INTRODUCTION

The Manhattan Project was what the government named the huge program to develop a nuclear bomb. It is hard to explain how amazing this program was. The program encompassed dozens of sites in the United States and Canada that employed tens of thousands. Leading this effort, Robert Oppenheimer and General Leslie built nuclear reactors and giant centrifuges. That initiative produced three bombs powered by the fission of uranium and plutonium—all of this only five years after the discovery of plutonium, seven years after the discovery of fission, and 25 years after the discovery of the atomic nucleus. The project cost about two billion dollars in 1940s dollars—that's about 40 billion today.

The main project sites were Hanford, Washington, where the plutonium was produced in a reactor; Oak Ridge, Tennessee, where the rare Ur 235 was separated from the predominant Ur 238; and Los Alamos, New Mexico, where the bomb design and mechanisms were made. The personnel included some of the most prominent physicists of the century, including Enrico Fermi, Richard Feynman, and Ernest Lawrence.

In Build an Isotope, students learn about isotopes by making a model of the different forms of atomic nuclei of an element.

MATERIALS

For Build an Isotope, you will need to build enough atomic models of isotopes for each group to end up with two models. Pint mason jars are a good choice. Models in Build an Atom can be used as a basis, but these will naturally be much larger. The identities can be kept secret by writing them on the underside of the lid. Students should be brought to notice how much larger these atoms are than the O and C they made earlier. These large nuclei are much less stable because all those protons don’t like being packed together.

STANDARDS

NGSS 5 PS1-3
Make observations and measurements to identify materials based on their properties.

NGSS MS PS1-1
Develop models to describe the atomic composition of simple molecules and extended structures.

NGSS MS PS1-5
Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

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A foundational concept in the understanding of the composition of molecules and the nature of chemical reactions is that there is a finite number of types of atoms. This is an extension of the previous activity. It gets students thinking about what makes an atom one element and not another (by the number of protons not neutrons). By creating their own models of isotopes students focus on the basic features of atoms and start making sense of them. In the process students exercise the Science and Engineering Practice of Developing and Using Models. They also use the Crosscutting Concepts of Patterns and Structure and Function.
Isotopes are forms of elements with different numbers of neutrons. For example, you may have heard in science class or in books about carbon dating. Carbon dating uses the fact that there are different isotopes of carbon. The most common isotope of carbon has six protons and six neutrons in its nucleus. Common isotopes are usually just symbolized as the elemental symbol, but to be clear, C12 could be used. There is a rare form of carbon with eight neutrons, C14. The rare form is radioactive—not really dangerous, but unstable and breaks down, and so over time there is less of it. To determine how old a sample is, the sample can be tested to determine how much of each isotope there is in it. By doing some math, the age of the sample can be determined.

Isotopes are also used to figure out how cold water was in the past. Oxygen is normally O16, but there is a stable (nonradioactive) isotope, O18. Because water containing O18 is predictably less likely to evaporate than water with O16, scientists can estimate the temperature of the earth when they collect ice from glaciers.

Take three more containers and make the common isotopes of the elements you already made. They will be H2, C14 and O16.

In the Manhattan Project, scientists were trying to get enough of the isotope of uranium they needed to make a bomb. The common isotope is U238. The isotope they needed was U235. U235 is only 0.72% of all uranium.

At first, the scientists tried to get enough U235 by separating them by the difference in their mass. That, as you can imagine, is very hard. Such a process uses some very special kinds of centrifuges. In the end, the scientists made only enough U235 for one weapon.

Along the way, they discovered that when U235 is hit by a fast neutron, U235 becomes a different element—plutonium. Plutonium can be used for making nuclear bombs. The scientists made a big enough reactor and made enough plutonium for three bombs when the war ended. One plutonium bomb was tested in the Trinity test, and one was used in the war. The third was used for research.

Your teacher will demonstrate how to make models of uranium and plutonium atoms.

Just by looking, how can you tell the difference between carbon and oxygen? Between O16 and O18? What about between plutonium and uranium? Or between their isotopes?

Is there another way you could find the difference between these isotopes? Without looking, or opening the models and counting, describe a method in the space below: