Editorial

Our Fear of Radiation

Few topics generate as much fear and uneasiness as radiation. Most people associate radiation with negative things such as cancerous mutations, disease, nuclear war and nuclear-power accidents. Consequently, most people view radiation as something that is "bad," regardless of the circumstances or consequences. True, radiation *can* be harmful: It's impossible to ignore the seriousness of radiation burns or the potential horrors of nuclear war. However, most radiation is harmless. Moreover, it is all around us: Every second our bodies are hit by about 15,000 radioactive particles, none of which affects us. Just as our environment is radioactive—naturally occurring ^{14}C in our atmosphere emits gamma rays—so too do our bodies contain radioactive ^{14}C and ^{40}K.

Many people fear radiation because they do not understand what radiation is or how it is measured. Radiation is the emission of nuclear particles and rays by unstable atoms as they decay to become more stable. This decay always involves the conversion of matter to energy. The most common unit for measuring the activity of radiation is the curie (Ci): One curie equals 37 billion disintegrations per second, the activity of one gram of radium. Dose, which is the amount of radiation absorbed by the body, is measured in units called rem: A dose of 600 rem will kill a person within two months.[1]

Although we have no human sense to detect radiation (e.g. a lethal dose of radiation increases the body temperature less than 0.1 C), we have built sensitive instruments that can measure tiny amounts of radiation—amounts less than one part per billion. Is this a lot of radiation? Not at all: A part per billion is equivalent to one drop of vermouth in five railroad cars of gin. That's quite a dry martini.

Now consider the picocurie of radioactivity in the cloud of radioactive fallout that reached the West Coast of the United States after the Chernobyl accident. Although newspapers warned of nuclear fallout, most reports failed to indicate that a picocurie is a part per trillion—an amount equivalent to one drop of vermouth in 5000 carloads of gin. This picocurie was hardly a threat to anyone's health. Indeed, to receive an amount of radioactivity from the Chernobyl cloud equivalent to that received during a diagnostic test for the thyroid, West Coast residents would have had to drink about 63,000 gallons of radioactive rainwater. Kidney problems and toilet blowouts would have caused the problems, not the radioactivity.

Radiation occurs naturally (radium, radon, cosmic rays) and as by-products of human activities (X-rays, television), and varies widely by location. This radiation produces an average annual dose of about 200 millirems in the United States.[2] These examples will help you put the 200 millirems in perspective:

1. *Three Mile Island accident's dose to within 10 miles (the highest dose to any one person was 100 millirems)*
   Average dose: 8 millirems.
2. *Transatlantic flight*
   Average dose: 10 millirems.
3. *Average diagnostic medical X-ray*
   Average dose: 40 millirems.
4. *Evacuee's dose at Chernobyl (cleanup workers were exposed to 30,000 to 40,000 millirems)*
   Average dose: 11,800 millirems.
5. *Average dose to Japanese in area of Hiroshima bombing, including Nagasaki*
   Average dose: 30 millirems.
6. *Cosmic rays in environment*
   Average dose: 30 millirems.

One of the most well-publicized examples of radiation is radon, which is part of the 14-step decay chain of uranium. Radon forms from the disintegration of radium:

radium (atomic no. 88) →
radon (atomic no. 86)
+ alpha particle[3]

Radon itself radiates weakly and has a half-life of about 3.8 days. It is relatively harmless because it is an inert, chemically neutral gas. Similarly, the alpha particles emitted during the disintegration of radium are harmless as long as they are outside the body: They cannot even penetrate a sheet of paper or the dead epithelial cells of our skin. The problem arises not from radon, but rather from the so-called "radon daughters," which include polonium-218, bismuth-214 and lead-214. These are solid particles that are intensely radioactive. Moreover, they often cling to dust particles, which become airborne and inhaled. They also cling to smoke particles, another reason that "passive smoking"—that is, breathing smoke in a closed atmosphere—is so dangerous. In the lungs, the radon daughters usually stick to and bombard sensitive tissue with intense radioactivity. These particles—not the radon *per se*—may cause lung cancer.

Radon formed in the soil seeps into buildings through cracks, crevices and the freshwater supply. The radon then becomes trapped in the building, often reaching levels 10- to 100-times greater than that in nature. How does this radon get out? The same way it came in: through cracks and openings. Modern, energy-efficient, tightly sealed homes are ventilated only about one exchange of the atmosphere per day. Since the entry of radon is constant but its exit is greatly reduced,

[1] The SI unit for activity is becquerel (Bq; 1 Bq = 1 disintegration per second = 2.7×10^{-11} Ci), while that for dose is the sievert (Sv; 1 Sv = 100 rem).

[2] Of this, 82 percent comes from natural sources such as radon, cosmic sources, terrestrial sources and internal ^{40}K. The remaining 18 percent that is human-made consists of medical (X-rays, nuclear medicine) and consumer products (tobacco, ceramics). The nuclear energy industry contributes less than 0.1 percent of our exposure to radiation.

[3] An alpha particle is a helium nucleus: It is positively charged and consists of two neutrons and two protons. Alpha particles are strongly ionizing.

don accumulates in buildings. If you
ant to protect yourself against radon,
you have to do is open your win-
ows and let in some fresh air.

We regularly benefit from radiation:
'e use it to improve our health (e.g.
uclear medicine), for our leisure ac-
vities (e.g. lantern mantles are radio-
ctive) and even to protect ourselves
e.g. smoke detectors are radioactive).
adiation also promises a plentiful
ource of energy that will become in-
reasingly important as fossil fuels dis-
ppear. Nevertheless, most people
have an irrational fear of radiation. To
best appreciate this, consider again the 40 trillion radioactive particles that hit each of us over our lifetime (i.e. 15,000 radioactive particles every second). The odds of any one of these particles causing a cancerous mutation is about 1 in 30 quadrillion. Despite these odds, many people remain afraid of background radiation.

The public's fear of radiation is unfounded, yet is likely to persist. It is another example of how belief can override evidence and reasoning. This triumph of belief over evidence is relatively common, as evidenced by the popularity of astrology, crystal power and other forms of pseudoscience. Indeed, even many well-educated people believe that men have one less rib than do women because of the myth that God created Eve from Adam's rib. This belief persists despite the availability of proof to the contrary: All people have to do is count the ribs in skeletons. Many people will not consider such evidence. The same mentality persists when people prefer to believe in myths such as "All radiation is bad."

Randy Moore

Editor

Survey on Nuclear Phenomena (page 267)

First complete these two introductory items:

Birthdate:

______ Before 1945 ______ After 1945

Major source of your knowledge of nuclear phenomena:
______ School ______ Television ______ Scientific magazines
______ Magazines/newspapers ______ Conversations with others

The following statements are designed to survey your understanding of nuclear-related phenomena. Mark the blanks to indicate whether you agree (A), disagree (D), or are unable to answer because of insufficient knowledge (U).

______ **1.** The atom is the smallest particle in nature.
______ **2.** Home smoke detectors may contain radioactive materials.
______ **3.** Radioactive materials and radiation are unnatural. They did not exist on Earth until created by scientists.
______ **4.** All radiation causes cancer.
______ **5.** Most of the space occupied by an atom is "empty."
______ **6.** Electromagnetic radiation should be avoided at all costs.
______ **7.** The human body is capable of detecting radioactivity.
______ **8.** Nuclear wastes are initially both thermally "hot" and radioactive.
______ **9.** All atoms of a given element are alike in all respects.
______ **10.** Radiation can be used to limit the spread of cancer.
______ **11.** Individuals vary widely in their ability to "safely" absorb radiation.
______ **12.** Small amounts of matter are converted into immense quantities of energy in nuclear bombs.
______ **13.** The human body naturally contains a small amount of radioactive material.
______ **14.** Cancer caused by radiation exposure can be distinguished by physicians from cancer having other causes.
______ **15.** Television tubes emit radiation.
______ **16.** The majority of nuclear waste generated to date has come from nuclear power plants.
______ **17.** Radioactive and nonradioactive forms of an element behave the same chemically.
______ **18.** Cells that divide rapidly are more sensitive to radiation than are cells that divide slowly.
______ **19.** Physicians use injections of radioactive elements in the diagnosis and treatment of certain disorders.
______ **20.** Medical X rays carry potential risks as well as benefits.
______ **21.** Nuclear reactors were originally designed to generate electricity.
______ **22.** Nuclear plants are the only electric power plants that create serious hazards to public health and the environment.
______ **23.** To date, no one has died from radiation released by nuclear power plants.
______ **24.** Nuclear power plants do not emit air pollution during normal operation.
______ **25.** Regardless of risks, nuclear power plants are necessary to keep the nation functioning and to free us from dependence on foreign oil.
______ **26.** A nuclear power plant can explode like a nuclear bomb, killing millions of people.
______ **27.** The major difference between a nuclear power plant and a coal-fired power plant is the fuel used to boil the water.
______ **28.** Some nuclear wastes must be stored for hundreds of years to prevent dangerous levels of radioactivity from escaping into the environment.
______ **29.** Nuclear power presently supplies more than 10% of our country's total energy needs and is increasing in importance each year.
______ **30.** If the half-life of a radioactive substance is six hours, all of it will have decayed in 12 hours.
______ **31.** More federal dollars have been spent on nuclear power development than on all other alternative forms of energy combined.
______ **32.** In the United States, the largest source of man-made radiation comes from nuclear power plants.
______ **33.** Some states have banned the construction of new nuclear power plants.
______ **34.** Nuclear wastes can be neutralized or made nonradioactive.
______ **35.** Nuclear power plants produce material that could be converted into nuclear weapons.
______ **36.** Nuclear power plants use much smaller quantities of fuel than coal-fired plants.
______ **37.** Nuclear power plants are less expensive to build than are coal-fired plants.
______ **38.** A national system for the long-term storage of radioactive wastes is now in operation.
______ **39.** The rate of radioactive decay can be slowed down by extreme cooling.
______ **40.** The United States should increase its reliance on nuclear power to generate electricity.