Nuclear Reactors:

Radiation is also useful in obtaining a renewable source of power: nuclear power. In a nuclear reactor, energy is produced when atoms undergo fission (they split into two smaller atoms). To produce fission in Uranium-235, beryllium is mixed with an alpha-emitting source of radiation. The alpha particles interact with the beryllium atoms, causing them to release neutrons, which are then "captured" by the Uranium-235 atoms. Uranium-235 is unstable, and is likely to split into two fragments upon capturing a neutron. This is fission. When the Uranium splits in two, more neutrons are released, which then cause more atoms to split and so on. Thus, there is a chain reaction. The series of fission events creates a great deal of heat, which produces steam. This steam then turns turbines, which generate electricity to power factories and homes.

Nuclear power plant. (Image courtesy of PennEnergy.com)

Significant care must be taken to make sure the chain reaction does not continue uncontrollably, resulting in catastrophe. Neutron-absorbing control rods are used to limit the amount of neutrons interacting with Uranium-235.

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Physics Brochures Series by Sarah Marie Bruno, '16
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It's Radioactive!!

HELPING TO FURTHER

PUBLIC UNDERSTANDING

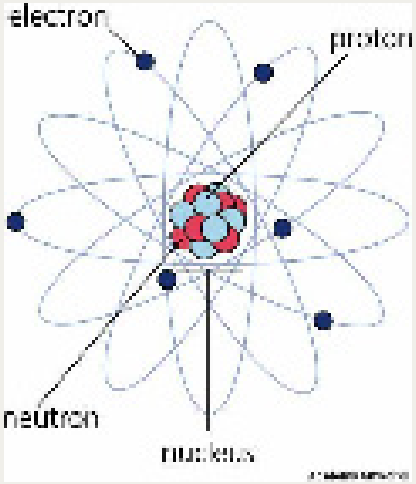
OF PHYSICS CONCEPTS

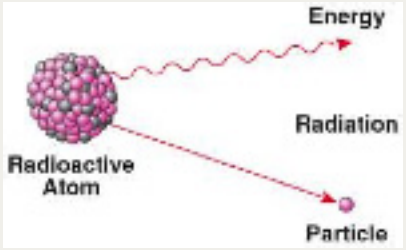
Radioactivity

What does it mean for something to be radioactive? First, let's review the building blocks of the atom. You may know that all matter—your pencil, this brochure, you and your aunt's dog—is made up of microscopic units called molecules, which in turn are made up of even smaller units called atoms. Most of the mass of an atom is confined to the tiny nucleus located at its center, which is made up of positively charged protons and neutral neutrons. The rest of the atom is made up of negatively charged electrons, which circle around the nucleus. The electrons are much less massive than the protons and neutrons.

Did you know that atoms are mostly empty space? If the hydrogen atom (one proton in the nucleus and one electron) was enlarged so that the electron's orbit encircled all of New York City, the nucleus would be the size of a baseball, and the electron would be a tiny speck!

Not all atoms are stable. You can imagine an unstable nucleus as one that just can't get comfortable. It must eject particles and/or energy out of its nucleus to become stable. This emission is radiation!





Source: NRC at http://www.nrc.gov/reading-rm/basic-ref/glossary/full-text.html

There are three main types of radiation: alpha, beta, and gamma. An alpha particle is made up of two protons and two neutrons (a helium nucleus). Since the nucleus contains protons and neutrons, it is easy to see how a nucleus can emit an alpha particle. Beta particles are a bit more mysterious. A beta particle is an electron that is ejected from a nucleus. But where does this electron come from? A neutron in the nucleus can actually split into a proton and an electron! The proton remains in the nucleus and the electron is ejected as a beta particle. If the number of protons in the nucleus changes, the atom becomes an entirely different element! This is because atomic number (the number of protons in an atom) is what determines the element of the atom. The third type of radiation is emission of a gamma ray. Instead of emitting a particle, the nucleus emits energy in the form of an electromagnetic wave (a gamma ray is light that is invisible to the human eye).

So why might radiation be dangerous? In a normal atom, the number of electrons equals the number of protons, so the net charge of the atom is zero (equal number of positive and negative charges). Some atoms, however, do not have an equal number of protons and electrons. These atoms are called ions. When an atom is "ionized," an electron is removed. The atom now has one more proton than it has electrons, and is positively charged. Radiation can be harmful to humans, because it can ionize the atoms in our bodies. Large amounts of this ionization can sometimes lead to severe health problems such as radiation poisoning or even cancer.

Small amounts of radiation, however, are not harmful, and are used in many medical procedures. For example, a radioactive tracer may be injected into a patient in order to detect the presence or spread of disease. The tracer will go to affected areas and an imaging machine will detect the emitted gamma rays, creating a three-dimensional image. Radiation is also used in the treatment of many types of cancer. For cancer in the thyroid gland, which is located in the neck, Iodine-131 is used to destroy cancer cells. The thyroid gland attracts iodine to itself, so even if the patient consumes radioactive iodine, it will still go directly to the thyroid. (The thyroid has no way of detecting whether the iodine is radioactive or not). In this way, a large amount of radiation is delivered to the cancer, but not to the rest of the body.

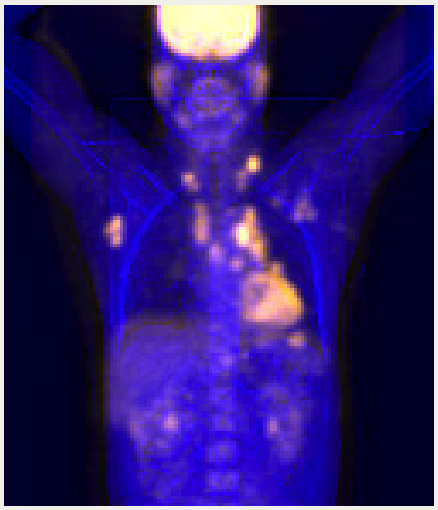


Image obtained using a radioactive tracer. Affected areas light up orange.