

Hiroshima / Fukushima:  
Gender Matters in  
the Atomic Age

**Mary Olson, Nuclear Information and Resource Service (NIRS)**  
www.nirs.org / maryo@nirs.org  
Presentation posted: <http://tinyurl.com/Olson2016>  
*Original paintings by Loren Olson*  
*Silhouette figures by Sara Lynch-Thomason*

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Mary Olson's work on radiation and gender is posted here:

<http://www.nirs.org/radiation/radhealth/radhealthhome.htm>

Other resources on radiation impacts are posted here:

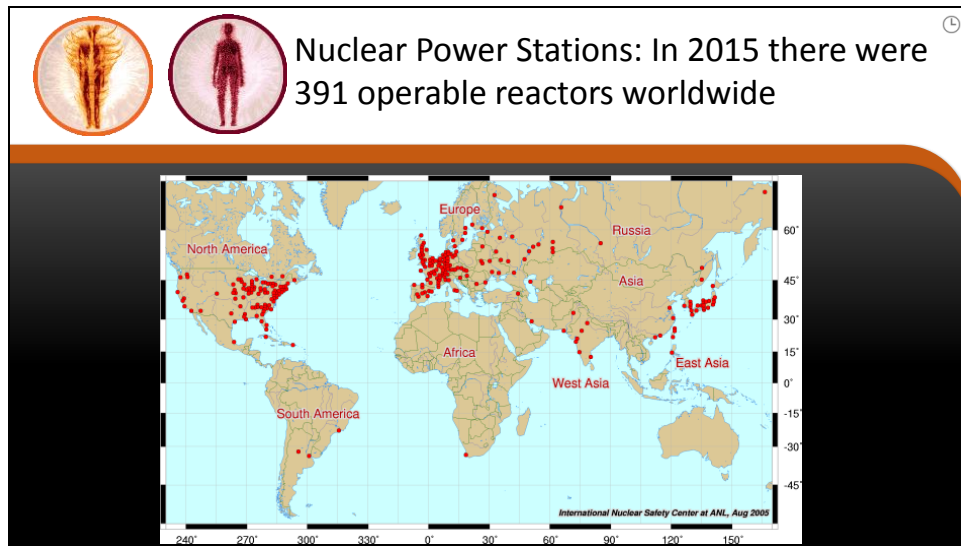
<http://www.nirs.org/radiation/radiation.htm>

Bio:

Mary Olson is Senior Radioactive Waste Policy Specialist with Nuclear Information and Resource Service (NIRS). Olson joined the NIRS staff in 1991, and has worked primarily on highly radioactive spent nuclear fuel and plutonium policy, including the Yucca Mountain proposal in Nevada and the US Surplus Plutonium Disposition Mixed Oxide Fuel proposal. Olson's background in biology, biochemistry and her own experience with radioactive contamination during her final biological research job, lead her to study radiation health consequences with leading radiation researchers of the 20<sup>th</sup> Century including Bertell, Stewart, Caldicott and Wing. She now serves as an educator on ionizing radiation impacts for impacted communities, the concerned public and decision-makers. The Fukushima Daiichi nuclear disaster caused Olson to follow on questions from the concerned public about greater harm to women from ionizing radiation exposures. Olson did her own independent review in 2011 of the data presented by the National Academy of Sciences, Biological Effects of Ionizing Radiation VII. Olson's findings are published in a short briefing paper entitled "Atomic Radiation is More Harmful to Women." Olson is a frequent speaker including three times to the UN General Assembly, policy advocate and "stake holder" for civil-society organizations and facilitator for groups working on decisions and planning regarding radioactive waste and ionizing radiation. In 2012 Olson was featured in a

new educational film *The Ultimate Wish: Ending the Nuclear Age*, in 2014 she spoke at the Vienna Conference on the Humanitarian Impacts of Nuclear Weapons, in 2015 she was the featured speaker at a side session at the United Nations during the Review of the Nuclear Nonproliferation Treaty, and in 2016 she is touring Japan speaking on ionizing radiation and its impacts on the human lifecycle.

Slide 2



Each red dot is a nuclear power reactor.

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Source: World Nuclear Industry Status Report, 2015. Mycle Schneider consulting. Schneider and Frogett, high resolution report posted here:  
<http://www.worldnuclearreport.org/IMG/pdf/20151023MSC-WNISR2015-V4-HR.pdf>



Chernobyl reactor unit 4 (shown on the left) exploded and then burned for 10 days beginning April 26, 1986. This year is 30 years.

Fukushima Daiichi underwent a series of explosions, triggered by the Tohoku earthquake and Tsunami on March 11, 2011. This year is 5 years.

Events like these have a beginning, but in the frame of human history, they do not have an end-point.

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NIRS has collections of documents on both of these nuclear disasters, see:  
<http://www.nirs.org/reactorwatch/accidents/accidentshome.htm>

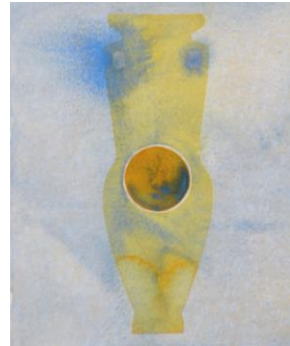
Arnie and Margaret Gundersen / Fairewinds Energy Education is one of the best resources in the world: <http://www.fairewinds.org/>

Ten years ago, 20 years after Chernobyl an independent report was published called the TORCH report:  
<http://www.chernobylreport.org/?p=summary>

This work is being updated by Dr. Ian Fairlie. See: <http://www.ianfairlie.org/?s=chernobyl>

Slide 4

I will speak of our human lifecycle—however  
radioactivity also impacts all life on Earth



My presentation will focus on our species, but we must not forget that all of life is impacted by ionizing radiation. Life on Earth is a web of interconnection. Atomic fission break many bonds in addition to atoms and molecules.

Thank you to my sister and brilliant artist, Loren Olson for use of these images.



Radiation regulation has been based on the “Reference Man.” We now know that we must protect the entire human lifecycle.

**Policy is a decision**

When a dangerous industry is regulated, policy-makers decide how many deaths are "OK."

1 cancer in a million people exposed is often the goal.

Regulation of public (lifetime) exposure to ionizing radiation **starts** at 1 fatal cancer in 286 = OK. This assumes male adults.

If the goal were 1 cancer in 1 million baby girls, then industrial nuclear operations would have to cease and sites would be CLEANED UP!



Source: Mary Olson, unpublished calculation

Policy is a decision:

When a dangerous industry is regulated, policy-makers decide how many deaths in the affected population are "OK."

One cancer in a million people exposed to a hazard is often the goal.

Federal Regulation (USA) of public (lifetime) exposure to ionizing radiation **starts** at 1 fatal cancer in 286 exposed = OK. This assessment assumes the impact will be to male adults.


If the goal were 1 cancer in 1 million baby girls, then industrial nuclear operations would have to cease and sites would be CLEANED UP! This is because radiation is so much more harmful to little girls than to the Reference Man used to set policy. One in a million is also a much higher bar than 1 in 286. If that is what we want, society will have to shut-down and clean up!

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Source of radiation risk estimate: US Nuclear Regulatory Commission, 1990 "Expanded Below Regulatory Concern Policy Statement."

See also: Olson, Mary, October 2011 "Atomic Radiation is More Harmful to Women" posted: <http://www.nirs.org/radiation/radhealth/radiationwomen.pdf>

And comments to the US Environmental Protection Agency on an Advanced Notice of Proposed Rulemaking to "update" US radiation standards, 40 CFR 190, 2014.



## Ionizing Radiation: No Safe Dose

- All regulatory agencies acknowledge that every exposure to ionizing radiation carries risk of harm:

**There is no “safe” dose of ionizing radiation:  
It is not safe for adult males.  
Recent findings:  
Ionizing radiation is even less safe for children and for females.**

All regulatory agencies acknowledge that every exposure to ionizing radiation carries risk of harm. **There is no “safe” dose of ionizing radiation:**

**It is not safe for adult males.**

**Recent findings:**

**Ionizing radiation is even less safe for children and for females.**

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#### **Citation and Resources:**

Nuclear Information and Resource Service: Factsheet, “The Myth of the Millirem” posted:

<http://www.nirs.org/factsheets/mythmiliremfactsht.htm>

Dr. Rosalie Bertell, 2000; “No Immediate Danger? Prognosis for a Radioactive Earth.”  
Summertown Books.

Dr. Helen Caldicott, 1994. “Nuclear Madness.” WW Norton Co.

Dr. John Gofman, 1990. “Radiation Induced Cancer from Low-Dose Exposure: an Independent  
Analysis.” Much of the book is posted here (no fee):

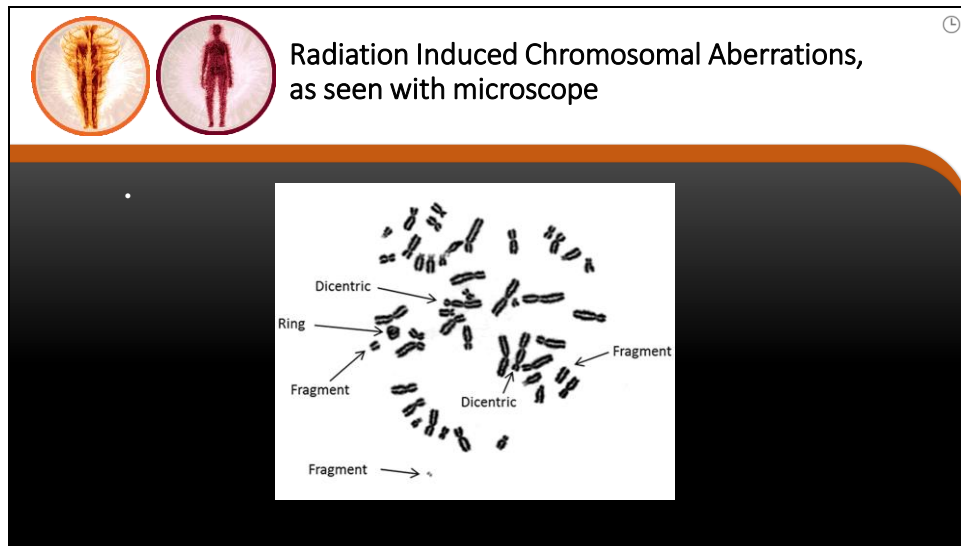
<http://www.ratical.org/radiation/CNR/RIC/contents.html>

Møller AP and Mousseau TA(2012) The effects of natural variation in background radioactivity  
on humans, animals and other organisms. Biological Reviews DOI: 10.1111/j.1469-  
185X.2012.00249.x

Ian Fairlie, 2013. “Recent Evidence on the risks of very low doses of radiation” posted:

<http://www.ianfairlie.org/news/recent-evidence-on-the-risks-of-very-low-level-radiation/>





Radiation is invisible but we can see the damage it has done to these chromosomes.

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**Resources:**

Dicentric and other chromosomal aberrations are common in people who have suffered acute radiation exposure. The damaged chromosomes are found in white blood cells and can be assessed as a biological dosimeter. More information here:

[http://www.rerf.jp/radefx/late\\_e/chromoab.html](http://www.rerf.jp/radefx/late_e/chromoab.html)

**RADIATION AND HEALTH**

Radiation is different from any other poison.

It BREAKS THE STORIES OUR BODIES HOLD THAT KEEP US HEALTHY. DAMAGED STORIES CAN BE PASSED ON TO OUR CHILDREN.

Radiation is a poison that stays in the land, water, plants and animals. It might be too dangerous to go there, so best to not collect and eat the many generations.

Radon gas is a colorless, odorless gas that is naturally found in the soil. It is a leading cause of lung cancer and is the second leading cause of lung cancer deaths in the United States.

Uranium in the water can cause kidney damage.

Mining uranium increases people's exposure to radiation.

There is no safe dose of uranium.


**URANIUM leave it in the ground**

**RADIATION HAS INTERGENERATIONAL CONSEQUENCES**


**IT BREAKS THE STORIES OUR BODIES HOLD THAT KEEP US HEALTHY. DAMAGED STORIES CAN BE PASSED ON TO OUR CHILDREN.**

Some traditional communities in Australia say the same thing this way:

“Radiation: Breaks the stories our bodies hold that keep us healthy. Damaged Stories can be passed on to our children.”



Ionizing Radiation:  
Non-Cancer Medical Impacts



Radiation impacts our cells.  
When the reproductive cells are harmed, deformations are one outcome.  
This happens to all babies: plants, animals, humans.

We also suffer:  
Loss of fertility;  
Spontaneous abortion and miscarriage;  
Possible heritable mutations;  
Avoidance of reproduction due to uncertainty.

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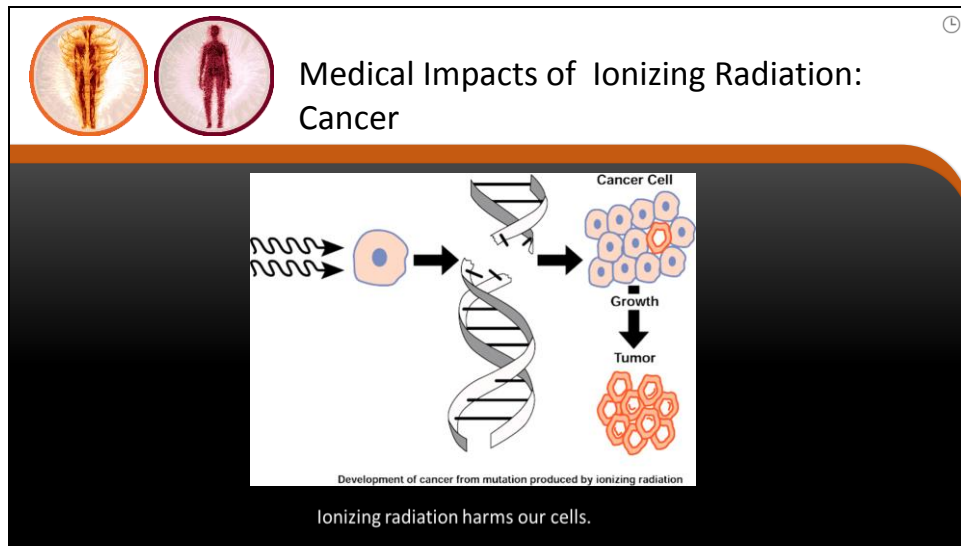
**Resources:**

Impact on radiation exposure on reproduction has been very difficult to study in human beings. The work of Moller and Mousseau on species with a shorter life span (birds, bugs, plants) shows that ionizing radiation does reduce population size, results in mutations that are heritable and that some of the mutations are expanding in populations outside the initial study areas near Chernobyl and Fukushima. See:

[http://www.academia.edu/1376987/Abundance of birds in Fukushima as judged from Chernobyl](http://www.academia.edu/1376987/Abundance_of_birds_in_Fukushima_as_judged_from_Chernobyl) and:

<http://cricket.biol.sc.edu/chernobyl/papers/moller-et-al-Ecol-Ind-2013.pdf>

Radiation exposure can also lower our overall immune function, leading to many symptoms like increases in other illness, chemical intolerance and in the extreme and AIDs-like syndrome.



Cancer is the most studied long-term consequence of non-lethal radiation exposure.

WHEN genetic material inside a living cell is damaged, sometimes our bodies can repair that damage. Otherwise the abnormal cell may sit quietly in the body for years or even decades before it makes us sick.

There is no way to predict which exposure will result in cancer. In general, more radiation equals more cancer risk. However, even an exposure too small to measure could, sometimes, result in cancer death.

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### Resources

Previous pages have listed some of the classic authors on radiation of the 20<sup>th</sup> century. The National Institute of Environmental Health in the United States published this broader piece "Cancer and the Environment: What You Need to Know." posted:

[http://www.niehs.nih.gov/health/materials/cancer\\_and\\_the\\_environment\\_508.pdf](http://www.niehs.nih.gov/health/materials/cancer_and_the_environment_508.pdf)


**Data Sets**

Because non-lethal exposures to ionizing radiation may or may not result in harm...

And because harm that is cancer takes many years to appear... and cancer is caused by many other things...

A large number of people, with radiation exposure tracked for a period of time is required for research.

This is called a data-set.



Policy is a decision

When a dangerous industry is regulated, policy-makers decide how many deaths in the population are “OK.”

One cancer in a million people exposed is often the goal.

Regulation of public (lifetime) exposure to ionizing radiation **starts** at 1 fatal cancer in 286 exposed = OK. This assessment assumes the impact will be to male adults.

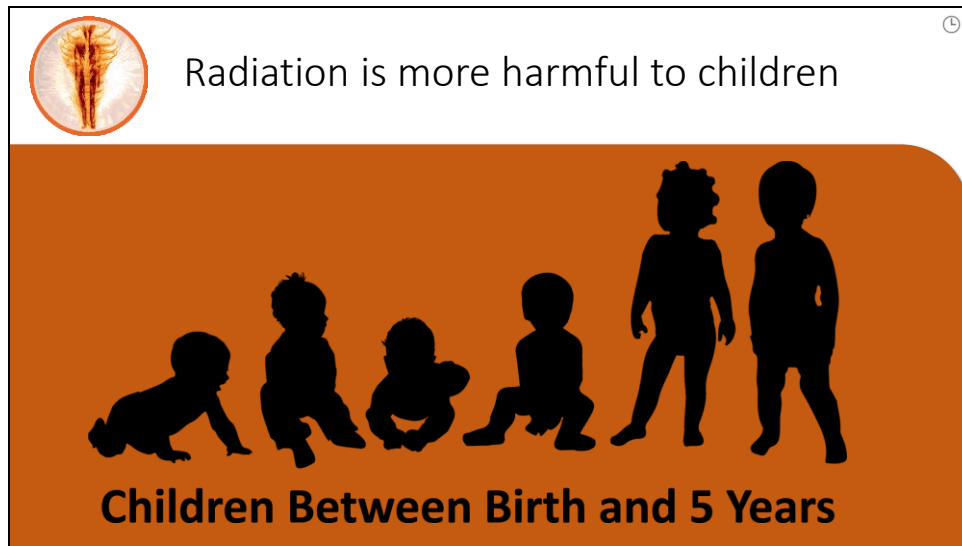
If the goal were 1 cancer in 1 million baby girls, then industrial nuclear operations would have to cease and sites would be CLEANED UP!

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Source: US Nuclear Regulatory Commission, 1990 “Expanded Below Regulatory Concern Policy Statement.”

See also: Olson, Mary, October 2011 “Atomic Radiation is More Harmful to Women” posted: <http://www.nirs.org/radiation/radhealth/radiationwomen.pdf>

And comments to the US Environmental Protection Agency on an Advanced Notice of Proposed Rulemaking to “update” US radiation standards, 40 CFR 190, 2014. Posted:



The graphic features a title "Radiation is more harmful to children" in the top right corner. To the left of the title is a circular icon containing a human spine. Below the title is a large orange rounded rectangle. Inside this rectangle, on the left, is a circular icon of a human spine. Below the icon is a series of six black silhouettes of children at different stages of development: a crawling baby, a sitting baby, a crawling baby, a sitting baby, a standing toddler, and a standing toddler. Below the silhouettes is the text "Children Between Birth and 5 Years".

Children's bodies are small; so the same amount of radiation delivers a larger dose.

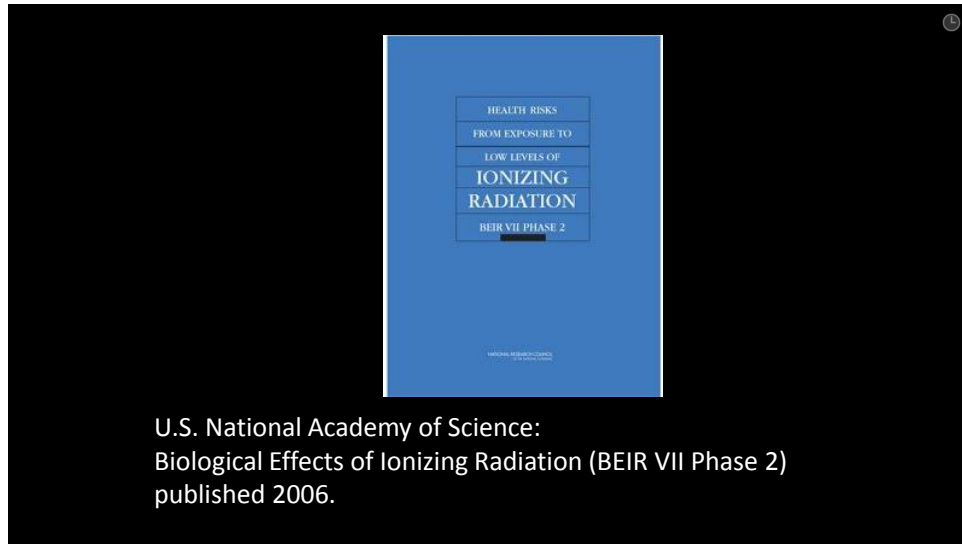
Since children are growing, the cells in their bodies are dividing more rapidly. The DNA in cells is more likely to be damaged when in cell division.

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**Art Credit:**

Saro Lynch-Thomason, Fullsteam Labs

Slide 14




This 2006 report, the Biological Effects of Ionizing Radiation, #7, also called BEIR VII is the source of the data for the findings I am about to present. The data in the report is primarily from the survivors of the Hiroshima and Nagasaki.

Citation:

The Biological Effects of Ionizing Radiation, VII; Phase 2 is available at no charge for a PDF file here: <http://www.nap.edu/openbook.php?isbn=030909156X>

Important note: BEIR VII assumes that the victim's radiation exposure was an acute external exposure (the moment of the bomb explosion); internalized radioactivity is not considered.



## Survivor Lifespan Study

- Data recording (ABCC) began in 1950. Deaths between 1945 and 1950 were not recorded.
- Survivors were strong; stronger than a typical population.
- Survivors (more than 90,000) were grouped by the age that they were at the time of the bomb.
- Cancers, and cancer deaths, were counted in these groups.
- In 2006 the first 60 years of data was published (BEIR VII)

The survivors of Hiroshima and Nagasaki still alive in 1950 were grouped by the age they were at the time of the bombing. These groups were tracked over their lifetimes. Cancers and cancer deaths were counted.

There are many problems with this data, but we can broadly say that those who were five years or younger in August, 1945 had the most cancer **at some point in their lives**.

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**Source:**

Olson, 2011. NIRS Briefing Paper: “Atomic Radiation is more harmful to women.” posted: <http://www.nirs.org/radiation/radhealth/radhealthhome.htm>

Makhijani, 2005 started the Healthy from the Start Campaign to address disproportionate impact of ionizing radiation on young females.

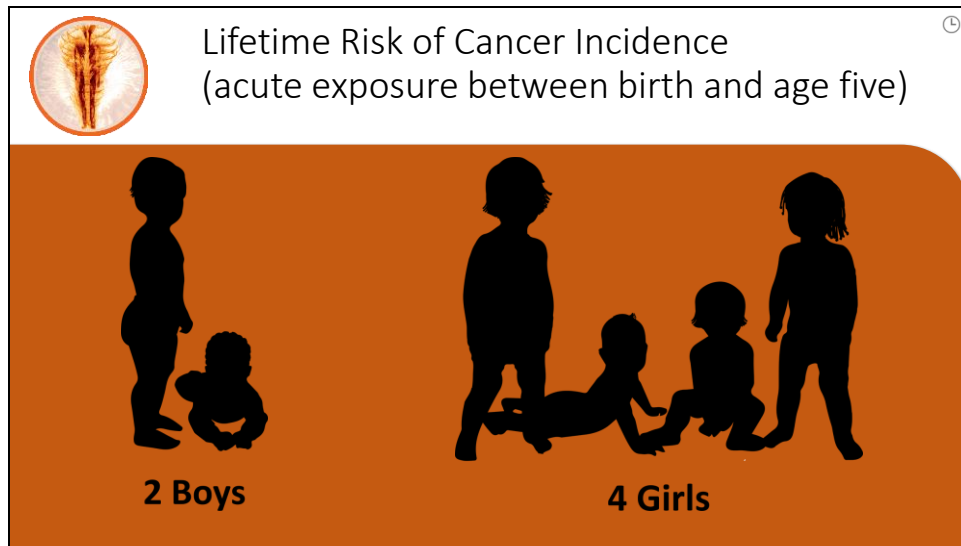
<http://ieer.org/projects/healthy-from-the-start/>

And <http://ieer.org/resource/health-and-safety/open-letter-to-president-bush-on-protecting-the-most-vulnerable/>

**Art Credit:**

Saro Lynch-Thomason, Fullsteam Labs





Of those exposed when 5 years or younger, girls were twice as likely to get cancer from the same level of radiation exposure as were boys the same age and exposure.

For every male in the 0-5 year cohort that suffered cancer at some point in his life, two females got cancer.

The BEIR VII report is where these numbers are found; the report itself does not discuss gender as a risk factor. I published my findings in 2011. In 2006, independent from my work, Dr. Arjun Makhijani published the same findings.

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**Source:**

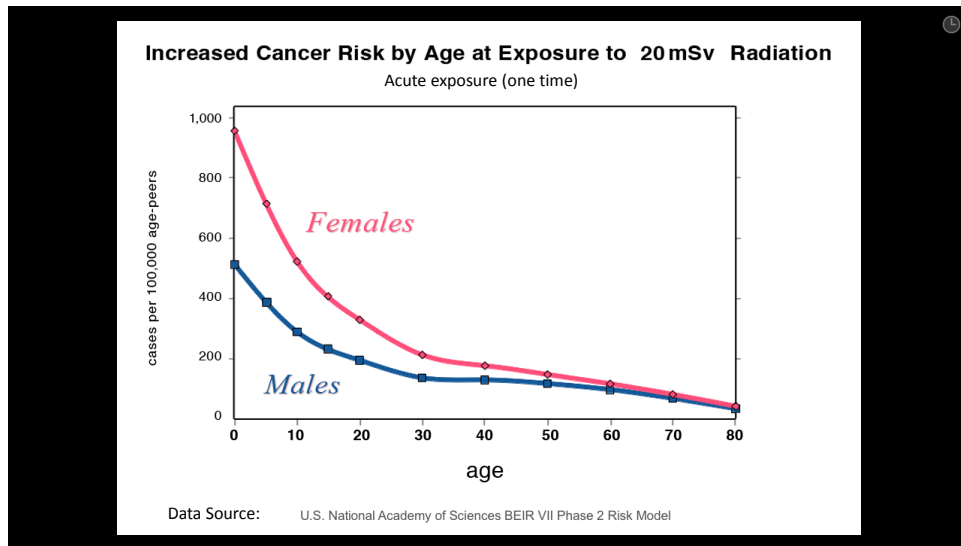
Olson, 2011. NIRS Briefing Paper: "Atomic Radiation is more harmful to women." posted:  
<http://www.nirs.org/radiation/radhealth/radhealthhome.htm>

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And <http://ieer.org/resource/health-and-safety/open-letter-to-president-bush-on-protecting-the-most-vulnerable/>

**Art Credit:**

Saro Lynch-Thomason, Fullsteam Labs



Here is the same information in graphic form.

The pink line is girls, the blue line is boys.

We can easily see the gender difference and that it is greatest when the exposure is to the youngest children.

This graph shows cancers from **one pulse** of 20 mSv of radiation by the age the person was when that exposure happened. This is an age-and-gender-response curve.

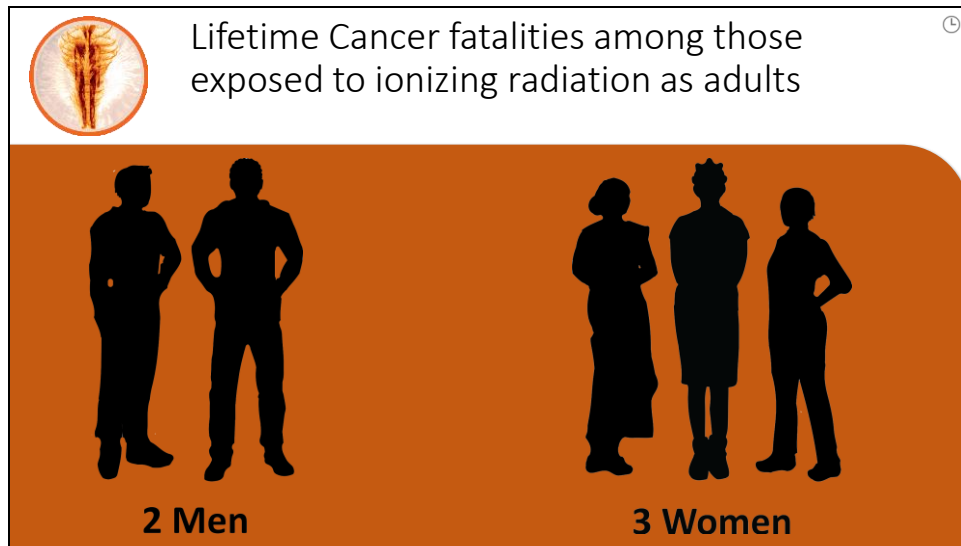
This graph does not show the age cancers appeared, but is a snapshot of our species lifecycle cancer-response to acute radiation exposure.

It is likely a picture of any radiation—exposed population.

Reading the graph we can see that those exposed as boys suffered nearly 5 times more cancer at some point in their lives compared to the adult male. Those exposed as little girls suffered nearly ten times more.

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Graph provided to NIRS by Ian Goddard.



Gender was also a factor for those who were adults at the time of the bombings.

Over their lifetime women exposed as adults suffered 50% more cancer death than did men in the same age group.

For every 2 men in these cohorts who died of cancer, three women died of cancer.


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Source:


(see above) Olson, Makhijani, numbers in tables of BEIR VII.

**Art Credit:**

Saro Lynch-Thomason, Fullsteam Labs

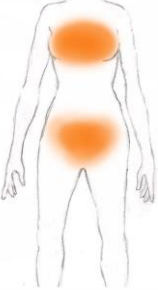


Why is Gender a risk-factor for more cancer?



Dr. Rosalie Bertell

Females have 50% more high-risk tissue compared to males



Why is gender a risk factor for cancer from exposure to ionizing radiation?

Today we do not know.

Dr Rosalie Bertell suggested that it is because female bodies have more sensitive reproductive cells.

Maybe it is due to a higher percentage of fatty tissue in females.

Or maybe differences in the endocrine system?

These questions have not been asked, let alone answered.

We must not however, wait! Little girls must be protected now, and that will protect everyone better.

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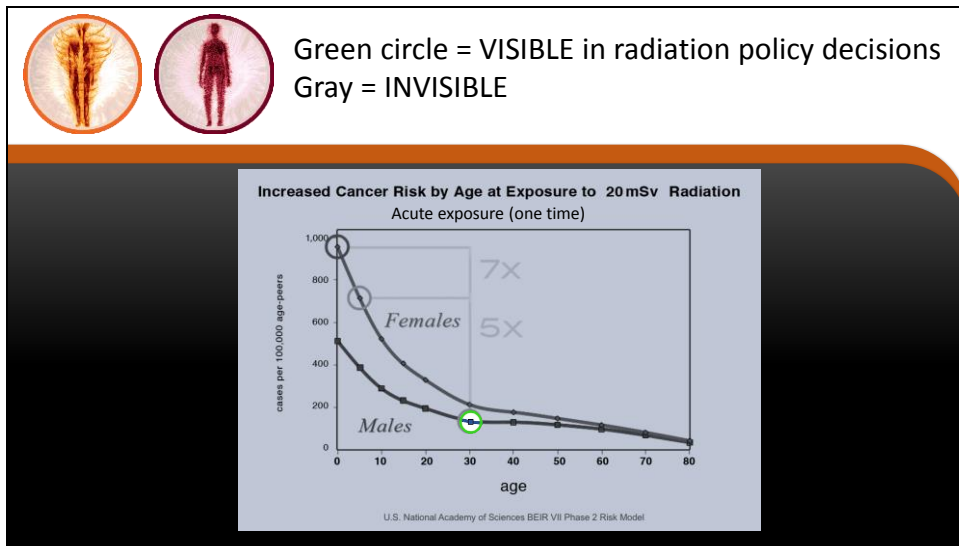
**Art Credit:**  
Dave Shannon

Slide 20



It is extremely important to understand that little girls are not a “sub-population.”  
We are an inextricable part of the human lifecycle.

We now know that girls are more impacted than any other post-birth expression of the human species. We must act NOW to change protection standards.




Fission began in 1942, it took 60 years to see that gender is a factor in radiation harm.


On this slide the green circle is the “Reference Man”— originally an adult male military or paramilitary atomic worker of the 1940’s.

The rest of the slide is gray: Decision-makers have not seen information about males of other ages, or females at all until very recently. We have been invisible.

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Hiroshima and Nagasaki are unique;  
not conservative



- Deaths that came after the blasts, between 1945 and 1950 not included in data;
- Survivors studied 1950 -- 2005 are **STRONGER** group than any “general population”

The A-Bomb survivor data set is incomplete. The studies and data collection began in 1950, 5 years after the bombs.

Many who survived the initial blasts then died in the next few years. These deaths are not part of the data-set.

As a result, the group that was studied is strong; stronger than the general population.

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Critiques of the Survivor Studies have been written by some of our greatest independent radiation researchers of the 20<sup>th</sup> Century:

Dr Steven Wing; Dr John Gofman, Dr Alice Stewart, the European Commission on Radiation Regulation (ECRR).

An annotated bibliography of these critiques is under production by this author, and will be posted, along with many other resources on these matters here:

<http://www.nirs.org/radiation/radhealth/radhealthhome.htm>

**RESEARCH**

**Risk of cancer from occupational exposure to ionising radiation: retrospective cohort study of workers in France, the United Kingdom, and the United States (INWORKS)**

David B Richardson,<sup>1</sup> Elisabeth Cardis,<sup>2,3,4</sup> Robert D Daniels,<sup>5</sup> Michael Gillies,<sup>6</sup> Jacqueline A O'Hagan,<sup>6</sup> Ghassan B Hamra,<sup>7</sup> Richard Haylock,<sup>8</sup> Dominique Launer,<sup>9</sup> Klervi Leuraud,<sup>9</sup> Monika Moissonnier,<sup>7</sup> Mary K Schubaue-Berigan,<sup>10</sup> Isabelle Thierry-Chef,<sup>7</sup> Ausrele Kesminiene<sup>9</sup>

Relative rate of mortality due to all cancer other than leukaemia by categories of cumulative colon dose, lagged 10 years in INWORKS. Vertical lines-90% confidence

- **“Study question:** Is protracted exposure to low doses of ionizing radiation associated with an increased risk of solid cancer?”
- **“Although high dose rate exposures are thought to be more dangerous than low dose rate exposures, the risk per unit of radiation dose for cancer among radiation workers was similar to estimates derived from studies of Japanese atomic bomb survivors.”**

What happens when the radiation is not a single Flash, like an X-ray or an A-Bomb? In 2015 a very important contribution to that question was published by Richardson, et al.

This team studied a different, but also very large data-set of nuclear workers in Europe and the USA.

**“Study question:** Is protracted exposure to low doses of ionizing radiation associated with an increased risk of solid cancer?”

**“Although high dose rate exposures are thought to be more dangerous than low dose rate exposures, the risk per unit of radiation dose for cancer among radiation workers was similar to estimates derived from studies of Japanese atomic bomb survivors.”**

So many small doses that total together make a similar level of harm as when the same exposure happens all at once.

Very interesting and lends support to the “No Safe Dose” principle.

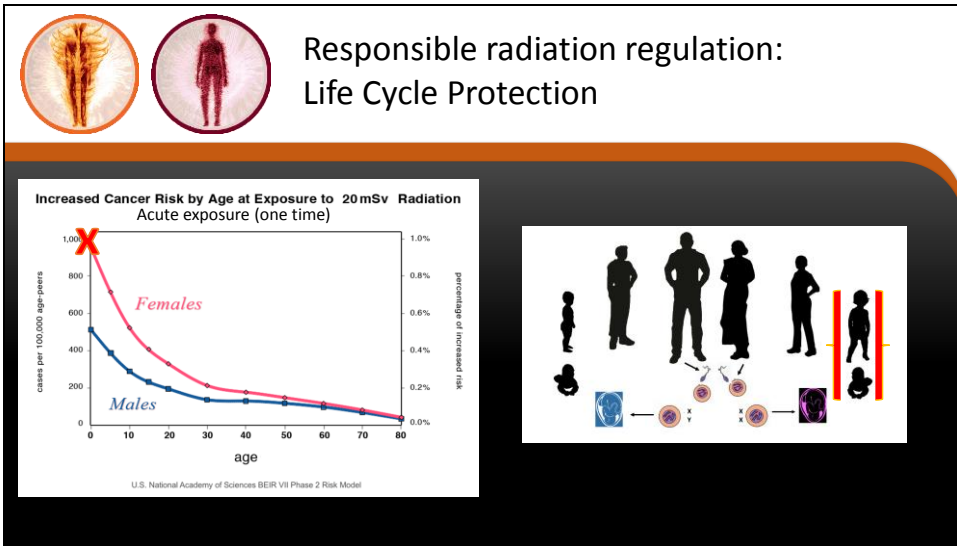
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Paper: Risk of cancer from occupational exposure to ionising radiation: retrospective cohort study of workers in France, the United Kingdom, and the United States (INWORKS)

David B Richardson, et al. *BMJ* 2015;351:h5359

doi: 10.1136/bmj.h5359





In order to ensure the viability of our species over time, regulations should protect its most vulnerable phase: on this graph that would be the X marking girls 0—5 years old. The picture on the right is a articulated human lifecycle. We now have basis to say that there is a somatic difference between male and female sufficient to draw a “Figure 8” to describe this species. The part requiring greatest protection in this picture is the juvenile female on the right, marked in red.

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Radiation regulation includes limits for occupational exposure of pregnant women, but, in general loss of pregnancy is not considered a “cost to society” and is not part of official risk assessments.

We do not have much human data.

This picture shows three generations.

The mother

The growing fetus

And the “primary germ cells” for the next generation are there too.

The egg you came from was formed inside your maternal grandmother.

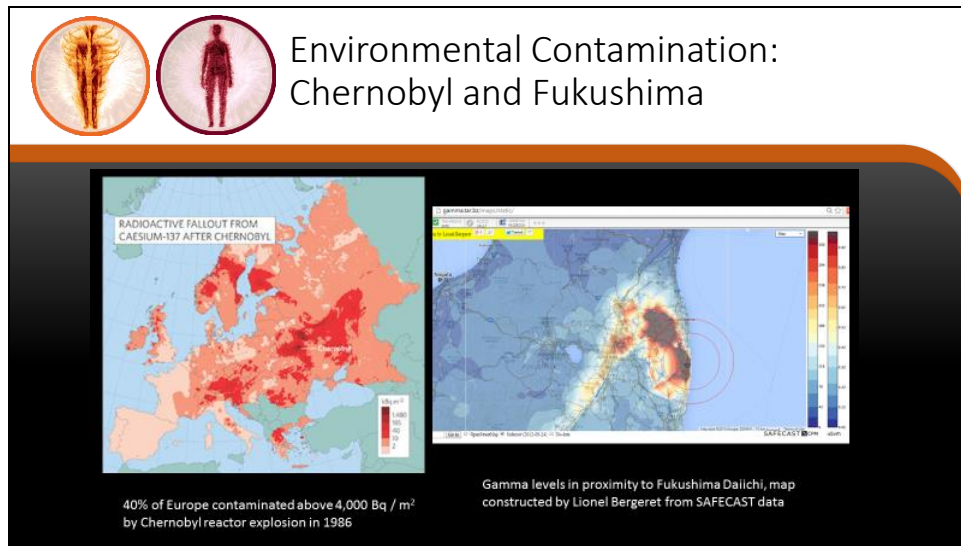
Your father’s *spermatogonia* were formed when he was inside your paternal grandmother.

The primary germ cells form an unbroken chain back to the beginning of our species.

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**Art Credit:**

Saro Lynch-Thomason, Fullsteam Labs



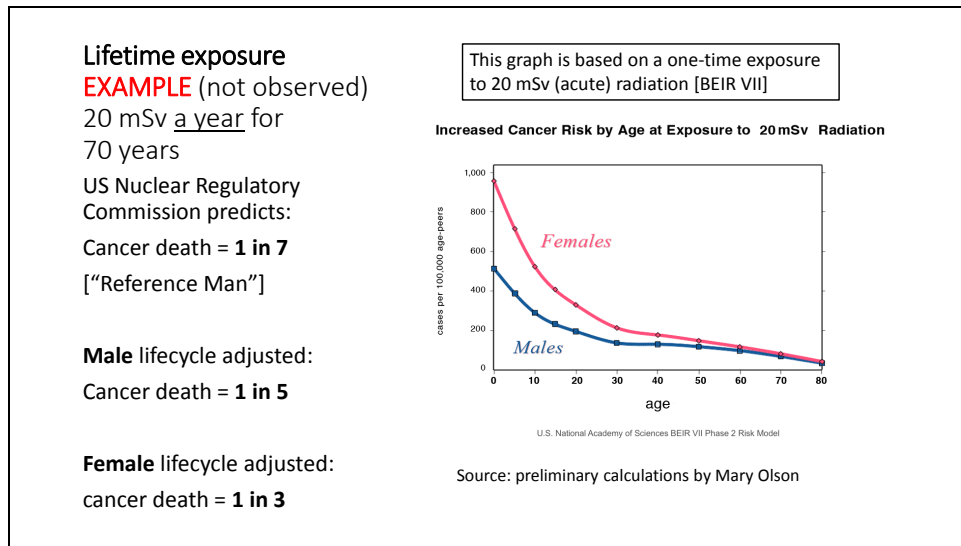
Major reactor accidents contaminate large areas of land and water.

The contamination from Chernobyl is shown across Europe on the left, and a very detailed map of Tepco contamination in Fukushima Prefecture is shown on the right. The map on the right is by Lionel Bereget based on data from Safecast.

These are screenshots, and not intended for distribution.

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See: [safecast.org](http://safecast.org)



Up to now we have been looking at a single, fast exposure to radiation (the A-Bomb survivors). What happens when radiation exposure is not all at once?

What happens if we live with radioactive contamination for a lifetime? I am making an EXAMPLE here. 20 mSv.

The good news is that many have refused to accept this level of exposure. Some people who are monitoring radiation say that a 20 mSv a year exposure is not common. It is my sincere hope that anyone who is exposed at that level will take action to reduce their exposure....

BUT agencies of the US federal government, and at least some officials in Japan have said that a 20 mSv / year exposure is “OK”

SO TAKING THIS AS AN EXAMPLE:  
20 mSv exposure a year, for a lifetime of 70 years.

The US NRC would predict that cancer death = 1 in 7. This is based on “Reference Man”

My own back-of-the-envelope application of the LIFECYCLE data shown at right suggests that if we include exposures during boyhood, the male cancer death rate rises to 1 in 5.

Calculating a female LIFECYCLE impact of this level of radiation impact over her lifetime, we get 1 cancer death in 3.

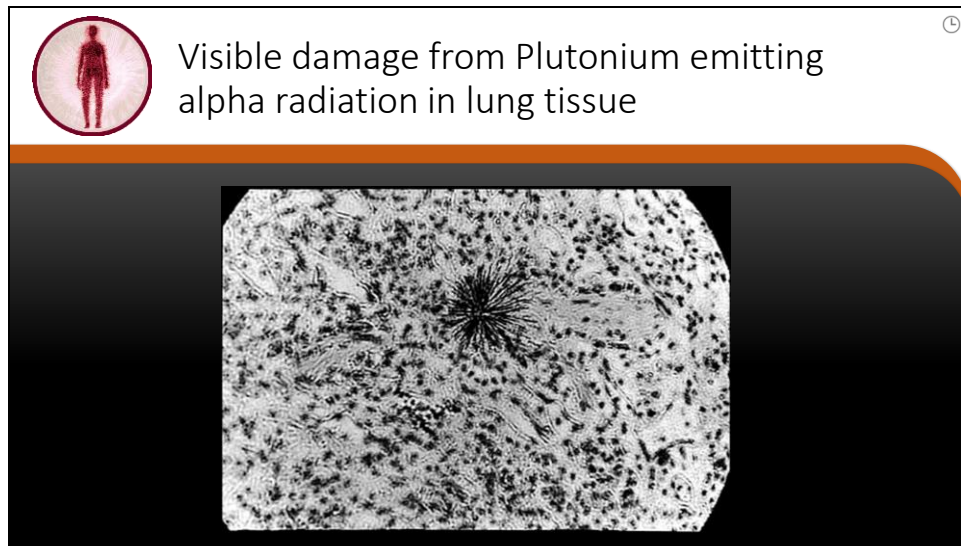
What does this say about the concept of DOSE, when it depends on who gets it?

Source: Mary Olson, unpublished calculations.

## Diaspora

- Definition: the dispersion of any people from their original homeland.
- There is no moral ground in which to require people to stay in their homes after a meltdown. These communities have become Diasporas:
  - Harrisburg... [Three Mile Island]
  - Pripyat... [Chernobyl]
  - Futaba, Namie, Tomioka... [Fukushima]

A Diaspora is not a good "data set."



This is a photograph of the damage to lung tissue from alpha particles coming from some plutonium, located in the center of the black starburst of dead cells.

Alpha particle emissions inside the body may damage cells and cell structures 1000 times more than an external gamma or X-ray

An internal dose of radioactivity may be so local in impact that there is “no” dose to the whole body; nonetheless, cancer may result.

These factors make it very difficult to form a large data-set from which to draw generalized conclusions.

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**Photo Credit:**

Robert Del Tredici (used by permission).

Resources with discussions of internal v external radiation exposure.

<http://www.euradcom.org/>

<http://www.euradcom.org/2011/2009confproc.htm>

Dr Donnell Boardman:  
Radiation is a physical event

- Every radiation exposure is unique;
- An exposure so small it cannot be measured may still result in cancer;
- Radiation is a PHYSICAL event, and like any collision, no two are exactly alike;
- The body's repair mechanisms are miraculous, but not perfect;
- Imperfect repairs may result in cancer (out of control cell reproduction).

Internal exposure outcomes:

Final stage of apoptosis  
White blood cell  
Apoptotic cell  
U.S. National Library of Medicine

What type of radioactivity?  
Where in the body does it concentrate?  
How long does it stay in the body?

Alpha, beta, gamma are all more damaging when emitted inside our body.

How cells repair DNA  
The body has the ability to repair DNA damage. This is a very powerful aspect of our bodies.

Base Excision Repair (BER)  
Nucleotide Excision Repair (NER)  
Mismatch Repair (MMR)  
Telomerase (TERT)  
DNA damage  
DNA repair  
apoptosis  
cancer

When radioactivity is in our air, food or water, it gets inside our body.

This is a complex subject, and I am glad to take questions about it. In order to determine the possible outcomes one must ask:

- What type of radioactivity?
- Where in the body does it concentrate?
- How long does it stay in the body?

Alpha, beta, gamma are all more damaging when emitted inside our body.

Upper left shows the death of a cell. When radiation kills a cell, it is less likely to become cancer. The body regularly absorbs dead cells.

When DNA is damaged, often our bodies repair that damage. This is a very powerful aspect of our bodies.

Nonetheless, a faulty repair can, sometimes, become cancer.

Physical damage to chromosomes is used in some areas of the world as a built-in dosimeter to gauge radiation exposure.



## Dr. Dennis Nelson: "DOSE" is not accurate

- The concept of a "dose" is based on toxic substances that can be diluted to the point where they are not toxic.
- Radiation is not like poison. It is a physical event that results in physical damage.
- Now we know that bodies are not the same. Age, gender, genetic factors can all influence the outcome of a radiation exposure.
- A "Rem" or Sievert" does not describe the complexity of radiation harm.

Dr Dennis Nelson is a biochemist and also grew up in St. George, Utah, downwind of the US nuclear weapons test-site in Nevada.

Dennis writes that the concept of a "dose" is based on toxic substances that can be diluted to the point where they are not toxic.

Radiation is not like poison. It is a physical event that results in physical damage.

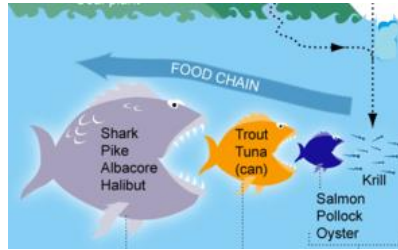
Now we know that bodies are not the same. Age, gender, genetic factors can all influence the outcome of a radiation exposure.

A "Rem" or Sievert" does not describe the complexity of radiation harm.

## Bio-Accumulation Aquatic food-chain

Concentration of heavy metals (including many radionuclides) is higher in larger fish since each step in the chain has a higher concentration than the one below.

Tritium is radioactive hydrogen and while it does not concentrate, tritium goes anywhere in the body that water goes, including across the placenta.



Currently monitoring of radioactivity in water is less of a focus than food. Over time aquatic food chains should be monitored.

Slide 34



Fission results in massive release of ionizing radiation. Earth's Biosphere is being changed in ways we cannot foretell.

Much radioactivity persists into Deep Time.

Thank you to Loren Olson, Artist, and my sister, for use of this image.

Slide 35



This is a picture of health:

These women have recently stopped a nuclear waste dump from being put on their People's Traditional lands.

Radiation prevention is more than avoiding harm. It is a source of health and empowerment.

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See: <http://www.foe.org.au/muckaty-winnerz>

Slide 36



The future is in our hands.

Thank you for being here and for listening.