requests these days. Due to the limitation of our capability, we have been facing a serious workload problem. Though we are still happy to receive your questions and requests, we really need enough time to answer or to process them. We would appreciate your understanding and patience.

Thank you for your cooperation,

Mitsuru Ohba
Producer, A-Bomb WWW Project

Welcome to A-Bomb WWW Museum

"Little Boy" is the nick name given to the atomic bomb dropped on Hiroshima on ***August 6, 1945***. It was Monday morning. Little Boy was dropped from the Enola Gay, one of the B-29 bombers that flew over Hiroshima on that day.



Little Boy

After being released, it took about a minute for Little Boy to reach the point of explosion. Little Boy exploded at approximately 8:15 a.m. (Japan Standard Time) when it reached an altitude of 2,000 ft above the building that is today called the "A-Bomb Dome."

The July 24, 1995 issue of Newsweek writes:

"A bright light filled the plane," wrote Lt. Col. Paul Tibbets, the pilot of the Enola Gay, the B-29 that dropped the first atomic bomb. "We turned back to look at Hiroshima. The city was hidden by that awful cloud...boiling up, mushrooming." For a moment, no one spoke. Then everyone was talking. "Look at that! Look at that! Look at that!" exclaimed the co-pilot, Robert Lewis, pounding on Tibbets's shoulder.

Lewis said he could taste atomic fission; it tasted like lead. Then he turned away to write in his journal. "My God," he asked himself, "what have we done?" (special report, "Hiroshima: August 6, 1945")
note: Paul Tibbets was Colonel, not "Lt. Colonel," when he was the pilot of the Enola Gay.

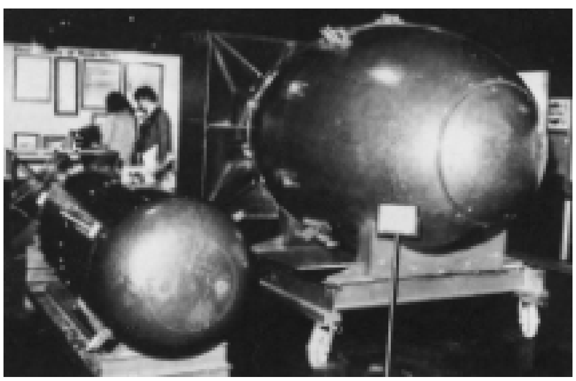
The Little Boy generated an enormous amount of energy in terms of air pressure and heat. In addition, it generated a significant amount of radiation (Gamma ray and neutrons) that subsequently caused devastating human injuries.

The people who saw the Little Boy often say "We saw another sun in the sky when it exploded." The heat and the light generated by the Little Boy were far stronger than bombs which they had seen before. When the heat wave reached ground level it burnt all before it including people.

The strong wind generated by the bomb destroyed most of the houses and buildings within a 1.5 miles radius. When the wind reached the mountains, it was reflected and again hit the people in the city center. The wind generated by Little Boy caused the most serious damage to the city and people.

The radiation generated by the bomb caused long-term problems to those affected. Many people died within the first few months and many more in subsequent years because of radiation exposure. Some people had genetic problems which sometimes resulted in having malformed babies or being unable to have children.

It is believed that more than 140,000 people died by the end of the year. They were citizens including students, soldiers and Koreans who worked in factories within the city. The total number of people who have died due to the bomb is estimated to be 200,000.



The A-Bombs used over Japan; Little Boy (left) and Fat Man (right)

Just three days after the bomb was dropped to Hiroshima, the second atomic bomb called "Fat Man" was dropped to Nagasaki. Though the amount of energy generated by the bomb dropped to Nagasaki was significantly larger than that of the Little Boy, the damage given to the city was slighter than that given to Hiroshima due to the geographic structure of the city. It is estimated that approximately 70,000 people died by the end of the year because of the bombing.

The volunteers who participated in this project, strongly believe that the world must learn about weapons of total destruction. We hope that the information presented here will help you understand the pain and devastation that nuclear weapons can cause. We don't want you to just feel sorry for the people of Hiroshima and Nagasaki, the war inflicted untold pain and suffering on many people in Asia and the Pacific. Rather we want you to work with us to ensure that all of us can live in a safe world.

We hope this document helps you understand what it was and what it means.

Mitsuru Ohba
Producer, A-Bomb WWW Project
Hiroshima, Japan

John Benson
Chief Director, A-Bomb WWW Project
Hiroshima, Japan

Goals of the project

- to provide all readers with accurate information concerning the impact the first atomic bomb had on Hiroshima.
- to provide the context for a constructive discussion of what the world can learn from this event and why such weapons of total destruction should never again be used.

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- **Short Story: Children of the Cloud**
- **Ditmar's Exhibition**
- **Message from the Mayor of Hiroshima**
- **Message from the Mayor of Nagasaki**
- **Contributions from the readers**
- **Tour around the Peace Park**
- **The atomic bombing of Nagasaki**
- **Hiroshima Peace Forum 21: Shimon Peres, Kenzaburo Ooe and Takashi Hiraoka**

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RADIATION reassessed

Glossary

Alpha particle

> A particle emitted from the nucleus of an atom, containing two protons and two neutrons, identical to the nucleus (without the electrons) of a helium atom.

Beta particle

> A high-speed particle, identical to an electron, emitted from an atomic nucleus.

Containment vessel

> A gigantic steel can used to hold in radioactive junk in case a reactor goes out of control.

Dose-response curve

> A curve on a graph showing the relationship between various doses and various responses, typically disease.

Excess relative risk

> The fraction by which the risk for an exposed person exceeds that of a person of the same sex and age who was not exposed. An excess relative risk of 1 means the person's risk is double that of an unexposed person.

Extrapolate

> To apply data learned about one range of doses to another range of doses.

Gamma ray

> An electromagnetic wave or photon emitted from the nucleus.

Hormesis

The notion that small doses of a toxin can be healthful.

Isotope

One of several forms of an element, distinguished by different number of neutrons.

Linear

A dose-response curve that increases or decreases in a straight line.

Nucleus

The center of an atom, containing protons, neutrons and most of the mass.

Radiation sickness

Radiation injury following exposure to excessive doses of radiation, such as the explosion of an atomic bomb.

Radon

See fact sheet for radon explanation.

Threshold

A "floor" below which a dose does not cause a disease.

See also our fact sheet. And here's some information on some of the units used to measure radiation.

home

There are 1 2 3 4 5 6 7 8 9 10 11 12 documents. (Update: 6 Mar 2002 | Glossary | Bibliography)

RADIATION reassessed

"Forget about it"

The Why? files back home radio-active facts next

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DOE Openness:

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The Office of Human Radiation Experiments, established in March 1994, leads the Department of Energy's efforts to tell the agency's Cold War story of radiation research using human subjects. We have undertaken an intensive effort to identify and catalog relevant historical documents from DOE's 3.2 million cubic feet of records scattered across the country. Internet access to these resources is a key part of making DOE more open and responsive to the American public.

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