GRADE LEVEL: 6-8 | TIME REQUIREMENT: 4 HOURS

CHEMISTRY: ELEMENTS AND THE PERIODIC TABLE

1 READING | 3 ACTIVITIES

INTRODUCTION

If you refer to the Adopt-Adapt-Apply model, most innovations are of the **Adapt** kind in that they take something and modify it for a new purpose, or they improve it to better fulfill its original purpose. Very few innovations are of the **Apply** kind—where pure science and basic facts are developed into a technology. **Apply** innovations are very exciting because they are often some of the most ground-breaking and furthest-reaching innovations.

The Manhattan Project represents an example of an **Apply** innovation. The basic knowledge of how atoms are structured and of what makes something one element and not another, all culminated in an investigation in a Berlin lab in 1938. That basic knowledge, combined with the discovery of a new element seven years and countless hours of work later, unlocked the secret of atomic energy and atomic weapons.

The Manhattan Project succeeded because of the work of some of the best scientists in the world, but it also took huge investments by two Allied countries, as well as lots of work from civilians and military personnel who had no idea what they were working on. The Manhattan Project at once represented a pinnacle of human scientific achievement, but also a led to a new era of fear and danger.

Many scientists were uncomfortable with what they had accomplished, and those results certainly changed the world forever, in profound ways.

OBJECTIVE

Together these resources introduce students to the basis of chemical diversity—the periodic table and nuclear structure. They start with historical context, describing the Manhattan Project and its race to understand and control fission. Then they have students explore the periodic table and nuclear structures, looking at patterns and building models. Electrons are not explicitly discussed, because the phenomena discussed have to do with nuclear physics and chemistry. But you could easily add in electrons if you need to.

STANDARDS

NGSS DCI PS1.A
Structure and Properties of Matter

NGSS DCI PS3.A
Definitions of Energy

NGSS DCI ETS2
Links Among Engineering, Technology, Science, and Society

NGSS SEP
Developing and Using Models

NGSS CCC
Structure and Function

NGSS CCC
Energy and Matter

PERFORMANCE EXPECTATIONS

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

NGSS DCI MS-PS1-3
Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

READING (1)

1. BIG SCIENCE

Description
This reading introduces the context for the rest of the unit and outlines for students the problem of understanding how to manipulate elements. Have students discuss what it might have been like to work in the Manhattan Project as a scientist. There are some great video selections on the Real World Science website to flesh out this reading.

ACTIVITIES (3)

1. BUILD A TABLE

Description
In this activity students will have the information about all the elements known when Mendeleev developed the first Periodic Table. Have the students work in structured groups to organize the elements based on their characteristics. If the students have learned already about the periodic table, you might find that they are trying to reproduce it here. Any form of organization is acceptable, as long as there is group consensus on the organization and group members can justify that choice based on characteristics of the atoms.

Supplies
A set of Element cards for each group

Instructions
Set up groups using your strongest Kagan structures or other cooperative learning methods to make sure groups reach consensus and everyone participates. Explain what the information on each card means, and ask the students to arrange the cards in a structure that makes sense to them. Be sure to have groups present to the whole class their organization and thinking so that they can see alternate ways of organizing the elements.

2. BUILD AN ATOM

Description
Students will use periodic tables to build small atomic nuclei. Then they will look at models you provide of larger atoms to identify them based on the number of particles they contain. If you want, you can use these models as a base for exploring electrons and ions. Since electrons and ions were largely irrelevant to the nuclear physics at the heart of the Manhattan Project, these activities don't focus on those aspects of atoms, but can be easily added.

Supplies (for each group)
3 Containers (small mason jars or pill bottles will work)
1 Cup each of 2 kinds of dried beans
1 Periodic table

Instructions
To make the best model, the two kinds of beans should be similar in size but different in color—kidney beans and pinto beans or black beans, for example. If you want to extend your model to electrons, you can use lentils or another small bean.

Each group will make a model of three small elements and will fill in the responses to the prompts. Then you will give students some atomic models, and they will count the parts of the models and use a periodic table to identify them. For these unknowns, pick smaller atoms like sodium and chlorine. You could make one different unknown for each group and then have the groups trade unknowns.

3. BUILD AN ISOTOPE

Description
This activity follows naturally from the previous. In building and discussing models of isotopes, students will naturally analyze what makes an atom one element and not another. The activity also gets students to look at what makes some nuclei less stable than others.

Supplies
(The same supplies used in Build an Atom)
Corn puffs, extra beans, salad spinner (optional)

Instructions
If you do this activity immediately following Build an Atom, students can just modify the models they have already built. After they make their own isotopes, you will show them the isotopes of Uranium and a Plutonium model. The main objective of this is to get students to see how comparatively large the nuclei of these elements are and how small the difference in physical characteristics between isotopes is. If you wish, you can demonstrate how centrifuges are used to separate isotopes. Put kidney beans and corn puff cereal inside a salad-spinner. When you spin this kitchen centrifuge, you will see that the beans tend to go to the outside and the cereal to the inside. However, the difference in mass is small, so it is still hard to separate the mixture. Such differences are why the Manhattan Project had so much trouble getting enough Uranium 235 to make an atomic bomb.

ADDITIONAL RESOURCES
To accompany these activities, try these books:

+ *Bomb: The Race to Build—and Steal—the World's Most Dangerous Weapon* by Steve Scheinken, Square Fish 2018 (middle school, fiction).
+ Trinity: A *Graphic History of the First Atomic Bomb* by Jonathon Fetter Vorm, Hill and Wang, 2013 (middle and high school, graphic non-fiction).

ACTIVITY

BUILD A TABLE

INTRODUCTION

The 1800s were an era in which human understanding of science advanced rapidly. One of the fastest developing fields of science at that time was chemistry. By 1863, chemists had identified 56 elements. An element was considered a fundamental substance in chemistry. Some chemists had noticed that there was a pattern to the elements if they were arranged by their mass. However, Dmitri Mendeleev, a Russian chemist, was the first to arrange elements into groups and to organize them in a table.

With his table, Mendeleev was even able to predict the existence of several elements that had not yet been discovered. Mendeleev's accomplishment was very impressive, given how little the scientists of his time knew about atomic structure. For example, the existence of electrons, neutrons, and protons—all packed into the atoms—was unknown.

In this activity, you will organize elements, just like Mendeleev did.

In the cards your teacher will give you, you will have all the information Mendeleev knew about the chemical elements.

Use these cards and the information in them to make your own table of elements. You will do this as a group. Your group must have come to consensus on the table's organization, and each member of your group must be able to explain why that structure was chosen and what data were used to make your choice.

Using the symbols on your cards, draw a diagram of how you organized the elements.

Se
Selenium
Gray or red solid
Atomic Mass 79

Br
Bromine
Very reactive reddish liquid
Atomic Mass 80

Rb
Rubidium
Reactive, soft gray metal
Atomic Mass 85

Sr
Strontium
Soft silvery metal
Atomic Mass 88

In
Indium
Soft silvery metal
Atomic Mass 115

Sn
Tin
Silvery-white metal
Atomic Mass 119

Sb
Antimony
Blue-white metallois, semiconductor
Atomic Mass 122

Te **Tellurium** Silver-white metalloid, semiconductor Atomic Mass 128	**I** **Iodine** Reactive, purple solid Atomic Mass 127	**B** **Boron** Gray metalloid, semiconductor Atomic Mass 11	**C** **Carbon** Black solid (graphite) or transparent (diamond) Atomic Mass 12
N **Nitrogen** Odorless gas, unreactive Atomic Mass 14	**H** **Hydrogen** Flammable odorless gas Atomic Mass 1	**Li** **Lithium** Soft metal, reactive Atomic Mass 7	**Be** **Beryllium** Grayish metal Atomic Mass 9
O **Oxygen** Flammable, reactive odorless gas Atomic Mass 16	**F** **Flourine** Very reactive yellowish gas Atomic Mass 14	**Na** **Sodium** Soft, highly reactive metal Atomic Mass 23	**Mg** **Magnesium** Flammable gray metal Atomic Mass 24
Al **Aluminum** Silvery metal Atomic Mass 27	**Si** **Silicon** Gray metalloid semiconductor Atomic Mass 28	**P** **Phosphorus** Spontaneously combustible solid of variable color Atomic Mass 31	**S** **Sulfur** Solid yellow powder Atomic Mass 32
Cl **Chlorine** Extremely reactive greenish gas Atomic Mass 35	**K** **Potassium** Reactive soft metal Atomic Mass 39	**Ca** **Calcium** Flammable silvery metal Atomic Mass 40	**As** **Arsenic** Gray metalloid Atomic Mass 74