Elements and You

Summary

Students are introduced to the periodic table and the concept of elements. The group will discuss how all material in the universe is composed of elements and that the atom is the smallest particle which still has the physical and chemical properties of any given element. As an exercise in statistics, the students will participate in a counting experiment, sampling the universal trail mix, to estimate the bulk composition of the universe. Finally, the idea of fusion is introduced with respect to creating heavier elements from hydrogen inside a star.

Purpose

To introduce the idea of an element, the abundance of different elements in the universe, and the role of fusion in a star.

Audience

Approximately 20 students (grade range 6^{th}-9^{th}) in a group works well

Objectives

- To understand what an element is
- To become familiar with a periodic table and common elements
- To determine the most abundant element in the universe
- To learn how heavier elements form from fusion
- To gain knowledge of the processes in the interior of a star

Badge Requirements

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Materials

- ♣ Example of a pure element (sheet of aluminum, copper tubing, etc.)
- ♣ 1 plain pound cake for demonstration
- ♣ 1 knife to cut the pound cake
- ♣ Napkins or paper plates for pound cake demonstration (1 per student)
- ♣ 1 large periodic table for display (if possible 1 small one per student)
- ♣ Scoops or Dixie cups for the trail mix demonstration (1 per student)
- ♣ 1 large mixing bowl
- ♣ 1 large bag of rice for the trail mix
- ♣ 1 small bag of unpopped popcorn kernels for the trail mix
- ♣ 1 small box of macaroni for the trail mix
- ♣ 1 small bag of uncooked beans for the trail mix (black beans worked well)
- ♣ 1 small bag of uncooked black-eyed peas for the trail mix
- ♣ 1 jar of multi-colored cake decorating sprinkle shapes
- ♣ 1 transparency of trail mix ingredients and what element they represent
- ♣ 16 lbs of red modelling clay (4 pounds per sphere = 32 sticks, to represent hydrogen)
- ♣ 8 lbs of yellow modelling clay (2 pounds per sphere = 16 sticks, to represent helium)
- ♣ 4 lbs of orange modelling clay (1 pound per sphere = 4 sticks, to represent carbon)
- ♣ 2 lbs of green modelling clay (1/2 pound per sphere = 2 sticks, to represent magnesium)
- ♣ 1 lb of blue modelling clay (1/4 pound per sphere = 1 stick, to represent iron)
- ♣ 1 transparency of model star clay colors and what element they represent
- ♣ 1 trash can or trash bag

Preparation

1. Universal Trail Mix: ~15 minutes

   Mix the ingredients ahead of the planned activity in a large bowl. Use the same size "measuring cup" for preparation as the students will each have during the activity. Mix the following:

   - ➢ 40 scoops of rice (to represent 89% abundance of hydrogen in universe)
   - ➢ 4 scoops of corn (to represent 9% abundance of helium)
   - ➢ 2 scoops of macaroni (to represent 0.75% abundance of carbon)
   - ➢ 2 scoops of beans (to represent 0.75% abundance of oxygen)
   - ➢ 1 scoop of black-eyed peas (to represent 0.25% abundance of nitrogen)
   - ➢ 1 scoop of sprinkles (to represent 0.25% abundance of all other elements)

2. Clay star: ~ 2 hours to assemble

   Make the clay star in 5 color coded layers. We found pre-cutting the ball as the layers were added to be helpful. The layers are as follows:

   - The interior clay ball will be blue in color ~ 2 inches in diameter
   - The next layer will be green in color with a shell thickness of ~ 1 inch
   - The next layer will be orange in color with a shell thickness of ~ 1 inch
   - The next layer will be yellow in color with a shell thickness of ~ 2 inches
   - The next layer will be red in color with a shell thickness of ~ 2-3 inches

   Make extra fusion demonstration small clay balls
   - 2 red ~ 1 inch in diameter for hydrogen
   - 2 yellow ~ 1.5 inches in diameter for helium
   - 1 orange ~ 2 inches in diameter for carbon

3. If using lead, or another potentially harmful substance, wrap it in plastic or otherwise prevent the students from handling it directly. Anybody who does handle it should wash their hands afterwards, and certainly before they eat or drink anything.

Activity

This activity can be completed in 45 minutes. A sample script and flow of discussion follows.

I: Poundcakium *(approximately 15 minutes)*

What is an element?

We'll start this activity with a freshly made pound cake. Let's pretend we just discovered this element. We'll call it "Poundcakium". What are some of its characteristics? Let the students answer.

This loaf of poundcakium is all one flavor, texture, and color.

Let's cut the loaf of poundcakium in half. What do we have now? We still have poundcakium, albeit two pieces of it. Let's cut it in half again, what do we have? That's right, still poundcakium. As we continue to cut this poundcakium in half, we eventually get to the smallest piece of poundcakium, and that is a single crumb of poundcakium. We have not destroyed or created any poundcakium as we divided it into smaller pieces.

Can anybody think of any examples of elements that you know? Allow them to answer. If they need prodding, suggest categories, such as 'things around us in the room,' 'things in your home,' 'metals used for money or jewelry,' etc. Guide the conversation, but let it go where they take it.

Things we are familiar with can be made up of many elements, or ingredients. Some are pure substances like a gold bar or a silver chain. Some are made of many ingredients. Pound cake (as opposed to our imaginary poundcakium), for example, is made of ingredients. Let one student read the ingredient list. The ingredients just read like flour, sugar, milk and eggs are made of elemental ingredients like carbon and hydrogen.

Hand out pieces of the pound cake to the students as a snack.

Have a volunteer student come up and try to cut the lead brick (or other sample of a pure element). They won't be able to.

Lead is very hard to cut, but we could imagine doing essentially the same experiment with a lead brick. If I were to cut the brick in half, would I have changed what the brick is made of? Let the students answer.

No, the brick would still be lead, and the total mass would still be the same as when we started, but it is now in two pieces. Since lead is an element, no matter how many times I might cut the lead brick in half, I will always be left with lead. We could cut the lead brick in half and in half again until all we were left with was a single atom of lead. An *atom is the smallest piece of lead, or any element, that we can have that still has the same properties as the original piece.*

An element is a chemically pure substance composed of atoms of a single type. Elements are the building blocks for all matter, everything that we can see and touch. Lead is an element which we can find naturally occurring on the Earth. All lead atoms are the same.

The elements known to scientists are cataloged into a table called the periodic table of elements. Some of you may have seen or used a periodic table before. The elements in rows and columns of the tables have common traits or characteristics. Each element is different from the next in many measurable ways. Some are solid, some are gas, and some are liquid. They each have a unique mass. They can all be described with qualities like hardness or softness.

One way you can tell different elements apart is to look at a spectrum of the element. A spectrum is like the element's signature or fingerprint. You can participate in the Rainbow Analysis activity and look at the spectrum of hydrogen, oxygen and other elements to see examples of the differences in signatures.

*You each have a periodic table to look at. Do you recognize any of the element*s? Let the students answer. *What is your favorite?* Let the students answer. *Do you see any in this room?* Let the students answer.

Some elements are common to us in their pure form, like silver or gold. Some are common to us in compounds like salt (NaCl) or water (H_2O).

II: Universe Trail Mix *(approximately 15 minutes)*

What is the most abundant element in the universe? Let the students give some guesses.

If we were to grab a handful of space particles, what would we have? Let the students give some guesses.

I have here some Universe Trail Mix to simulate the elements in space. Each one of you will take a scoop of the Universe Trail Mix back to your seat, and you will count or estimate how much of each Trail Mix ingredient (element) you have on the napkin provided. Give the students 5-10 minutes to get a scoop, return to their seats and to inventory their ingredients.

Make a tally of the ingredients from each student or group. Ask either how many pieces of each ingredient the students have or ask how many students have at least one piece of a certain ingredient.

You should all have mostly rice, some corn, and very few of the others.

The most abundant element in the universe is hydrogen, the first element on the periodic table. Almost 90% of the universe is hydrogen. The second most abundant element is helium. Nearly 10% of the universe is helium. All of the other elements exist in much lower abundances, much less than 1%. Carbon, nitrogen, oxygen, magnesium, silicon, and iron are some of the common and more abundant heavier elements in the universe.

What are your bodies are made of? Let the students answer. *Water (which has a lot of oxygen!), carbon, nitrogen, etc. How did we come to have this rich selection of elements on Earth? How do we go from mainly hydrogen and helium to all of these elements we need to build people and plants? You need a hot, dense environment to take hydrogen and helium and make something else. Where are the hot, dense environments? Any guesses?* Let the students answer.

III: Fusion (approximately 15 minutes)

What do you know about atoms? Let the students answer. [If they don't mention protons and electrons, we just leave them out. But if they do mention them, then as needed we can include them (i.e. different elements determined by number of protons).]

Where do the elements come from? At the big bang, we start with H (hydrogen) and He (helium). This is partly why there is so much of it in the universe.

But where did everything else come from? They come from stars, but how?

Where is it always hottest in the star? Let the students answer. *The center of a star is very hot - millions of degrees - and rather dense. The hottest stuff and thus the heaviest element formation is always in the middle of the star. There's lots of H in the center, and these H atoms bump into each other. Often a pair of these H atoms will stick together. Scientists call this fusion.*

Have a student volunteer come up. Show the small clay balls representing hydrogen, and let the volunteer stick the pair together. *The process of fusion releases energy. And, it is this energy that makes the sun and all other stars shine.*

But when H fuses, it forms a new element. It forms He. Ask for another volunteer to come up. Now bring up a different color clay ball that represents helium. Let the student hold the helium clay ball. Explain that if you could change the color of the H clay balls as they join, you'd get this second color.

Although there is a lot of H in the star, at some point the H in the center runs out. When this happens the core of the star shrinks. This increases the temperature. Now the He can start fusing. When He fuses, C (carbon) forms. Let the second volunteer stick two helium clay balls together. Then, bring up the last small clay ball representing carbon.

This continues until the He runs out. For stars like our Sun, this is where the process stops. But in stars much more massive than our sun, the process continues.

[To compare the mass/size of the Sun to that of Earth, the Sun's mass is 330,000 times that of the Earth; the Sun's volume is 1.3 million times that of the Earth. To compare the mass/size of a large star to that of the Sun, these can be 15 times more massive than the Sun, and have volume 4000 times that of the Sun.]

The carbon fuses together to form Mg (magnesium). C and He can fuse together to make O (oxygen). Different elements can fuse together to make new elements.

This process continues in massive stars until iron is created. In the core of a star, iron can't fuse into anything else and the reason is this. In all of these fusion processes, energy is being released, and the star stays hot and gives off light. But in order to fuse iron, energy is required. That means you have put in energy instead of getting energy out. [If they ask why this is so, it's because Fe (iron) is the most stable of the nuclei, and the process of fusion takes less stable nuclei to more stable nuclei.]

So at the end of its life, the center of a massive star will have an iron core and looks like this. Cut open the large model star clay ball. Have a volunteer student carry one half around the room so that each of the students can see it up close while you hold the other half for all to see. *All the elements that the star has created in its lifetime are inside the star. The colors of clay used in this model are not necessarily the color of the elements or the star. They are just bright colors used for the demonstration. If you participate in the Supernova activity, you'll see what happens next. In particular, how the elements get out of the center of this star and into space (where they eventually can become part of the earth and you and me).*