

Uranium and its decay products in the human body: Where do they go and what do they do?

By Cindy Folkers

Uranium is radioactive. Humans have been digging uranium out of the earth worldwide for over a century, using it in everything from pottery glaze to atomic bomb production. While health impacts of uranium and its decay products were at first unknown, by the time of the Cold War atomic arsenal buildup, obvious health impacts (lung cancer, for instance, had become associated with uranium mining as early as the 1930s) were ignored in favor of nuclear warhead production. Uranium mines and mills spread across the U.S.

In the Western U.S., as in most of the rest of the world, the miners and people living near these facilities were largely indigenous. Not only was the health of workers impacted, but because uranium industrial processes left radioactive contamination in soil and water, people living in the area also suffered health effects. Uranium and decay products still litter these landscapes, posing a continuing danger, particularly when inhaled or ingested.

While these radioisotopes occur naturally, they are artificially available due to industrial processing. Although mining for uranium is the most obvious source, gold and other mine processes can also release these materials. Mine sites and surrounding areas pose the greatest danger of exposure to uranium and all of its decay products.

Additional sites that could pose a danger from individual decay products include thorium waste disposal sites and factories that used radium paint for commercial and military items such as watch and airplane dials. These sites dot the North American landscape and although a number of these facilities have been cleaned up as part of the Superfund program, for some, monitoring is ongoing. Radon gas can leach out from the ground in many places, not just from mines, and become trapped in buildings. In this instance, however, radon can be easily, safely removed by simple technology as recommended by the U.S. Environmental Protection Agency (EPA), posing essentially no danger.¹

While all exposed are at risk, radiation poses a particular danger to women, children and pregnancy. Pregnancy is a unique concern, as the impacts are not accounted for in current radiation exposure standards.²

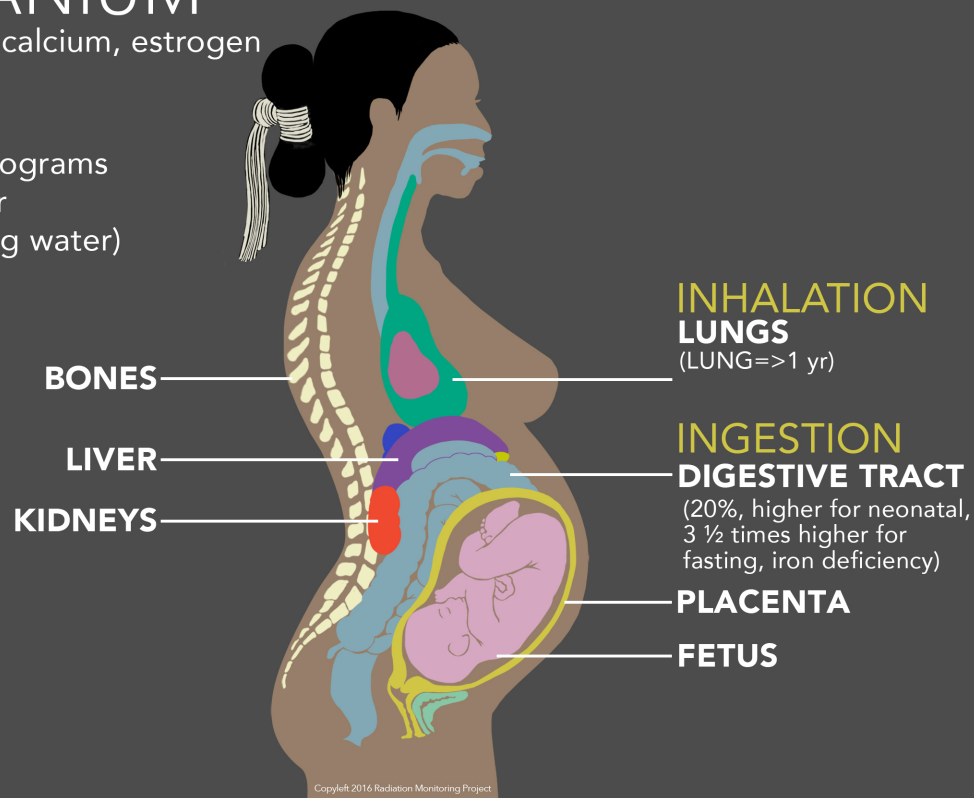
Uranium decays to a number of radioactive isotopes. In this article, we review the impact of uranium and five of its decay products that are the most impactful to health: thorium, radium, radon gas, polonium and radioactive lead. We examine where they travel in the human body, using images representing pregnancy.* Although the EPA has some exposure standards for these isotopes, it has not classified radium, radon or uranium for carcinogenicity.³

* All pregnancy images appear courtesy of [Radiation Monitoring Project](#) and are copyrighted.

URANIUM

mimics calcium, estrogen

30 micrograms
per liter
(drinking water)



URANIUM mimics the mineral calcium and can enter your body by inhalation or ingestion. Replacing healthy, non-radioactive calcium with radioactive uranium can cause a host of subtle and not so subtle health impacts. There is also evidence that the element uranium mimics the essential hormone estrogen. If you inhale uranium into the lung, it can take years for it to leave the lung and be absorbed into the rest of your body. When it leaves the lung, it goes mostly to bone with some traveling to the kidneys and liver.⁴ Ingested uranium will end up in the same organs and tissues, but can be absorbed faster in the neonatal gastrointestinal tract. Fasting and iron deficiency will increase uranium absorption rates.⁵

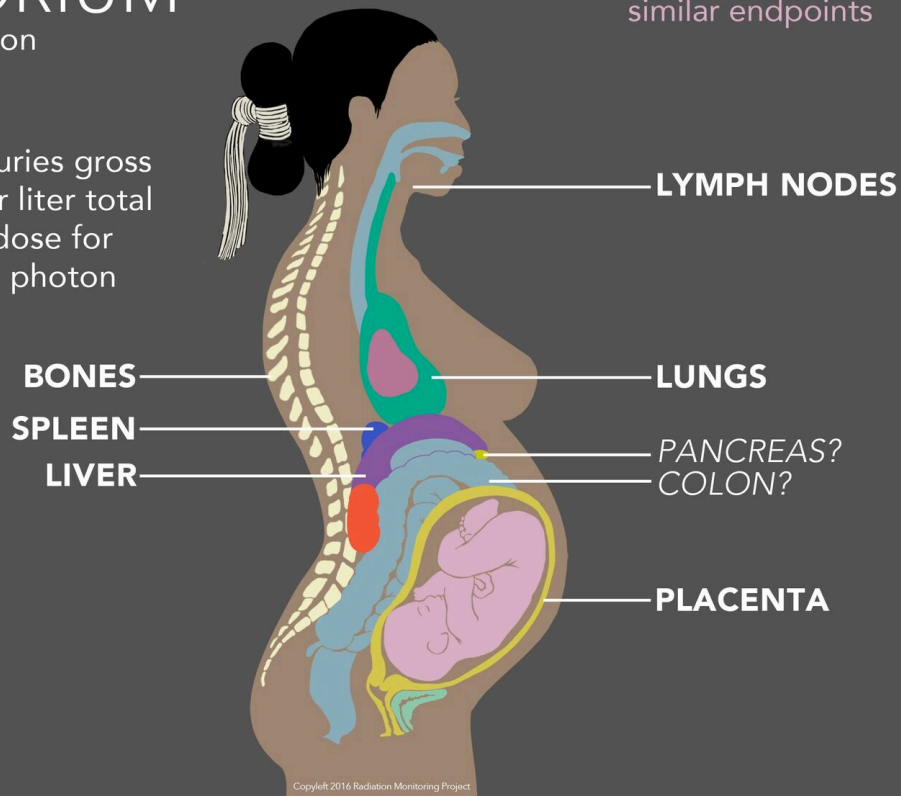
In the body, uranium can cause kidney damage, bone diseases, and developmental problems.⁶ Research indicates that even at levels below EPA's allowed limits in water, uranium can cause negative reproductive health impacts including decreased fertility, reduction in testosterone, decreased fetal body weight and growth weight and⁷ ovarian failure in offspring,⁸ and smaller placentas.⁹ Incidence of gonadal cancer in New Mexico Native American children and teenagers is 8-fold greater than that in non-Native American individuals.¹⁰

THORIUM

mimics iron

Inhalation & ingestion:
similar endpoints

15 picocuries gross
alpha per liter total
4 mrem dose for
beta and photon



THORIUM¹¹ collects in the same places in the body whether inhaled or ingested. Thorium mimics the mineral iron, which is necessary for healthy bones and blood. Target organs include the lungs, lymph nodes, bones,¹² liver and spleen.¹³

At higher medical and occupational doses, thorium is associated with lung cancer, pancreatic cancer, colorectal cancers, chronic respiratory diseases, and liver damage.¹⁴

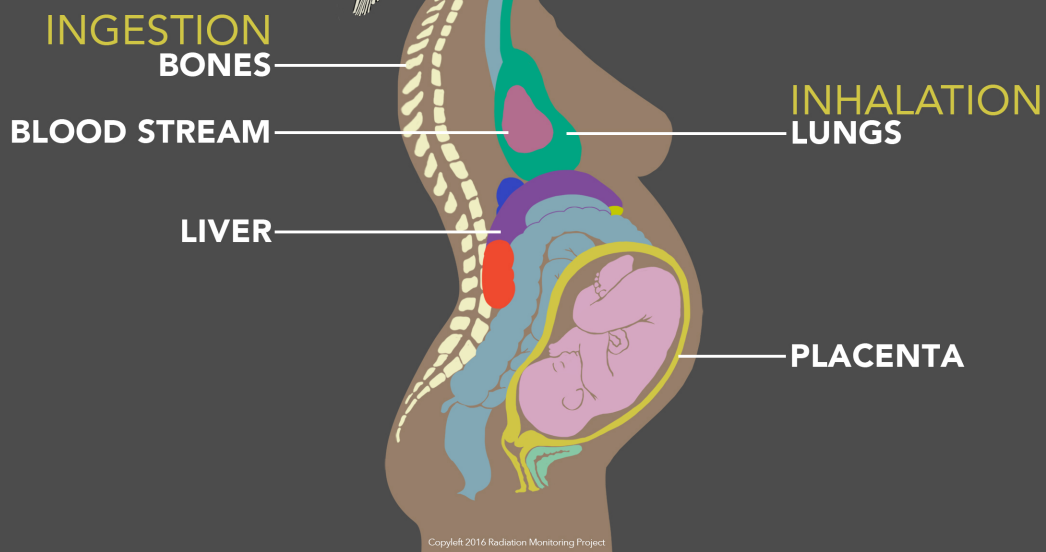
Residents in the vicinity of a thorium waste disposal site in New Jersey have increases in birth defects and liver disease, although specific tests for body contamination have not been conducted.¹⁵

Even small amounts of thorium in the placenta increase its weight.¹⁶

RADIUM

mimics calcium

5 picocuries per liter

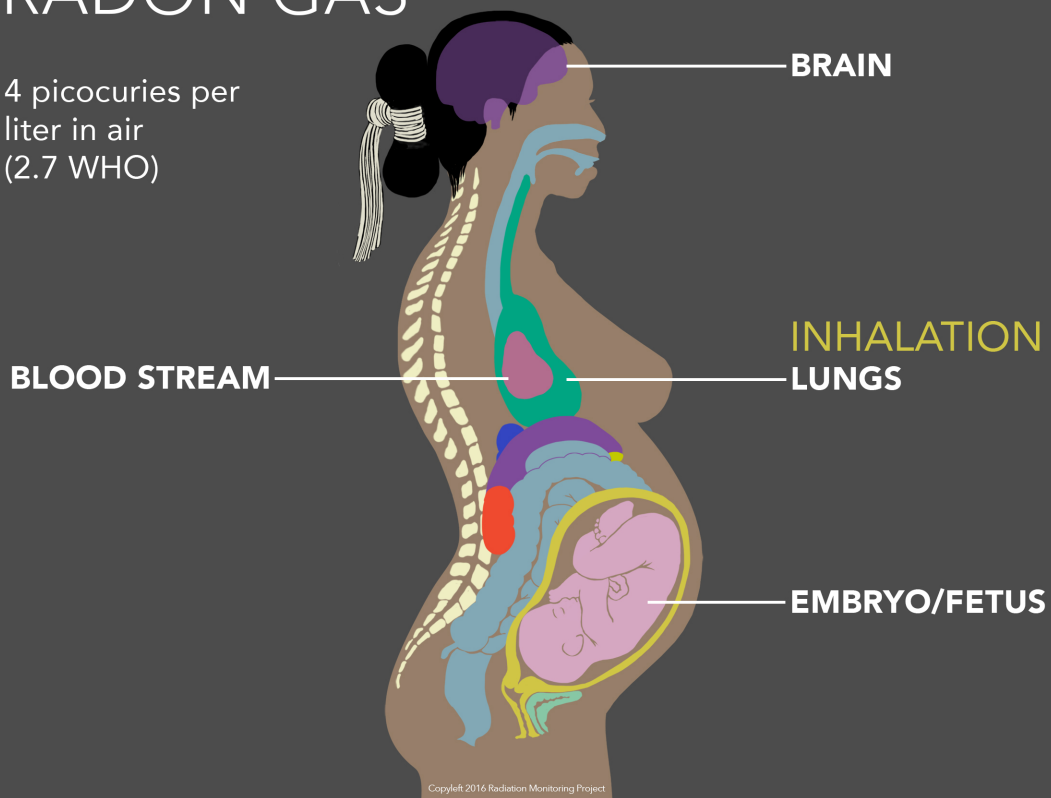


RADIUM, like uranium, mimics the necessary mineral calcium and crosses the placenta in the same ratio as in the mother's blood.

Because of its similarity to calcium, ingested radium lodges in bone, causing rapid changes in bone structure, red blood cell formation (hematopoiesis) in addition it causes bone sarcomas.¹⁷ Through the burning of fossil fuels, we can inhale radium into the lungs. From there it gradually enters the bloodstream.¹⁸ Chronic exposure to radium in humans, by inhalation, has resulted in a decrease of white blood cells (acute leukopenia). Oral exposure has resulted in anemia, necrosis of the jaw, abscess of the brain, and terminal bronchopneumonia. No information is available on the developmental or reproductive effects of radium in humans or animals.¹⁹

RADON GAS

4 picocuries per
liter in air
(2.7 WHO)



RADON GAS is a radioactive gas that itself doesn't accumulate in organs, but its decay products can. When it is inhaled, the dose from radon is given mainly to the lung.²⁰ Radon can travel to the brain where its decay products can irradiate brain tissue. It can pass through the placenta irradiating the developing embryo or fetus.

Radon is thought to be the second major cause of lung cancer after smoking,²¹ responsible for 15K to 22K cancer deaths per year in the U.S. alone.²²

When radon travels to the brain, its decay products can cause Alzheimer's disease and Parkinson's disease. Some research indicates that radon causes multiple sclerosis.²³ Chronic exposure has resulted in respiratory effects including chronic lung disease, pneumonia, fibrosis of the lung, and decreased lung function.²⁴

Radon can pass through the placenta and into the developing embryo where its decay products can produce DNA lesions that will most likely kill it. If the pregnancy is at the fetal stage, radon and decay products will be drawn to lipids, where it will most likely not kill the fetus, but may have severe impacts on brain development.²⁵

POLONIUM

mimics sulfur

15 picocuries gross
alpha per liter

Biokinetics of po-210 is
still not clear, despite
years of study.

BONE MARROW

LUNGS

LIVER

KIDNEYS

PLACENTA

FETUS

OVARIES

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POLONIUM'S movement within our bodies has been studied extensively but despite this, we still don't know how to interpret the data correctly for a number of reasons. Much of the important biological and toxicological research on polonium is more than four decades old.²⁶

Polonium can be inhaled and ingested, collecting in the liver, kidneys, bone marrow and gonads, particularly the radiosensitive ovaries. Polonium also accumulates in the yolk sac of the embryo and in the fetal and placental tissues.²⁷

Polonium is toxic because of its radioactivity rather than its chemical properties. Low-level exposure to polonium may have subtle, long-term biological effects because of its affinity for reproductive and embryonic and fetal tissues. Polonium can damage the placenta. Little is specifically known about the effects of polonium exposure to the embryo and fetus, but exposure could lead to subfertility and miscarriage.²⁸

RADIOACTIVE LEAD

15 parts per billion (ppb)

Inhalation or ingestion result in nearly same organ deposition

BONES & TEETH
(MAJORITY)

BLOOD

ALL ORGANS

PLACENTA

FETUS

RADIOACTIVE LEAD can do damage both from its radioactive and its chemical properties.²⁹ The majority of lead collects in bones and teeth. The rest collects in all organs of the body. Lead collects in the placenta and crosses into the developing embryo or fetus.

A high exposure to lead can lead to poisoning. Symptoms include abdominal pain, constipation, fatigue, headaches, irritability, loss of appetite, memory loss, pain or tingling in the hands or feet, and weakness.

Symptoms of chronic, lower level lead exposure include miscarriage, stillbirths, male and female infertility, behavioral problems, nervous system damage, reduced intelligence, neurological effects, mental retardation, high blood pressure, heart disease, kidney disease, and cancer. For radioactive lead, the risk of cancer increases over non-radioactive lead, but the chemical disease risks remain.^{30,31}

We would like to recognize and thank [Radiation Monitoring Project](#) for the images in this article. RMP hosts workshops on understanding and monitoring radioactive contamination in the environment by purchasing and distributing radiation detectors to contaminated and frontline communities in the U.S. RMP is a collaboration between [Diné No Nukes](#), [Nuclear Energy Information Service](#) & [Sloths Against Nuclear State](#).

¹ <https://www.epa.gov/radon>

² https://beyondnuclearinternational.files.wordpress.com/2018/07/radiation-and-harm-to-human-health_27-july.pdf

³ [Radionuclides \(including Radon, Radium and Uranium\) Hazard Summary](#). EPA. 2000, 2016?

⁴ Craft et al. *DEPLETED AND NATURAL URANIUM: CHEMISTRY AND TOXICOLOGICAL EFFECTS*. Journal of Toxicology and Environmental Health, Part B, 7:297-317, 2004.

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- ⁵ Craft 2004.
- ⁶ Craft 2004.
- ⁷ Raymond-Whish, et al. *Drinking Water with Uranium below the U.S. EPA Water Standard Causes Estrogen Receptor-Dependent Responses in Female Mice*. Environmental Health Perspectives. VOLUME 115. NUMBER 12. December 2007.
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- ⁹ Mirderikvand et al.
- ¹⁰ Whish 2007.
- ¹¹ <http://hpschapters.org/northcarolina/NSDS/thorium.pdf>
- ¹² Ulsh, et al. [Retrospective Dose Reconstruction for Thorium, 232 Activities at the Mound Laboratory](#), Preliminary Report, NIOSH, 2012.
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- ¹⁴ Najem, et al. [Health Effects of a Thorium Waste Disposal Site](#). *AJPH*. April 1990.
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- ¹⁶ Rakhmanbek, et al. [The effect of low concentrations of radioactive nuclides on morphometric characteristics of human placenta](#). *EHP abstracts*. 2013.
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- ¹⁹ [Radionuclides \(including Radon, Radium and Uranium\) Hazard Summary](#). EPA. 2000, 2016?
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- ²² ["Radon and Cancer: Questions and Answers"](#). *National Cancer Institute*.
- ²³ Groves-Kirkby et al. [Environmental Radon Gas and Degenerative Conditions – An Overview](#). IRPA, Paris. 2006.
- ²⁴ [Radionuclides \(including Radon, Radium and Uranium\) Hazard Summary](#). EPA. 2000, 2016?
- ²⁵ [Radon: Molecular Action and Genetic Effects](#). University of Minnesota School of Public Health.
- ²⁶ Leggett et al. [A systemic biokinetic model for polonium](#). *The Science of the Total Environment* 275. 2001. 109-125.
- ²⁷ Seiler, et al. [Occurrence of 210Po and Biological Effects of Low-Level Exposure: The Need for Research](#) *Environ Health Perspect.* 2012.
- ²⁸ Seiler 2012.
- ²⁹ [Health Problems Caused by Lead](#). CDC. 2013.
- ³⁰ [TOXICOLOGICAL PROFILE FOR LEAD](#) U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES Public Health Service Agency for Toxic Substances and Disease Registry. 2007.
- ³¹ CDC 2013.