

Biological Effects of Radiation

Radiation is all around us. It is in our environment and has been since the Earth was formed. As a result, life has evolved in the presence of significant levels of ionizing radiation. It comes from outer space (cosmic), the ground (terrestrial) and even from within our own bodies. It is in the air we breathe, the food we eat, the water we drink and the materials used to build our homes.

Some foods such as bananas and Brazil nuts naturally contain higher levels of radiation. Brick and stone homes have higher radiation levels than homes made of other materials such as wood. The U.S. Capitol, which is largely built of granite, contains more radiation than most homes. A lot of our exposure is due to radon, a gas from the Earth's crust that is present in the air we breathe.

This natural radiation that is always present is known as “background” radiation. Background levels can vary greatly from one location to the next. For example, Colorado, because of its altitude, has more cosmic radiation than the East or West Coast. It also has more terrestrial radiation from soils rich in naturally-occurring uranium. So people living in Colorado are exposed to more background radiation than residents of the coasts.

On average, a U.S. resident receives an annual radiation exposure from natural sources of about 310 millirem (3.1 millisieverts or mSv). Radon and thoron gases account for two-thirds of this exposure. Cosmic, terrestrial, and internal radiation account for the rest.

Man-made sources of radiation from medical, commercial and industrial activities contribute roughly 310 mrem more to our annual exposure. Among the largest of these sources is a computed tomography scan, which accounts for about 150 mrem. Other medical procedures make up another 150 mrem or so each year. Some consumer products such as tobacco, fertilizer, welding rods, exit signs, luminous watch dials and smoke detectors contribute about 10 mrem per year. The pie chart below shows the sources that make up the average annual U.S. radiation dose of 620 mrem.

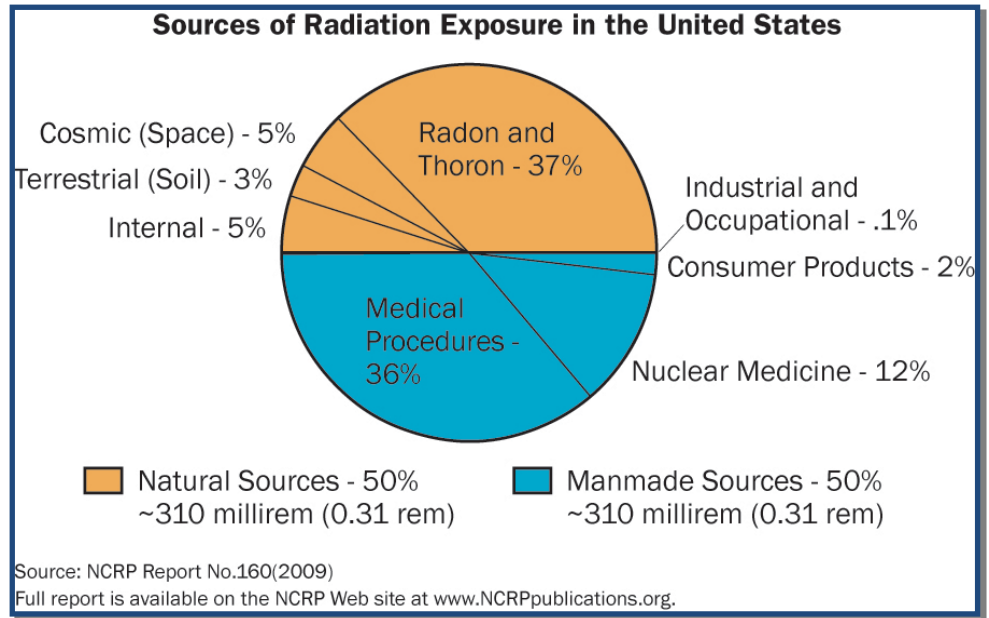
Natural and man-made radiation may come from different sources, but both affect us in the same way. The NRC does not regulate background radiation. But the NRC does require its licensees to limit exposure to members of the public to 100 mrem (1 mSv) per year above background. Exposure to adults working with radioactive materials must be below 5,000 mrem (50 mSv) per year. NRC’s radiation exposure limits are contained in [Title 10 of the Code of Federal Regulations, Part 20](#).

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We tend to think of the effects of radiation in terms of how it impacts living cells. For low levels of exposure, the biological effects are so small they may not be detected. The body is able to repair damage from radiation, chemicals and other hazards. Living cells exposed to radiation could: (1) repair

themselves, leaving no damage; (2) die and be replaced, much like millions of body cells do every day; or (3) incorrectly repair themselves, resulting in a biophysical change.

The data on links between radiation exposure and cancer are mostly based on populations receiving high level exposures. Much of this information comes from survivors of the atomic bombs in Japan and people who have received radiation for medical tests and therapy. Cancers associated with high-dose exposure (greater than 50,000 mrem, or 500 mSv—500 times the NRC limit to the public) include leukemia, breast, bladder, colon, liver, lung, esophagus, ovarian, multiple myeloma and stomach cancers.



The time between radiation exposure and the detection of cancer is known as the latent period. This period can be many years. It is often not possible to tell exactly what causes any cancer. In fact, the National Cancer Institute says other chemical and physical hazards and lifestyle factors (e.g., smoking, alcohol consumption and diet) make a significant contribution to many of these same diseases.

The data show high doses of radiation may cause cancers. But there are no data to establish a firm link between cancer and doses below about 10,000 mrem (100 mSv – 100 times the NRC limit).

Even so, the regulations assume any amount of radiation may pose some risk. They aim to minimize doses to radiation workers and the public. The international community bases standards for radiation protection on something called the linear, no-threshold model. The idea is that risk increases as the dose increases. And there is no threshold below which radiation doses are safe. This model is a conservative basis for both international and NRC radiation dose standards. This means the model may overestimate risk.

High radiation doses (greater than 50,000 mrem, or 500 mSv) tend to kill cells. Low doses may damage or alter a cell's genetic code, or DNA. High doses can kill so many cells that tissues and organs are damaged immediately. This in turn may cause a rapid body response often called Acute Radiation Syndrome. The higher the radiation dose, the sooner the effects of radiation will appear, and the higher the probability of death.

Many atomic bomb survivors in 1945 and emergency workers at the 1986 Chernobyl nuclear power plant accident experienced this syndrome. Among plant workers and firefighters at Chernobyl, 134 received high radiation doses – 80,000 to 1,600,000 mrem (800 to 16,000 mSv) – and suffered from

acute radiation sickness. Of these, 28 died within the first three months from their radiation injuries. Two workers died within hours of the accident from non-radiological injuries.

Because radiation affects people in different ways, it is not possible to say what dose is going to be fatal. Experts believe that 50 percent of people would die within thirty days after receiving a whole body dose of 350,000 to 500,000 mrem (3,500 to 5,000 mSv) over a period ranging from a few minutes to a few hours. Health outcomes would vary depending on how healthy the person is before the exposure and the medical care they receive. If the exposure affects only parts of the body, such as the hands, effects will likely be more localized, such as skin burns.

Low doses spread out over a long period would not cause an immediate problem. The effects of doses less than 10,000 mrem (100 mSv) over many years, if any, would occur at the cell level. Such changes may not be seen for many years or even decades after exposure.

Genetic effects and cancer are the primary health concerns from radiation exposure. Cancer would be about five times more likely than a genetic effect. Genetic effects might include chromosome changes, stillbirths, congenital abnormalities, and infant and childhood mortality. These effects can result from a mutation in the cells of an exposed person that are passed on to their children. These effects may appear almost immediately if the damaged genes are dominant. Or they may appear several generations later if the genes are recessive.

While scientists have observed genetic effects in lab animals given very high doses of radiation, no evidence of genetic effects has been seen in the children born to Japanese atomic bomb survivors.

NRC regulations strictly limit the amount of radiation that can be emitted by a nuclear facility, such as a nuclear power plant. A 1991 study by the National Cancer Institute, "Cancer in Populations Living Near Nuclear Facilities," concluded that there was no increased risk of death from cancer for people living in counties adjacent to U.S. nuclear facilities.

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