The discovery of radioactivity took place over several years beginning with the discovery of x-rays in 1895 by Wilhelm Conrad Roentgen and continuing with such people as Henri Becquerel and the Curie family. The application of x-rays and radioactive materials is far reaching in medicine and industry. Radioactive material is used in everything from nuclear reactors to isotope infused saline solutions. These technologies allow us to utilize great amounts of energy and observe biological systems in ways which were unthinkable less than a century ago.

Introduction

What is the definition of radioactive? If you look up the meaning in the dictionary the convoluted answer that you will receive is: 

**Radioactive** - adjective: emitting or relating to the emission of ionizing radiation or particles. This definition begs the questions: What are ionizing radiation or particles? What exactly is meant by emission? Can you see or feel these particles? What makes something radioactive?

The Discovery Of Radioactivity

Wilhelm Conrad Roentgen (1845-1923)

**Contribution:** Received the first Noble Prize in physics for his discovery of x-rays in 1901.

On November 8, 1895, at the University of Wurzburg, Roentgen was working in the lab when he noticed a strange fluorescence coming from a nearby table. Upon further observation he found that it originated from a partially evacuated Hittof-Crookes tube, covered in opaque black paper which he was using to study cathode rays. He concluded that the fluorescence, which penetrated the opaque black paper, must have been caused by rays. This phenomenon was later coined x-rays and though the phenomenon of x-rays is not the same as radioactivity, Roentgen opened the door for radioactive discovery.

Antoine Henri Becquerel (1852-1908)

**Contributions:** Received the Noble Prize in physics for being the first to discover radioactivity as a phenomenon separate from that of x-rays and document the differences between the two.

Henri Becquerel learned of Roentgen's discovery of x-rays through the fluorescence that some materials produce. Using a method similar to that of Roentgen, Becquerel surrounded several photographic plates with black paper and florescent salts. With the intention of further advancing the study of x-rays, Becquerel intended to place the concealed photographic paper in the sunlight and observe what transpired. Unfortunately, he had to delay his experiment because the skies over Paris were overcast. He placed the wrapped plates into a dark desk drawer. After a few days Becquerel returned to his experiment unwrapping the photographic paper and developing it, expecting only a light imprint from the salts. Instead, the salts left very distinct outlines in the photographic paper suggesting that the salts, regardless of lacking an energy source, continually fluoresced. What Becquerel had discovered was radioactivity.
Pierre (1859-1906) and Marie (1867-1934) Curie

**Contributions:** Pierre and Marie were awarded the Nobel Prize in Physics in 1903 for their work on radioactivity. Marie Curie became the first woman to be awarded the Nobel Prize and the first person to obtain two Nobel prizes when she won the prize for the discovery of Polonium and Radium in 1911.

Though it was Henri Becquerel that discovered radioactivity, it was Marie Curie who coined the term. Using a device invented by her husband and his brother, that measured extremely low electrical currents, Curie was able to note that uranium electrified the air around it. Further investigation showed that the activity of uranium compounds depended upon the amount of uranium present and that radioactivity was not a result of the interactions between molecules, but rather came from the atom itself. Using Pitchblende and chalcolite Curie found that Thorium was radioactive as well. She later discovered two new radioactive elements: Radium and Polonium which took her several years since these elements are difficult to extract and extremely rare. Unfortunately, the Curies died young. Pierre Curie was killed in a street accident and Marie died of aplastic anemia, almost certainly a result of radiation exposure.

Ernest Rutherford (1871-1937)

**Contributions:** Ernest Rutherford is considered the father of nuclear physics. With his gold foil experiment he was able to unlock the mysteries of the atomic structure. He received the Nobel Prize in Chemistry in 1908.

In 1909 at the University of Manchester, Rutherford was bombarding a piece of gold foil with Alpha particles. Rutherford noted that although most of the particles went straight through the foil, one in every eight thousand was deflected back. "It was as if you fired a fifteen inch naval shell at a piece of tissue paper and the shell came right back and hit you," Rutherford said. He concluded that though an atom consists of mostly empty space, most of its mass is concentrated in a very small positively charged region known as the nucleus, while electrons buzz around on the outside.

Rutherford was also able to observe that radioactive elements underwent a process of decay over time which varied from element to element. In 1919, Rutherford used alpha particles to transmute one element (Oxygen) into another element (Nitrogen). Papers at the time called it "splitting the atom."

What They Had Discovered:

We now have the essentials to utilize radioactive elements. Roentgen gave us x-rays, Becquerel discovered radioactivity, the Curies were able to discover which elements were radioactive, and Rutherford brought about transmutation and the "splitting of the atom." All of these discoveries and curiosity came with a price. Time showed the damaging effects of radiation exposure and the incredible destruction that could be harnessed from these elements.

Applications

Radioactive isotopes are presently used in many aspects of human life today. Most people recognize radioactivity's contributions to industry, research and war, but it is even used within many peoples homes. Here are a few examples of how radioactive isotopes are utilized today.
At Home

Most people have radioactive material in their very own homes, or at least we would hope so. Why? Because in most every smoke detector unit today there is a very small amount of Americium-241. How does it work? Well Americium-241 is present in the detector in oxide form and it emits alpha particles and very low energy gamma rays. The alpha rays are absorbed in the detector, while the non-harmful gamma rays are able to escape. The alpha particles collide with oxygen and nitrogen in the air of the detector's ionization chamber producing charged particles, or ions. A small electric voltage runs across the chamber which is used to collect these ions and operate a small electric current between two electrodes. When smoke enters the chamber it absorbs the alpha particles disrupting the rate of ionization in the chamber, thereby turning off the electrical current, which sets off the alarm.

For more information go to: http://home.howstuffworks.com/smoke2.htm

Nuclear Power

On June 7th 1954 the the USSR produced the world's very first nuclear power plant. These plants, though clean burning, produce a great deal of toxic nuclear waste which is difficult to eliminate. To date, approximately 15% of the worlds electricity and 6% of the worlds power is produced in nuclear power plants. With the rise in gas prices many countries around the world considered increasing their use nuclear energy.

The problem with nuclear energy is that although it is "clean" in the sense that only water vapor is emitted into the atmosphere, it has its share of problems. It must be kept constantly regulated, and is extremely hard to dispose of. In the past, poor regulation of nuclear power has caused major problems, such as the Chernobyl incident in 1986. Even when regulated properly, the waste can cause contamination which lasts for many years and destroys natural resources.

For more information and a specific example go to: http://www.world-nuclear.org/info/ch...byl/inf07.html

Industry

Gamma Sterilization

Large scale gamma irradiation is used to sterilize disposable medical supplies such as syringes, gloves and other instruments that would be damaged by heat sterilization. Large scale gamma irradiation is also used for killing parasites found in wool, wood and other widely distributed products. In the 1960's the irradiation of meat was allowed by the US, and it is now a commonly used food sterilization method. Small scale irradiates are also used for blood transfusions and other medical sterilization procedures.

Gamma Ray Analysis

Gamma Rays can be used to determine the ash content of coal. By bombarding stable elements with radioactive rays one can cause a fluorescence, the energy of fluorescent x-rays can help identify if any elements are represented in a material. The intensity of the rays can indicate the quantity of that material. This process is commonly used in element processing plants.
Medicine

Radioisotopes are used as tracers in medical research. People ingest these isotopes which allow researchers to study processes like digestion and locate medical problems like cancers and obstructions within an individual's digestive tract.

Radioactive elements are also used in clearing angioplasty obstructions and eliminating cancer.

War

To date the only country to utilize nuclear weapons and actually use them is the United States. On August 6th and 9th 1945, the US dropped nuclear weapons on Nagasaki and Hiroshima, Japan. These weapons were a part of a top secret project known today as the Manhattan project. Though those within the blast zone were instantly killed, the effects of these weapons would be felt for many years to come. Many more people died in the months following the bombing due to radiation poisoning, and years later, birth defects would prove the effects of radioactive bombardment upon DNA.

A good resource on the industrial and medical uses of radioactive isotopes: http://www.world-nuclear.org/info/inf56.htm

List Of Radioactive Elements

All of the naturally occurring radioactive elements are concentrated between atomic numbers 84 and 118 on the periodic table, though Tc and Pm are an exception. Also note that there is a break between 110 and 118 on the table, which are suspected radioactive elements that have yet to be discovered. 29 radioactive elements have been identified by scientists to date:

- Technetium (TC)- Transition metal
- Promethium (Pm)- Rare earth metal
- Polonium (Po)- Metalliod
- Astatine (At)- Halogen
- Radon (Rn)- Noble gas
- Francium (Fr)- Alkali Metal
- Radium (Ra)- Alkali Earth Metal
- Actinium (Ac)- Rare Earth metal
- Thorium (Th)- Rare Earth Metal
- Protactinium (Pa)- Rare Earth Metal
- Uranium (U)- Rare Earth Metal
- Neptunium (Np)- Rare Earth Metal
- Plutonium (Pu)- Rare Earth Metal
- Americium (Am)- Rare Earth Metal
- Curium (Cm)- Rare Earth Metal
- Berkelium (Bk)- Rare Earth Metal
- Californium (Cf)- Rare Earth Metal
Einsteinium (Es)- Rare Earth Metal
Fermium (Fm)- Rare Earth Metal
Mendelevium (Md)- Rare Earth Metal
Nobelium (No)- Rare Earth Metal
Lawrencium (Lr)- Rare Earth Metal
Rutherfordium (Rt) or Kurchatovium (Ku)- Transition Metal
Dubnium (Db) or Nilsborium (Ns)- Transition Metal
Seaborgium (Sg)- Transition Metal
Bohrium (Bh)- Transition Metal
Hassium (Hs)- Transition Metal
Meitnerium (Mt)- Transition Metal

http://www.theodoregray.com/PeriodicTable/Elements/Radioactive/index.html

References


Contributors:

- Sarah E. (UCD)
- Nyssa Spector (UCD)