Radiation Basics

"There is no safe level of exposure and there is no dose of (ionizing) radiation so low that the risk of a malignancy is zero" --Dr. Karl Morgan, the father of Health Physics

What is radiation?

Radiation is energy that travels in waves. It includes visible light, ultraviolet light, radio waves and other forms, including particles. Each type of radiation has different properties. *Non-ionizing* radiation can shake or move molecules. *Ionizing* radiation can break molecular bonds, causing unpredictable chemical reactions. Ionizing radiation includes not only energy waves but particles as well. Humans cannot see, feel, taste, smell or hear ionizing radiation. Unavoidable exposure to ionizing radiation comes from cosmic rays and some natural material. Human exposure to natural radiation is responsible for a certain number of mutations and cancers. Additional exposure above natural background radiation is cause for concern since it may result in otherwise preventable disease.

Where does ionizing radiation come from?

Ionizing radiation is matter or energy that is given off by the nucleus of an unstable atom in the process of decaying and reaching a stable (ground) state. This energy is released in the form of subatomic particles (alpha and beta) or waves (gamma and x rays). Most elements and their atoms are not radioactive. A few radioactive elements, like uranium, radium, and thorium, occur in nature.

Humans, through nuclear power, bomb production and testing, have created and released *man-made* radioactive elements (radionuclides) that were previously unknown in the environment. Through mining and industrial processing *naturally radioactive* elements like uranium and thorium have been released to flow through the natural systems on which life depends. These substances were, with few exceptions, geologically isolated from the environment under layers of shale and quartz before human beings dug them up by the ton and contaminated the biosphere. Because of poorly conceived and implemented nuclear technologies, such as atomic energy, bomb production and reprocessing, we and our descendants are left with a legacy of radioactive waste with no proven isolation method.

From A to X

Alpha particles are high energy, large subatomic structures. They can't travel very far and can be stopped by a piece of paper or skin. However, alpha particles hit hard and can do a great deal of damage to the cells they rip through. Once inhaled, ingested or otherwise taken inside the body (as through a cut in the skin), they have the power to tear through cells in organs or blood, releasing their energy to surrounding tissue and leaving extensive damage in their wake. A single track of a single alpha particle can deliver a large dose of radiation to a cell. Plutonium is an alpha emitter. Other alpha emitters include radon gas, uranium, and americium.

Beta particles are electrons. They are a fraction of the size of alpha particles, can travel farther and are more penetrating. Betas pose a risk both outside and inside the body, depending on their energy level. External exposure can result in beta penetration through the surface to the most sensitive layers of skin. Inhalation or ingestion of a beta-emitting radionuclide poses the greatest risk. Externally, a half-inch of Plexiglas or water shielding can generally stop a beta. Strontium-90 and tritium are two beta-emitting radionuclides routinely released from nuclear power reactors during normal operation. Our bodies often mistake strontium-90 for calcium, collecting it in our bones that make our new blood cells. Once there, it increases our risk of bone and blood cancers like leukemia. Every one of us has strontium-90 in our bodies as a result of nuclear bomb testing. Tritium is radioactive hydrogen, which binds where normal hydrogen does. Hydrogen is the most abundant element on the earth, and is a component of water, which cushions our genetic material (DNA). Tritium can bond in this water, irradiating our DNA at very close range.

Gamma rays are the most penetrating type of radiation and can be stopped only by thick lead blocking their path. Cesium-137 is a gamma emitter often released from nuclear reactors. It mimics potassium, collecting in muscle. Iodine-131and Iodine-

129 are also gamma-emitters released through bomb testing and at atomic reactors. Radioactive iodines collect in the thyroid gland emitting both beta and gamma ionizing radiation to the surrounding tissue.

X-rays are much like gamma rays except they are most often generated electrically by a machine (rather than a radionuclide), usually for medical diagnostic procedures. X-rays also require lead shielding. When generated by medical equipment, their production does not create nuclear waste.

HALF-LIVES AND DECAY CHAINS

Different radionuclides have different half-lives. Half-life is the time it takes for one-half of a radioactive element to decay the next step toward stability. Some radionuclides decay to a stable element in a single step. For others, like uranium, the movement toward stability may be a long, complex process. Uranium-238 has a half-life of 4.5 billion years, about the age of the Earth. All told, it has 17 decay steps before reaching a final, stable form of lead. Half-lives can range from fractions of seconds (Polonium-214, .00016 seconds), to days (Iodine-131, 8.04 days) to billions of years (Uranium-238, above). A radionuclide may also decay to another radioactive element that has a longer half-life and is more biologically active than the original radionuclide. For instance, xenon-135 (9-hour half-life) decays to cesium-135 with a half-life of 3 million years. Cesium mimics potassium and collects in muscle in the body. Xenon-135 is released regularly by nuclear reactors. Hazardous life is defined as 10-20 times the half-life. This is how long it will take for a given quantity of the radioactive element to decay to undetectable levels.

Some radioactive atoms give off more than one type of radiation. For instance radium, which humans collect and concentrate from an ore called pitchblende, gives off gamma and alpha radiation. Shortly after the Curies (research physicists in France) discovered radium, when its harmful effects were not known or believed, it was widely used, especially among the wealthy. Exposure to radium, ingested in water, painted on watch faces and carried in pockets, caused many debilitating illnesses and excruciating deaths. Marie Curie died of aplastic anemia (leukemia) most likely caused from her exposure to radium through the extraction process she used to concentrate it. To this day, her notebooks are dangerously radioactive.

BIOACCUMULATION

With man's increased uses of radioactive material, more radionuclides have been and continue to be released to the environment. Once released, they can circulate through the biosphere, ending up in drinking water, vegetables, grass, meat, etc. The higher an animal eats on the food chain, the higher the concentration of radionuclides. This is bioaccumulation. The process of bioaccumulating radionuclides can be especially harmful to humans since many of us eat at the top of the food chain.

"MADMAN IN A LIBRARY..."

Ionizing radiation travels through our living tissue with much more energy than either natural chemical, or biological functions. This extra energy tears mercilessly at the very fabric of what makes us recognizably human—our genetic material. Elderly and people with immune disorders are more susceptible to ionizing radiation. Children and the unborn are especially susceptible because of their rapid and abundant cell division during growth.

Cancers linked to ionizing radiation exposure include most blood cancers (leukemia, lymphoma), lung cancer, and many solid tumors of various organs. Birth defects can include downs syndrome, cleft palate or lip, congenital malformations, spinal defects, kidney, liver damage and more.

Evidence exists that radiation is permanently and unpredictably mutating the gene pool and contributing to its gradual weakening. The *New Scientist* quotes a report that calls genetic or chromosomal instabilities caused by radiation exposure a "plausible mechanism" for explaining illnesses other than cancer, including "developmental deficiencies in the fetus, hereditary disease, accelerated aging and such non-specific effects as loss of immune competence."

A living being's genetic material is the library that houses the instructions for many important aspects of that being and his/her offspring, including the ability to defend against diseases. If we allow ionizing radiation to tamper with our genes, it could cause irreversible damage, not just to this generation through cancer, but to future generations through gene mutations and ensuing disease.

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