SCIENCE FEATURE

From bombs to bananas: A dose of radiation reality

David Szondy | December 7th, 2016

Radiation may be frightening, but we live with a surprising amount of natural radiation every day (Credit: chesterf/Depositphotos)

Ever since 1896 when Henri Becquerel noticed that certain minerals blurred photograph plates sealed in paper, radiation has fascinated and frightened the public. The trouble is that over the past century this mysterious and powerful force has been surrounded by many misconceptions, which can be more dangerous than radiation itself. To clear away the fog in the cloud chamber, New Atlas looks at the facts about radiation in our everyday lives.

It's easy to be worried about radiation in a way that we aren't about other environmental hazards. Radiation is tasteless, odorless, and, except in the greatest intensities, invisible. In the popular imagination, it's a mysterious force that can transform sleeping dinosaurs into atomic dragons that stomp Tokyo flat on a regular schedule, turn teenagers into wall-crawling superheroes, and innocent scientists into giant raging green monsters.

We know that such scenarios are the work of fiction, yet many people still think of radiation as a universal destructor that leaves nothing but inevitable death in its wake. It's a mysterious force that produces terrible human mutations, causes terrible medical conditions even in the mildest of doses, and the only way to handle it is to avoid it entirely.

Yet despite its reputation, radiation is part of our everyday lives and has been ever since the first protozoa evolved hundreds of millions of years ago. The millirem is the unit of absorbed radiation dose and according to the US Nuclear Regulatory Commission (NRC), the average American is exposed to 620 millirem (mrem) of radiation every year. Half of this comes from natural background radiation, while the other half comes mainly from medical X-rays, with industrial sources a distant second. Before we look at what dangers, if any, this poses, here's a primer on what we mean when we talk about radiation.

What is radiation?

The Oxford dictionary defines radiation as, "The emission of energy as electromagnetic waves or as moving subatomic particles, especially high-energy particles which cause ionization." This means it includes such things as visible light, radio waves, infrared, ultraviolet, and microwaves. But for our purposes, what we're looking at is ionizing radiation. In other words, radiation consisting of subatomic particles, X-rays, gamma rays, or cosmic rays, with sufficient energy to knock apart or ionize any atoms they may encounter.

Most of the radiation we encounter is made of subatomic particles caused by the decay of unstable atoms from heavy elements or unstable isotopes. When these atoms decay or break apart, they emit one of several types of radiation: alpha, beta, neutron, and gamma.

Alpha radiation

Alpha radiation is made up of alpha particles, which are heavy, positively charged particles made up of two protons and two neutrons bound together like a helium nucleus. Because of their mass, alpha particles can be stopped by a sheet of paper or even human skin, but they're still regarded as dangerous if alpha-emitting elements are breathed in or ingested to expose internal tissues.

Beta radiation

Beta radiation is made up of high energy electrons or positrons released in atomic decay. Beta particles are more penetrating than alpha particles, but they can still be stopped by 2 cm of air or a few millimeters of aluminum sheeting.

Gamma radiation

Gamma rays are electromagnetic radiation like X-rays, light, and radio waves, but are so energetic that they are classed as ionizing radiation. They are capable of passing straight through the human body, but can be stopped by thick concrete walls or lead sheeting.

Neutron radiation

Neutrons are uncharged particles. Technically, they aren't a form of ionizing radiation, but when they collide with atoms they can cause them to split, releasing, alpha, beta, or gamma radiation. Neutrons can only be stopped by very thick shielding of concrete, water, or paraffin.

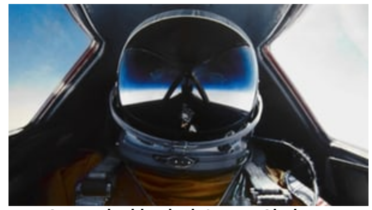
Cosmic rays

Found only from natural sources, cosmic rays come from the Sun or distant, high-energy events far out in space, including a pair of giant black holes colliding or a supermassive galaxy exploding. They are so high energy that they can only be stopped by the thickest of shielding or the combined protection of the Earth's magnetic field and atmosphere. When these cosmic rays strike the Earth's atmosphere, they convert inert carbon atoms into radioactive carbon-14.

Where does radiation come from?

Radiation can be either natural or man made. Aside from cosmic rays, natural radiation comes from the fact that the Earth is basically one huge low-level fission reactor. If the Earth had cooled naturally from its original molten state, it would by now be a solid, frozen lump of rock and iron and about as capable of supporting life as a ball bearing in a deep freeze. However, our planet contains loads of radioactive elements, like uranium, radium, and thorium, slowly decaying over billions of years, releasing energy that keeps the core of the Earth molten.

There are also deposits of uranium and thorium in the Earth's crust, which are the source of most of the natural radiation we encounter either directly or in decay products, like radium or radon gas.



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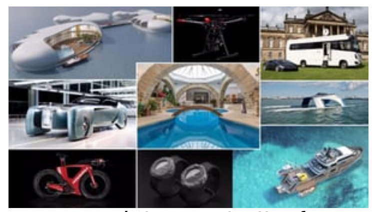

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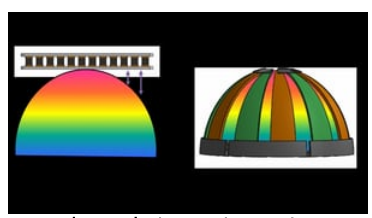

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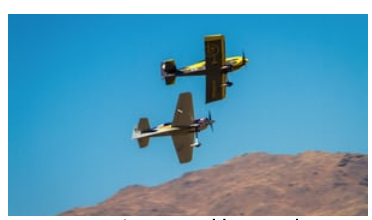


Wing to wing: Wild men and machines of the Reno Air Race

A plug of highly enriched uranium (Credit: Department of Energy/Wikimedia)

As to man made radiation, for most people, 96 percent is from medical X-rays - a chest X-ray delivers 10 mrem, a full-body CT scan 1,000 mrem, and a dental X-ray 1.5 mrem. The small bit that's left over, surprisingly, doesn't come from nuclear power plants, which provide 0.09 millirem per year, but from coal, which the Imperial College London says puts out three times more radiation than an operational reactor plant. The remainder is fallout traces from atmospheric nuclear tests from 1945 through 1980.

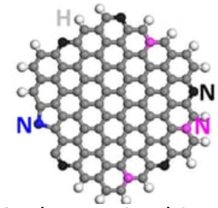
Why is radiation dangerous?

Radiation is dangerous because it causes damage to living tissue not just on the cellular, but on the molecular level. How much damage depends on how big a dose and where in the body it occurs. Plutonium, for example, is safe enough that you could make a paperweight out of it or hold it in your hand for a short while. However, if you ground it up and inhaled the dust, the effect of the radiation on your lungs would be catastrophic because it would be irradiating the unprotected living tissues.

This is because radiation causes harm by disrupting the constant, delicate ballet of chemical reactions that go on in living cells - especially in the DNA that makes up the genetic code that tells the cells what to do. In very small doses, cells can repair themselves and carry on as before, But in cases of large or constant exposure, the cells can be so damaged as to be killed or worse, genetically damaged, so they become cancerous or, in the case of reproductive cells, result in fatal mutations or birth defects.

Radiation in common items

If the preceding paragraphs made you want to build an underground bunker and go the full Dr. Strangelove route, then you're already out of luck. We live in a constant bath of radiation that literally impossible to escape. All living things contain radioactive isotopes, like potassium-40 and radium-226. Every time you breathe in you bring carbon-14 into your lungs. Never mind what awaits in the kitchen.



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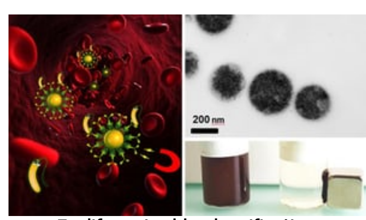

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Foods

A handful of nuts a day may keep the grim reaper away

Bananas

The seemingly innocent banana is so radioactive that it's used as a measurement of radiation in itself as in "equivalent to x bananas." Each banana contains 45 mg of potassium, which includes the radioactive isotope potassium-40. The radiation from bananas measures out as 3,520 picocuries per kilo - that's high enough to set off the more sensitive type of radiation alarms. If you ate one banana per day, you'd receive a dose of 2.6 mrem per year.

Brazil nuts

Brazil nuts are about a thousand times more radioactive than most common foods and if you ate half a pound (226 g) per year, you'd get a dose of 0.5 mrem. This is because the deep roots of Brazil nut trees are very good at collecting trace metals in the soil, resulting in the nuts containing up to 7,000 pCi/kg of radium-226. Fortunately, the body has no need of radium, so even the most avid Brazil nut fan will excrete the isotope before it can do any harm.

Oranges

Delicious, full of vitamin C, and one 8 oz glass a day will get you 2.5 mrem of radiation per year.

Potatoes

Potatoes may be classed as comfort food, but they don't give much comfort in the radiation stakes. Eating one medium baked jacket potato a day will net you 4.3 mrem per year. If you go for a large order of French fries instead, you'll get 4.7 mrem.

Breakfast

Breakfast means starting the day on a radioactive note with a cup (236 ml) of raisin bran cereal each morning giving you 1.8 mrem per year. Have a cup of cantaloupe once a week, and you'll get 0.4 mrem per year.

Spinach

A can of spinach may make Popeye a human dynamo, but one cup a week will provide 0.6 mrem of radiation per year.

Meat & Fish

If you fancy a double hamburger, remember that one per day will expose you to 2.9 mrem or radiation. At least it's better than tucking into a six-ounce halibut fillet a day. That works out to 4.9 mrem per year.

Water

Even playing it safe with a glass of water isn't, well, safe. Tap water has a surprising amount of radioactive isotopes dissolved in it - enough to expose the average person to 0.244 mrem per year.

Other common sources

Tobacco

Cigarettes are a no-win situation. Not only do you get tar, nicotine, and a good chance of an early grave, but 20 a day will net you 36 mrem per year right to the lungs.

Canary glass

Even a trip to the antique shops is no escape from radiation. Canary glass, also known as Bohemian glass, has a third name: uranium glass. It's the uranium it contains that gives it its distinct color. It also gives you four mrem per year.

Gemstones

The song says diamonds are a girl's best friend, but they' re also a radiation source of up to 0.03 mrem per year. Some, like Zircon, are naturally radioactive, while others are bombarded with neutrons to enhance their color.

Building materials

Even where you live can cause the Geiger counter to click. Aberdeen, Scotland is famous as the Granite City and all the radionuclides expose the inhabitants to 120 mrem per year. If you live in a brick house, that's 1.31 millirem per year and concrete is 7 mrem a year.

But the worst in our homes is radon gas, which seeps out of the earth and collects in basement areas to give the residents a whopping 200 mrem per year.

Old televisions and monitors

If you have an old television or computer monitor, you might want to swap it for a flat screen. That will save you 1 mrem per year in X-rays.

Smoke detectors

Oddly enough, the one thing you would think would be a major source of radiation isn't. Most home smoke detectors use a particle of radioactive americium-241 to ionize smoke particles. Total dosage? A miserly 0.009 mrem per year.

The person you're sleeping next to ... and you

A much larger source of radiation is the person sleeping next to you. Lying there sweating and breathing, they expose you to 2 mrem per year. If that make you want to sleep on the couch, remember that *you* emit 40 mrem per year. If you have ceramic caps or false teeth, add another 0.07 mrem.

Travel

Travel broadens the mind, but it also ups the radiation doses. Every security scan is worth 0.002 mrem and a cross-country flight in the US is 2 to 5 mrem from cosmic rays coming in through the thinner atmosphere at cruising altitude. According to the US EPA, frequent fliers receive 200 mrem per year.

Putting it into perspective

So far, so scary, but how to put all of this into perspective? As we said, it's estimated Americans are on average exposed to a total of 620 mrem per year. To give a point of comparison, a lump of uranium would give you a dose of 1,376 mrem per year. That's over twice normal exposure, but uranium is mainly an alpha emitter with some weak gamma rays thrown in, so you'd have to carry it in your pocket full time to be at risk.

According to Professor Gerry Thomas, a radiation expert from the Department of Surgery and Cancer at Imperial College London, radiation is something much less to be feared than is popularly believed.

"Radiation saves far more people every year than it kills, but we still perceive it as a great danger," she says. "Yet it is just like any other toxin - such as alcohol or even salt, it is safe in small doses but dangerous in high amounts. If you measured radiation levels in Aberdeen, which is built on granite, there would be higher background levels of radiation than in Fukushima."

According to the NRC, a 3 mrem dose increases the chances of premature death by one in a million. That's equivalent to breathing New York City air for two days, riding a motorcycle for one mile, riding in a car for 300 miles, eating 40 tablespoons of peanut butter at once, eating 10 charbroiled steaks, or smoking one cigarette.

Even famous catastrophes have turned out to be less disastrous than thought from a radiation perspective. Thomas says that being exposed to the direct radiation of the Hiroshima explosion was less dangerous than being obese. As for the worst nuclear disaster in history at Chernobyl in 1986, though 43 people died as a direct result of the accident, 4,000 others exposed have shown no ill effects. In addition, the surrounding area has been turned into a wildlife preserve and, though the radioactive fallout has certainly affected the flora and fauna, some experts note the overall effect is less than that of a forest fire or chemical pollutants with none of the feared mutations resulting in little more than animal stillbirths.

Part of the problem with assessing the effects of radiation is that while extreme cases like nuclear weapon attacks, or accidents like Chernobyl or Fukushima lend themselves to straightforward analysis, small doses are much harder to study. This is because large doses of radiation produce obvious symptoms and prognoses, but small doses soon descend into an ocean of complicated causes and effects.

Taking a hypothetical example, someone is exposed to a small dose of radiation, then later on develops cancer. Did the radiation cause it? Did it increase the likelihood of cancer? If so, by how much? Or was the cancer due to smoking, diet, occupational hazards, heredity, congenital defects, or a combination of these? Did the radiation make this worse or did it have no effect at all? Because there are so many possible causes and the human body has a limited ability to recover from radiation, these are very hard questions to answer.

Because of these uncertainties, scientists since the 1940s have adopted the no safe minimum dose standard. Since there aren't enough people exposed to harmful levels of radiation and no way to create a control group, the most conservative approach was taken, which was to extrapolate backwards from the severe cases at Hiroshima and Nagasaki based on the assumption that no dose of radiation, however small, was safe.

The world has come a long way from a century ago when almost nothing was known about radiation. That was a time when radium was used to make luminous watch dials and eventually sparked a major scandal when the women who painted the radioactive solution on the watch hands came down with radiation poisoning from ingesting the paint.

It was also a time when radium was looked up as a miracle cure and all manner of nostrums, from "radium" inhalers to "radium" water, could be bought over the counter. Today, we have a better grasp of what everyday radiation involves. We have a better understanding of how much surrounds us on a daily basis and the risks involved. But it isn't a recipe for complacency. Rather, it's one for education and continued vigilance. Radiation is not the mysterious force of science fiction, but it's still very dangerous.

But the most important thing is to keep a sense of perspective. True, radiation is all around us, but the hazards it poses to our lives are so slight it can't be measured with any certainty. And there many other hazards that are more immediate.

Let's put it this way. Don't worry about dying of radiation poisoning from eating too many bananas - you'd have to eat 400 at a sitting to do yourself harm, and you'd be dead of potassium poisoning or indigestion long before the radiation hurt you.

If you are curious as to what your annual radiation dose might be, the NRC has a calculator here.

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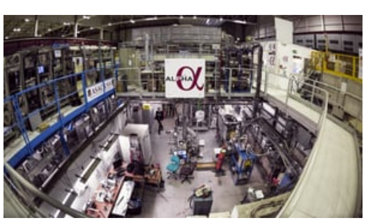

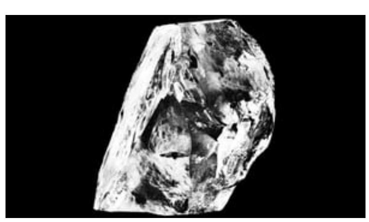

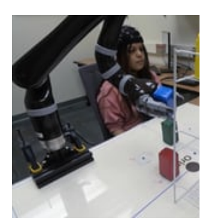

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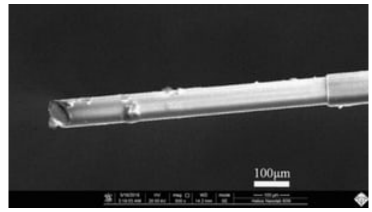

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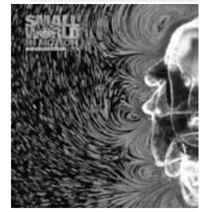

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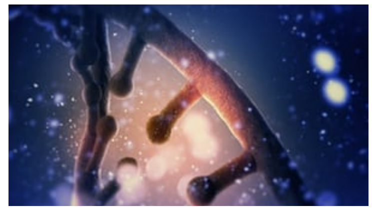

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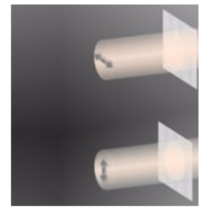

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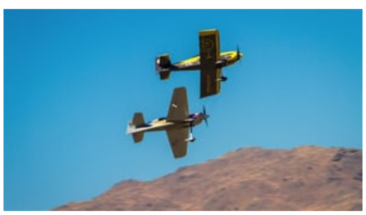

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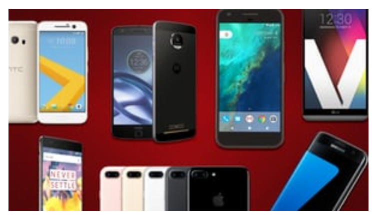

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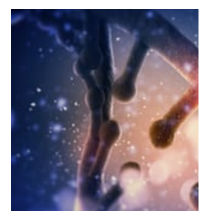

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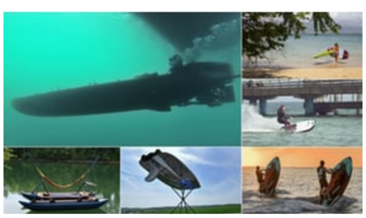

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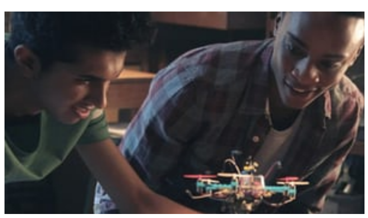

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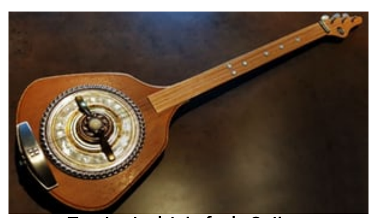

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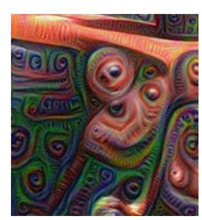

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