Radioactivity and nuclear chemistry, both involving changes within the nuclei of atoms, often result in one element changing into another. One of the "real-life" sciences, radioactivity has numerous practical applications, including the diagnosis and treatment of medical conditions including heart or thyroid disease, cancer, and abnormal kidney, bladder or intestinal functions. Additionally, naturally-occurring radioactivity allows scientists to estimate the age of fossils, rocks, ancient artifacts, and other data. Perhaps most notably, radioactivity is responsible for discovering nuclear fission which has since evolved to nuclear weapons and generate electricity.

**Introduction**

 A French scientist Antoine-Henri Becquerel discovered reactivity in France in the late 1890s. Fascinated by the newest scientific discovery, X-rays, Bercquerel began a new division of research. He hypothesized that X-rays were emitted with phosphorescence (an emission of light that sometimes follows the absorption of light by certain atoms and molecules). As seen on many glow in the dark toys and stickers, after it is exposed to the light, phosphorescence allows the product to reemit some of the light at slightly longer wavelengths. Becquerel's ground breaking hypothesis presented that X-rays and phosphorescence are linked.

Months later, upon discovering a photographic plate showing a dark exposure spot, even then the plate and crystals were stored in a drawer not exposed to sunlight. The crystals themselves were constantly emitting something that exposed the photographic plate, regardless of whether or not they phosphoresced. Several experiments later, Bercquerel concluded his experiment with understanding that uranium within the crystals was the source of the emissions, naming them uranic rays.

One of the first women in France to pursue doctoral work, Marie Sklodowaska Curie, researched uranic rays for her doctoral thesis, intending to determine whether any other substances besides uranium emitted these rays. Curie discovered two new elements that emitted uranic rays, and named them polonium after Poland and radium because of its high level of radioactivity. After discovering these rays were not unique to uranium, Curie changed uranic rays to the term radioactivity. Curie is also known for her work with cloud chambers and magnetic fields to bend radiation. She shared the physicist Nobel Prize with Pierre and Becquerel in 1903, becoming the first woman to receive the price ever. She won a second Nobel Prize in 1911 for her work on radium and radium compounds in the field of chemistry.

**Types of Radiation**

Scientists focused on characterizing radioactivity and determined that emissions are produced by the nuclei of radioactive atoms. The nuclei of these elements are relatively unstable and decompose spontaneously, releasing small factions of itself to gain stability. Reactivity that occurs in nature can be categorized into several different factions, including alpha decay, beta decay, gamma ray emission, and positron emission.

In alpha decay, a nucleus emits a particle composed of two protons and two neutrons. When an element emits an alpha particle, the element is transformed into a different element because the number of protons in its nucleus changes. This phenomenon is evidenced by a nuclear equation, an equation that represents the nuclear process of radioactivity. In this instance, the original atom is the parent nuclide, and the product of the decay is called the daughter nuclide. Like a chemical equation, a nuclear equation must be balanced meaning the sub of atomic numbers on both sides of a nuclear equation must be equal, and the sum of the mass numbers on both sides must also be equal.

An alpha particle is the largest, most geometrically massive of all particle emitted. Alpha radiation has the potential to interact with, feed upon, and damage other molecules. When radiation ionizes molecules within human cells, molecules undergo detrimental chemical reactions and cells begin to die or reproduce abnormally. These rays also possess the highest ionizing power, the ability of radiation to ionize other molecules and atoms. This type of radiation does not easily penetrate into cells because it can be stopped by a simple piece of paper, clothing, or even human hair follicles; however, if an alpha particle have been ingested and have direct access to the molecules that compose organs and tissue, it becomes very dangerous to the body.

Beta decay occurs when a neutron emits an electron and becomes a proton. When an atom emits a beta particle, its atomic number increases because it has an additional proton. Again, the nuclear equation for beta decay must be balanced, the sum of the mass numbers equal and the sum of the atomic numbers equal on both sides. These protons are much smaller than alpha particles, and have a lower ionizing power as a result. Due to their smaller size, beta particles have a higher penetrating power and require something substantial, such as a sheet of metal or a thick piece of wood, to deflect them. As such, a beta emitter outside of the body poses a much larger risk than an alpha emitter, however does less damage if ingested as compared to the alpha emitter.

Significantly different, gammy ray emission is a form of electromagnetic radiation. These rays are short-wavelength, high-energy photons that have no charge and no mass. Gamma rays are often emitted at the same time as other types of radiation, including alpha and beta emissions. These rays have the lowest ionizing power but have the highest penetrating power.

Positron emission occurs when a positron is penetrated by an unstable nucleus. The positron is the antiparticle of the electron, meaning it has the same mass but opposite charge as an electron. If a positron collides with an electron, the two particles collide spontaneously and annihilate each other, releasing residual energy in gamma rays; in protron emission, a proton is converted into a neutron and emits a positron. When an atom emits a positron, its atomic number decreases by one because it has one less proton after emission.

On the opposite end of the spectrum, electron capture involves a particle being absorbed by instead of emitted from an unstable nucleus. Electron capture occurs when a nucleus assimilates an electron from an inner orbital of its electron cloud. As an atom undergoes electron capture, its atomic number decreases by 1 because it has one less proton.

All nucleons (protons and neutrons) are attracted to one another by the strong force, which only acts at short distances. The neutrons in the nucleus play the most important role in stabilizing the nucleus by attraction other nucleons. Additionally, the ratio of neutrons to protons is important to determine the stable nuclei.

For a study break, examine radioactive dating and half-lives using M&Ms:

Each group begins with 100M&Ms in a container to demonstrate radioactive decay. Parent isotopes are represented by the M side up as radioactive, and daughter isotopes are represented by the M side down as stable.

Students pour 100 M&Ms and set aside stable isotopes (M side down). Gather the remaining radioactive M&Ms, put them in the container and pour them out again. Then set aside stable isotopes, and continue this process until all M&Ms are stable (M side down). Students compare the parent isotopes to the number of half-lives.

**Detecting Radioactivity**

All particles emitted by radioactive nuclei can be detected due to their conspicuous amounts of energy. Radiation detectors can be as simple as photographic film that become exposed when radiation passes through them. Additionally, devices such as a Geiger-Muller counter measure particles emitted by radioactive nuclei as they pass through an argon-filled chamber and create a train of ionized argon atoms. Each of the newly formed ions are producing an electrical signal that can be measured and displayed on a meter. A secondary device used to detect radiation instantly is a scintillation counter. In this measurement, radioactive emissions pass through material that emits ultraviolet or visible light, atoms release this energy light which is detected and turned into an electrical signal that can be read on a meter.

Radioactivity occurs naturally throughout the environment, likely leading individuals to accidental or residual exposure. Small amounts of radiation from space make it into our atmosphere, just as a residual amount of radioactive atoms are absorbed via to food one eats. Humans and other living organisms have evolved to survive in these environments. There are many reasons for the radioactivity in our environment.

Geologists and archeologists use radiocarbon dating to determine the ages of artifacts and fossils. Uranium/lead radiometric dating techniques as well as other radiometric dating techniques have been used to measure the ages of rocks on earth.

Acute radiation damage results from large amounts of exposure to radiation in a short period of time, mainly from nuclear bombs or exposed nuclear reactor cores. Such high levels of radiation kill large numbers of cells rapidly. People exposed to extremely high levels of radiation have a weakened immune system and a lowered ability to absorb nutrients from food. Oftentimes, increased cancer risk and genetic defects may result from large amounts of exposure. It takes much more than the average natural radiation dose or the dose from a medical diagnostic procedure to produce significant health effects in humans. Radioactivity can be used in medicine to diagnose, as well as in radiotherapy to kill rapidly dividing cells, as well as killing microorganisms. Radioactivity is central to the diagnosis if medical problems by means of radiotracers and positron emissions tomography (PET) and techniques that provide data about the metabolic activity and physical appearance of an organ, or to help locate a tumor. Radiation works effectively to treat cancer because it kills cells, and can also be used to kill bacteria in foods and to control harmful insect populations.

**Summary**

 The alpha particle is the largest particle and has the most potential to interact with other molecules. Beta decay occurs when a neuron emits an electron and becomes a proton. Gamma ray emission is electromagnetic radiation rays that are short-wavelength, high-energy photons that have no charge or mass. All nucleons are attracted to one another at short distances, and all particles emitted can be detected due to their conspicuous amounts of energy. There are minute amounts of radioactivity in the environment, however the human body has evolved to survive.