Understanding Radiation

Its Effects and Benefits
The type of radiation we hear about most often is ionizing radiation, which is used in X-rays, CT scans, nuclear power plants and much more. It is called “ionizing” because it removes electrons from atoms, causing the atoms to become electrically charged ions. Scientists have studied ionizing radiation for more than a century, and it is one of the best-understood forms of energy.

Radiation exposure, or “dose,” is a measure of the amount of energy deposited in the body, typically expressed in millirem. The average American receives 300 millirem of radiation annually from natural sources and about the same amount from medical procedures.

Scientists have found no indication of adverse health effects from low doses of radiation—in the range of 5,000 millirem to 10,000 millirem or less—depending on whether the dose occurs in a short period or over a long time. However, at high dose levels, radiation can be harmful or lethal. The same attributes that make high levels of radiation useful for treating certain cancers also make it hazardous to healthy tissue. Stringent regulation and other controls protect workers, patients and the general public from unnecessary exposure to man-made radiation.

What Is Radiation?

Radiation has been part of our natural environment since the Earth was formed. The planet is bathed in cosmic radiation from outer space, and radioactive materials naturally present in the soil, rocks, air and seawater also emit this type of energy. From the very beginnings of human civilization, radiation has been part of everyday life.

The type of radiation we hear about most often is ionizing radiation, which is used in X-rays, CT scans, nuclear power plants and much more. It is called “ionizing” because it removes electrons from atoms, causing the atoms to become electrically charged ions. Scientists have studied ionizing radiation for more than a century, and it is one of the best-understood forms of energy.

Radiation exposure, or “dose,” is a measure of the amount of energy deposited in the body, typically expressed in millirem. The average American receives 300 millirem of radiation annually from natural sources and about the same amount from medical procedures.

Scientists have found no indication of adverse health effects from low doses of radiation—in the range of 5,000 millirem to 10,000 millirem or less—depending on whether the dose occurs in a short period or over a long time. However, at high dose levels, radiation can be harmful or lethal. The same attributes that make high levels of radiation useful for treating certain cancers also make it hazardous to healthy tissue. Stringent regulation and other controls protect workers, patients and the general public from unnecessary exposure to man-made radiation.

Scientist Marie Curie was awarded two Nobel Prizes for her studies in radioactivity.

The black or magenta trefoil on a yellow background is the international symbol for radiation. It is posted where radioactive materials are handled or where radiation-producing equipment is used.
Where Does It Come From?

Natural Radiation
Natural background radiation accounts for 48 percent of the U.S. public’s annual exposure to ionizing radiation.

Radon is a common, naturally occurring gas that results from the radioactive decay of radium-226, which is a decay product of uranium-238. Both elements are widely found in soil and rocks, so the air around us typically contains at least a small amount of radon. Radon is a health concern if inhaled at higher concentrations—which can develop when ventilation is limited—because the radioactive particles may damage sensitive lung tissue. The National Academy of Sciences found that radon exposure multiplies the risk of lung cancer in smokers and may contribute to lung cancer in non-smokers. Federal regulations prohibit smoking in work environments where radon is present, such as underground mines. The most effective way to manage radon exposure is dilution of the particles in the air through ventilation.

Medical Procedures
In 2006, medical procedures accounted for nearly half of the average annual exposure to ionizing radiation. This reflects a tremendous increase over the past few decades in the number of procedures performed each year that involve ionizing radiation—especially CT scans. However, medical imaging procedures involving ionizing radiation are used only when necessary to diagnose injury or illness. No ionizing radiation is involved in ultrasound or magnetic resonance imaging studies.

Sources of Radiation Exposure
(annual)

The average American receives about 300 millirem of radiation exposure annually from nature. Medical procedures, such as CT scans, add about the same amount of radiation dose.
Medical Diagnosis and Treatment

Medical applications of nuclear technology include radiology—X-rays used alone or in combination with other techniques—as well as nuclear medicine procedures and radiation oncology.

X-rays are used to look for such diseases as pneumonia, emphysema or lung cancer; to identify dental problems; and to reveal bone fractures. Fluoroscopy uses X-rays with a contrast medium. For example, barium is placed in the large intestine so doctors can see the intestine more clearly using X-rays and identify blockages or other problems. Radiology also includes computerized tomography (CT), which uses X-rays and computer processing to generate two-dimensional images of the inside of the body.

Nuclear medicine procedures involve injecting a tiny amount of a radioisotope—a chemical element that produces radiation—into a patient’s body. A specific organ picks up the radioisotope, enabling a special camera to take a detailed picture of how that organ is functioning. For example, myocardial perfusion imaging maps the blood flow to the heart, allowing doctors to see whether a patient has heart disease and determine the most effective course of treatment.

Increasingly precise radiation oncology techniques target cancerous tumors while sparing healthy tissues. Large devices called linear accelerators deliver high-energy beams of X-rays or electrons to a tumor. A remarkable device called a Gamma Knife allows surgeons to use radiation to destroy diseased brain tissue without an incision. Intersecting beams of radiation are focused on the tumor, delivering the treatment dose of radiation precisely where the beams intersect.
Electricity Generation
America’s 104 nuclear power plants generate 20 percent of our electricity, while emitting no carbon dioxide or air pollution. Instead of burning fuel like a fossil-fueled power plant, nuclear plants use the heat released by splitting atoms of uranium fuel to make the steam that drives their turbines. Multiple barriers and backup safety systems prevent the inadvertent release of radiation. As a result of these safety measures, nuclear plants represent one of the smallest sources of radiation exposure to the public, accounting for less than 1 percent of the average person’s total exposure. In fact, the average person living within 50 miles of a nuclear power plant receives about the same radiation dose from the plant as from a smoke detector in the home.

Scientific Research
Researchers in nearly all fields of science use radioisotopes in their work. Carbon-14, a naturally occurring, long-lived radioisotope, allows archaeologists to determine when artifacts containing plant or animal material were alive, created or used. The U.S. Food and Drug Administration requires testing of all new drugs for safety and effectiveness. More than 80 percent of those drugs are tested with radioisotopes. Radioisotopes also are essential to the biomedical research that seeks causes and cures for diseases such as AIDS, cancer and Alzheimer’s disease. Researchers also use radioisotopes in metabolic studies, genetic engineering and environmental protection studies.

Food Safety and Agriculture
Irradiation is used in more than 40 countries to enhance food safety by killing bacteria, insects and parasites that can cause salmonella, trichinosis, cholera and other food-borne illnesses. Irradiation does not make the food radioactive, nor does it change the food any more than canning or freezing. In the United States, the Food and Drug Administration (FDA) has approved the use of irradiation for fruits, vegetables, pork, poultry, red meat and spices. For example, the FDA approved irradiation of iceberg lettuce and spinach to help protect consumers from infection by such bacteria as salmonella and E. coli. In agriculture, radiation is widely used to eradicate pest insects.
Consumer Products
Many consumer products—from smoke detectors to cosmetics—use small amounts of radiation. Smoke detectors rely on a tiny radioactive source to sound an alarm when smoke is present. Treating nonstick pans with radiation ensures that the coating will stick to the surface.

Photocopiers use small amounts of radiation to eliminate static and prevent paper from sticking together and jamming the machine. Radiation also sterilizes cosmetics, hair products, contact lens solutions and medical bandages, removing irritants and allergens.

Industrial Applications
Among industries that use radioactive materials in their processes and products are automobile and aircraft manufacturers, mining and oil companies, and construction companies. Industry has used radioisotopes to develop highly sensitive gauges to measure the thickness and density of many materials, including sheet metal, textiles, paper napkins, newspaper, plastics and photographic film.

Radioactive materials are used to inspect metal parts and welds for defects. They also are used to generate heat or power for remote weather stations, space satellites and other special applications.

Space Exploration
Unmanned spacecraft rely on radioisotope thermoelectric generators (RTGs) for the power to explore deep space. RTGs use heat from plutonium to generate electricity. They are safe, reliable and long-lived, even in the harsh climate of our solar system.
How Is Radiation Controlled?

The U.S. Environmental Protection Agency and the U.S. Nuclear Regulatory Commission are the principal federal agencies responsible for establishing radiation protection regulations. EPA establishes standards to protect the general environment. The NRC prescribes and enforces limits on the amount of radiation that workers and members of the public can receive from commercial use of radioactive materials.

Radiation safety is based on time, distance and shielding. The less time spent near a source, the less radiation received. The greater the distance from a source, the less radiation received. Shielding also plays a vital role. For example, dentists place a lead blanket on patients receiving X-rays. Used nuclear power plant fuel is stored underwater or in steel-lined concrete containers to protect people from penetrating radiation such as gamma rays.

Although scientists have found no adverse health effects from doses lower than 10,000 millirem, radiation experts recommend keeping doses from man-made sources “as low as reasonably achievable.” This concept, known as “ALARA,” is the basis for all radiation safety practices.

Putting Radiation Dose in Context

<table>
<thead>
<tr>
<th>Source</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoke detector in the home (annual)</td>
<td>0.008 millirem</td>
</tr>
<tr>
<td>Living within 50 miles of a nuclear power plant (annual)</td>
<td>0.009 millirem</td>
</tr>
<tr>
<td>Living within 50 miles of a coal-fired power plant* (annual)</td>
<td>0.03 millirem</td>
</tr>
<tr>
<td>Round-trip flight from New York City to Los Angeles (single trip)</td>
<td>5 millirem</td>
</tr>
<tr>
<td>Medical X-ray (single exposure)</td>
<td>10 millirem</td>
</tr>
<tr>
<td>Food and water consumed (annual)</td>
<td>30 millirem</td>
</tr>
<tr>
<td>Mammogram (single exposure)</td>
<td>100 millirem</td>
</tr>
<tr>
<td>Average exposure for a nuclear power plant worker (annual)</td>
<td>120 millirem</td>
</tr>
<tr>
<td>Average exposure from natural radiation (annual)</td>
<td>300 millirem</td>
</tr>
<tr>
<td>CT scan (single exposure)</td>
<td>1,000 millirem</td>
</tr>
<tr>
<td>NRC’s limit for occupational exposure (annual)</td>
<td>5,000 millirem</td>
</tr>
<tr>
<td>Cardiac catheterization or coronary angiogram (single exposure)</td>
<td>5,000 millirem</td>
</tr>
</tbody>
</table>

*Coal contains naturally radioactive elements. Sources: U.S. Environmental Protection Agency, Health Physics Society.

The four major types of radiation—alpha, beta, gamma and X-rays—vary in their ability to penetrate materials. Gamma radiation and X-rays are the most penetrating forms.
The Nuclear Energy Institute is an industry policy organization that fosters the beneficial uses of nuclear technologies worldwide.

The Institute’s members include leading universities, research laboratories, radiopharmaceutical and radioisotope manufacturers, companies that operate commercial nuclear power plants, their suppliers, labor unions and others.