Health Physics Society
Specialists in Radiation Safety

Fact Sheet
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Environmental Radiation

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The background level of radiation in the natural environment surrounds us at all times—it is ubiquitous. Since the Earth formed and life developed, *background radiation** has been our constant companion.

Sources of Background Radiation

Background radiation (which scientists call "ubiquitous background radiation") is emitted from both natural and human-made radioactive chemicals (*radionuclides*). Some naturally occurring radionuclides are found in the earth beneath our feet, while others are produced in the atmosphere by radiation from space. Human-made radionuclides have entered the environment from activities such as medical procedures that use radionuclides to image the body and electricity generation that uses radioactive uranium as fuel.

Humans are continuously irradiated by sources outside and inside their bodies. Outside sources include *space radiation* and *terrestrial radiation*. Inside sources include the radionuclides that enter our bodies in the food and water people ingest and the air they breathe. Whatever its origin, radiation is everywhere (or "ubiquitous") in the environment.

Radiation from Space

Radiation that enters the Earth's atmosphere from space can come from as close as the Earth's radiation belts and the sun or as far away as beyond the boundaries of the solar system and even beyond the Milky Way galaxy. Radiation from beyond the solar system has enough energy to generate additional radiation as it passes through Earth's atmosphere, creating either radionuclides in the air or secondary particles. Some secondary particles reach the Earth's surface—most readily near the magnetic poles where shielding by the Earth's magnetic field is weakest and at high altitudes where the Earth's atmosphere is thinnest. Radionuclides created by space radiation are called *cosmogenic* radionuclides. They include tritium (hydrogen-3), beryllium-7, carbon-14, and sodium-22.

Terrestrial Radiation

Radiation that originates on Earth is called terrestrial radiation. *Primordial* radionuclides (radioactive chemicals that were present when the Earth formed about 4.5 billion years ago) are found around the globe in igneous and sedimentary rock. From rocks, these radionuclides migrate into soil, water, and even air. Human activities such as uranium mining have also redistributed these radionuclides. Primordial radionuclides include the series of radionuclides produced when uranium and thorium decay, as well as potassium-40 and rubidium-87.

In the past, one human activity that contributed to terrestrial radiation was production of nuclear weapons. Today, atmospheric weapons testing is not a significant contributor to background radiation because fallout has decayed since weapons testing was stopped (in the United States, testing ended in 1963). The reactor accident at Chernobyl in 1986 is also not a significant source of background radiation in the United States.

Radionuclides in the Body

Terrestrial and cosmogenic radionuclides enter the body through the food we eat, water we drink, and air we breathe. As with all chemicals, radionuclides are used and eliminated by the body during normal metabolism. Some radionuclides decay away quickly but are replaced through fresh ingestion or inhalation. Other radionuclides decay more slowly and may concentrate in

*Words in italics are defined in the Glossary on page 5.

specific body tissues (such as radium in bone); others are not readily absorbed by the gut and are quickly eliminated.

The most important radionuclides that enter the body are terrestrial in origin. Primary among them are the radon gases (and their decay products) that a person constantly inhales. Radon levels depend on uranium and thorium content of the soil, which varies widely across the United States. The highest levels are found in the Appalachians, the upper Midwest, and the Rocky Mountain states.

Other radionuclides in the body include uranium and thorium and their decay products, as well as potassium-40. These terrestrial radionuclides are in the soil where food grows and eventually find their way into the water supply.

Most drinking-water sources have very low levels of terrestrial radionuclides, including radium-226, radium-228, and uranium. These radionuclides may be higher in some areas of the United States than in others—for example, radium levels are higher in some Midwestern states, while uranium levels are higher in some Western states. Typically these levels are less than the limits set by the United States Environmental Protection Agency.

Dose from Background Radiation

A person receives a radiation dose from exposure to radiation sources outside the body (for example, external radiation from uranium in concrete used to build homes) and inside the body (for example, internal radiation from radioactive potassium absorbed by the cells when a person eats food). Here the term "dose" is used to mean *effective dose*, which describes the amount of radiation energy absorbed by the body.

When scientists describe dose, they use the units of *sievert* (Sv), one-thousandth of a sievert (millisievert or mSv), or one-millionth of a sievert (microsievert or μSv), much in the way units of meters are used to describe distance. Another dose unit is the *gray* (Gy) and one-trillionth of a gray (nanogray or nGy).

Each year, a resident of the United States receives an average total dose from background radiation of about 3.1 mSv. The sources of this dose are shown in Figure 1 and are discussed in detail following. Note that the annual dose values given here are averages for the United States. Some people receive less (although no one receives zero), some people receive more, and a few percent of the population receive much more.

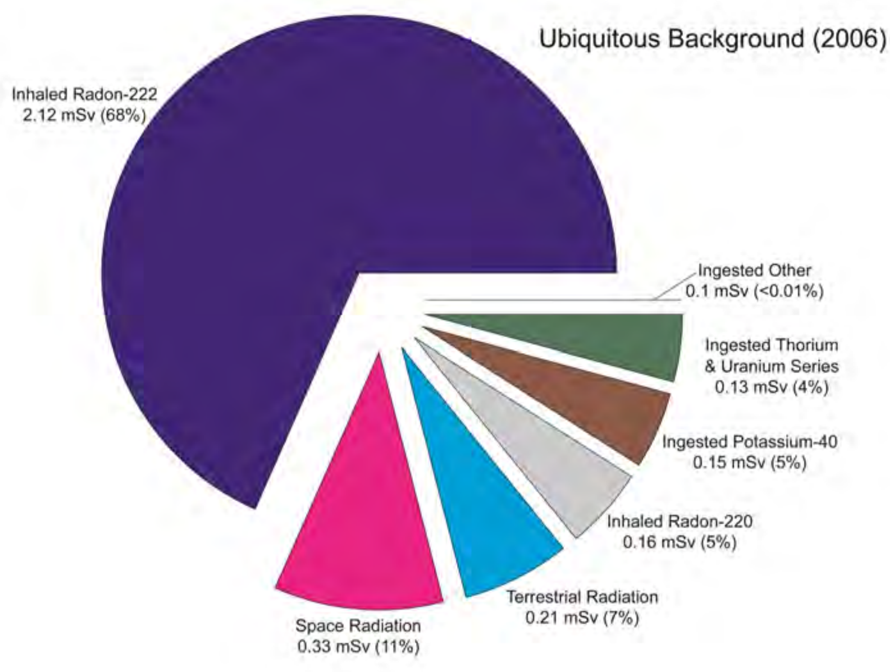

Figure 1: Distribution of the population dose among the various sources of background radiation (Figure 3-19 from NCRP 160); reprinted with permission of the National Council on Radiation Protection and Measurements, http://NCRPonline.org.

Dose from Space Radiation

In the United States, most people receive an average dose from space radiation of about 0.3 mSv each year. As Figure 2 illustrates, this dose depends on where a person lives—the latitude and altitude. In Honolulu (at sea level and near the equator) the average dose from space radiation is 0.2 mSv (200μSv), while in Colorado Springs (high altitude and latitude) the average space radiation dose is 0.7 mSv (700 μSv). The average space radiation dose makes up about 11 percent of the average total dose from background radiation.

Traveling by airplane can expose people to slightly more space radiation because at high altitudes, there is less atmosphere to shield the incoming radiation. For example, one study found that on a flight from New York to Chicago, travelers would receive a dose of about 0.009 mSv. This dose can vary significantly, too, depending on flight path and the sun's 11-year cycle of solar flares.

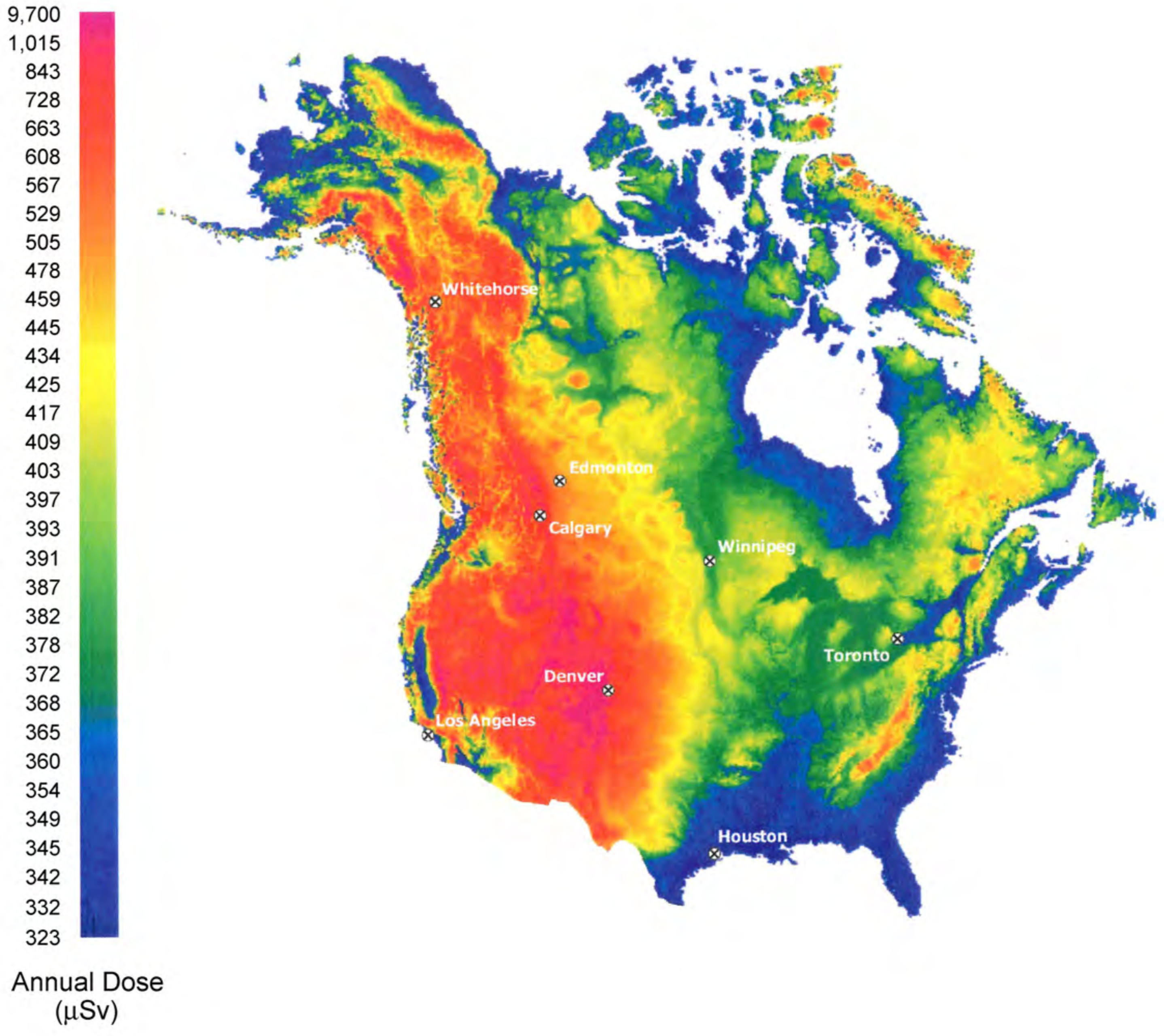

Figure 2: False-color map of calculations of annual doses (μSv y^{-1}) in North America due to space radiation showing variability (Grasty and LaMarre, 2004) (Figure 3.4 from NCRP 160); reprinted with permission of the National Council on Radiation Protection and Measurements, http://NCRPonline.org.

Dose from Terrestrial Radiation

People living in the United States receive an average dose from terrestrial radiation (not including the dose from ingested and inhaled radionuclides) of about 0.2 mSv per year. As Figure 3 shows, the dose from terrestrial radiation also varies with location: doses on the Atlantic and Gulf coastal plains are lowest, while doses in the mountains of the western United States are highest.

Nuclear fallout from past weapons testing is not a significant contributor to terrestrial radiation. In fact, the dose from fallout is so low today that instruments can't measure it. The average terrestrial radiation dose (not including the dose from radionuclides in the body, discussed below) is about 7 percent of the average total dose from background radiation.

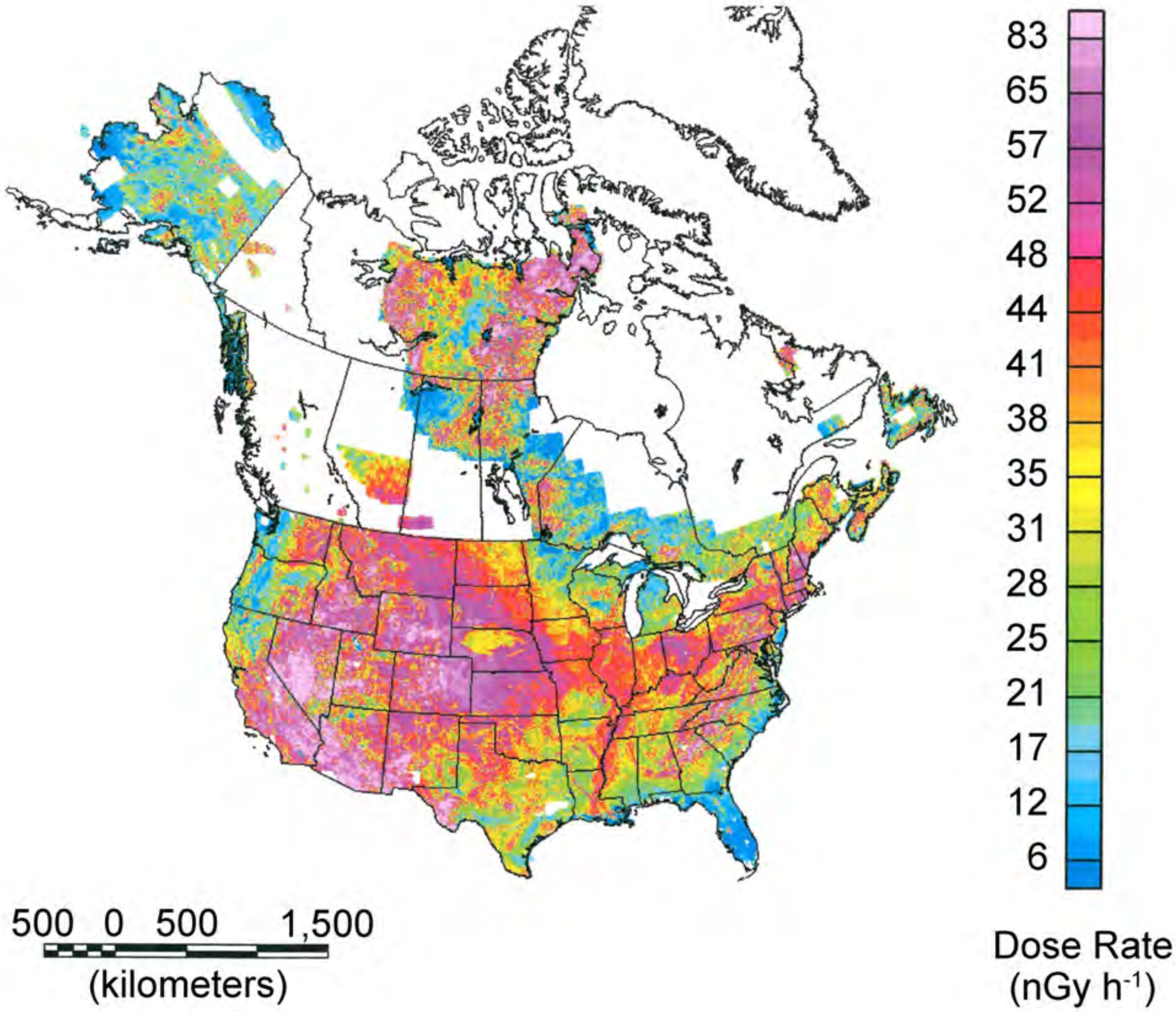

Figure 3: Map of absorbed dose rate in air from the U.S. Geological Survey data, with blue being the lowest (<6 nGy h^{-1}) and lavender the highest (>83 nGy h^{-1}) (Duval et al., 2005) (Figure 3.9 from NCRP 160); reprinted with permission of the National Council on Radiation Protection and Measurements, http://NCRPonline.org.

Dose from Radionuclides in the Body

Inhaled radionuclides include cosmogenic radionuclides and terrestrial radionuclides that become airborne. Of all sources of background radiation, radon (the gas emitted by uranium and thorium in soil and rocks) and its decay products result in the greatest dose to humans. Yet indoor radon concentrations are also the most variable dose components, since they depend on how a house is built, the soil it is built on, where in the house the radon is measured, and more. Even granite countertops can contribute to the radon levels in a house, but this contribution is typically very small compared to the radon from the soil under the house. The average dose from all inhaled radionuclides is about 2.3

mSv per year, which is about 73 percent of the average total dose from background radiation.

People ingest radionuclides when they eat food grown in soil that contains uranium, thorium, potassium, and rubidium; drink milk from animals fed crops that grow in the soil; and drink water containing dissolved terrestrial radionuclides. The average dose from all ingested radionuclides is about 0.3 mSv per year (about 9 percent of the average total dose from background radiation).

Health Effects of Background Radiation

Exposure to high levels of radiation is known to cause cancer. But the effects on human health from very low doses of radiation—such as the doses from background radiation—are very hard to determine because there are so many other factors that can mask or distort the effects of radiation. For example, among people exposed to high radon levels, cigarette smokers are much more likely to get lung cancer than nonsmokers. Lifestyle choices, geographic locations, and individual sensitivities are difficult to account for when trying to understand the health effects of background radiation.

A United Nations committee concluded that exposure to varying levels of background radiation does not significantly affect cancer incidence. A committee of the National Academy of Sciences suggested that while there may be some risk of cancer at the very low doses from background radiation, that risk is small.

Still, while the overall risk is low for all cancers, it is not zero and it is greater for some types of cancer than others. For lung cancer caused by breathing radon (and its decay products), the Environmental Protection Agency estimates that there are about 21,000 deaths each year, which is about 13 percent of all lung-cancer deaths. There is no evidence of increased risk of diseases other than cancer.

Glossary

Background Radiation
Widespread radiation from space and from natural and human-made radionuclides originating in space and on the Earth.

Cosmogenic
Radionuclides produced when space radiation interacts with molecules in the atmosphere.

Dose (or Effective Dose)
Amount of radiation energy absorbed by the body, which is calculated to account for the different types of radiation (such as alpha and beta) and how sensitive different organs are to radiation (for example, bone compared to lungs).

Gray (Gy)
An International System of Units (SI) unit for absorbed radiation dose that can be converted to traditional U.S. units of rad (1/100 of a Gy).

Primordial
Radionuclides present in the Earth when it formed.

Radionuclide
A radioactive element, man-made or from natural sources, with a specific atomic weight.

Sievert (Sv)
An International System of Units (SI) unit for equivalent or effective radiation dose that can be converted to traditional U.S. units of rem (1/100 of a Sv) or millirem (mrem; 1/100 of a millisievert [mSv]).

Space Radiation
Radiation originating outside the Earth’s atmosphere, including solar radiation.

Terrestrial Radiation
Radiation emitted by radionuclides in soil and rocks.

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Resources for more information

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The Health Physics Society is a nonprofit scientific professional organization whose mission is excellence in the science and practice of radiation safety. Formed in 1956, the Society has approximately 5,500 scientists, physicians, engineers, lawyers, and other professionals. Activities include encouraging research in radiation science, developing standards, and disseminating radiation safety information. The Society may be contacted at 1313 Dolley Madison Blvd., Suite 402, McLean, VA 22101; phone: 703-790-1745; fax: 703-790-2672; email: HPS@BurkInc.com.