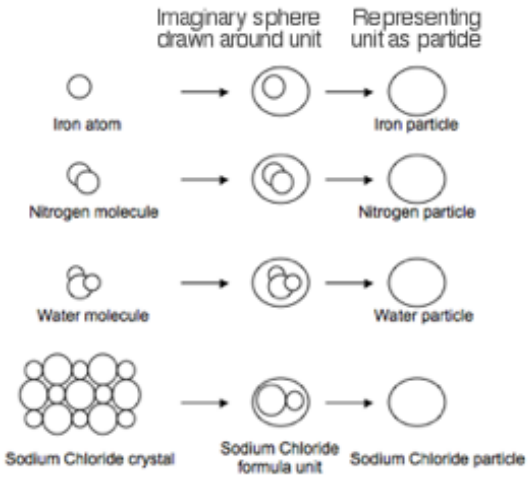
ACTIVITY 1: Physical Changes vs. Chemical Reactions

Purpose and Key Questions

In the Physical Changes unit, we investigated several kinds of processes, including expansion and contraction during warming and cooling; changes in state during melting, boiling, evaporation; etc. In all these cases the particles of the material stayed the same, and only the spacing between particles or their configuration (arrangement) changed. These kinds of processes are called physical changes.

At the macroscopic and particle levels, physical changes are accompanied by conservation of mass. Those properties of a material that can be observed or measured without changing the composition of the particles that make up the material are called physical properties. Examples include temperature, mass, density, pressure, etc.

In this unit, we will be looking at what the characteristic properties of the material can tell us about the internal composition of the particles. It is likely that in your previous study of science, you learned that all materials consist of atoms and that atoms can combine to form molecules or formula units. Until now, we have only been concerned with particles, not the internal structure of molecules or formula units. This idea is illustrated in the drawing to the right.



In this lesson we will be investigating changes to matter and making inferences about the composition of the particles that make up the different type of materials.

The key questions for this lesson are:

What happens when we change the composition of particles?

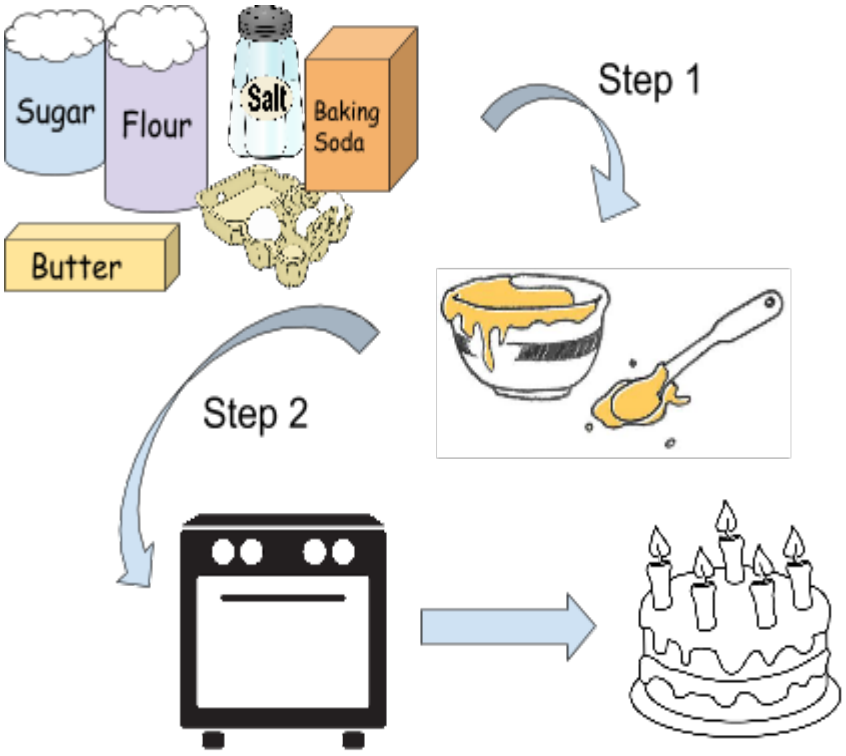
Is mass conserved during all of these changes?

What are useful ways to categorize the types of matter that exist?

Initial Ideas

When making a cake, one must combine all of the ingredients (flour, sugar, eggs, etc.) into a bowl to make the batter (Step 1). Then the batter is placed in the oven to bake (Step 2). After some time, the cake is completely baked and ready to eat.

What are some differences between mixing the ingredients (Step 1 below) for a cake and baking it (Step 2 below)?



Collecting and Interpreting Evidence

For all explorations, check with your instructor how you should dispose of all experimental materials and products after you finish.

Exploration #1: What is the difference between mixing sulfur and iron and heating sulfur and iron together?

Part 1: Mixing Sulfur and Iron

You will need:

- Gloves and goggles
- Iron filings
- Powdered sulfur. **Safety note**: If you have sulfur allergies, please inform your instructor AND do not handle the sulfur.
- Magnet (in plastic bag)
- Magnifying lens or dissecting microscope
- Watch glass
- 1 M HCl in dropper bottle

Follow the steps below:

STEP 1. Obtain about ¼ teaspoon of iron filings on a piece of weigh paper.

STEP 2. Examine the appearance of the iron filings and record your observations in Table 1 below. Look for some physical properties, such as color, luster, shape (appearance under a magnifying lens or dissecting microscope).

STEP 3: Keeping the magnet in a plastic bag, test to see how the iron filings react in the presence of the magnet and record your observations in Table 1

You will also be looking at a new kind of property called a **chemical property**. A chemical property indicates how the substance reacts with another substance. In this case, the **chemical property** we will be investigating is the reaction with hydrochloric acid (HCl). In this case a **positive reaction** will produce bubbles.

STEP 4: Place the sample of iron on a watch glass, and then add 5-10 drops of HCl onto the iron filings and observe. Record your observations in Table 1.

STEP 5: Repeat Steps 1-3 using a sample of sulfur. Be sure to clean your watch glass thoroughly before repeating Step 3.

Table 1

	Appearance	**Using a microscope**	**Magnet**	**Reaction with HCl**
Iron				
sulfur				
Iron and Sulfur mixture				

Obtain about 3 grams of iron filings and 2 g of sulfur powder. Then follow Steps 6-9 below.

STEP 6: Thoroughly mix the two substances together. You may want to use a wooden tongue depressor or spatula to help you.

STEP 7: Examine the mixture by repeating Steps 1-3 and recording your observations in Table 1.

STEP 8: Place a very small (about ¼ teaspoon) amount of the mixture on a clean watch glass and add 5-10 drops of HCl. Record your observations in Table 1.

STEP 9: Keep the remaining mixture to complete Experiment 2.

Does the appearance of the iron change when it is mixed with the sulfur? If so, describe the change.

Does the iron react differently to the magnet? To the HCl?

Is there evidence that a new material with different properties from the original materials was formed? Cite as much evidence as possible to support your claim.

Part 2: Heating the Mixture

IF a fume hood is available, follow Steps 1-7 below.

You will need:

- Fume hood, goggles and gloves
- Remaining mixture of iron and sulfur from experiment 1
- test tube
- balloon
- beaker (250 mL)
- balance
- Test tube clamp
- Bunsen burner

STEP 1. Carefully transfer the mixture of iron and sulfur into the test tube, and cover the test tube with the balloon.

STEP 2. Place this test tube in a beaker and record the mass in Table 2 below.
STEP 3. Light the Bunsen burner and adjust the flame so that you have a strong blue flame.

STEP 4. Holding the test tube with the test-tube clamp, heat the iron-sulfur mixture. **CAUTION: Make sure that the mouth of the test tube is pointed away from you and others.**

STEP 5. Move the test tube around in the flame so that all the contents are evenly heated. When you see a red glow (like a burning ember in a camp fire), remove the test tube from the Bunsen burner and watch. You may need to repeat the heating. Record your observations in the Table 2.

STEP 6. Keep the balloon on the test tube, and place the test tube in the beaker. Allow it to cool for a few minutes.

STEP 7. Record the mass of the test tube and its contents, balloon, and beaker in Table 2. (Make sure to remove the test tube clamp before measuring the mass.)

Table 2

Mass of iron, sulfur, test tube, balloon and beaker initially (g)	
Observations during heating	
Mass of Product, test tube, balloon and beaker after Reaction (g)	

 Is mass conserved during this interaction? What evidence do you have?

Part 3: Investigating the Properties of the Product

IF a fume hood is available, follow Steps 1-7.

You will need:

- Gloves and goggles
- Fume hood
- Test tube with the product of Experiment 2 (cooled to room temp)
- Cloth
- Hammer
- Forceps (tweezers)
- Magnet (in plastic bag)
- Magnifying lens or dissecting microscope
- Watch glass
- 1 M HCl in dropper bottle
- Broken glass receptacle

STEP 1. Remove the balloon from the test tube in the fume hood.

STEP 2. Completely cover the test tube with the cloth.

STEP 3. Smash the cloth and test tube with the hammer, so that the test tube breaks.

STEP 4. Carefully uncover the broken remains.

STEP 5. Using the forceps, remove some of the product, careful to remove all the broken glass from the sample.

STEP 6. Place the broken glass in the proper receptacle.

STEP 7. Examine the appearance of the product and record your observations in Table 3 below. Look for some physical properties, such as color, luster, and shape (appearance under a magnifying lens or dissecting microscope).

STEP 8. Keeping the magnet in a plastic bag, test to see how the product reacts in the presence of the magnet and record your observations in Table 3.

STEP 9. In the fume hood, place the product on a clean watch glass and add 5-10 drops of HCl. Record your observations in Table 3.

Table 3: Product after heating

Appearance	Under microscope or magnifying lens	Magnet	Reaction with HCl

Does the appearance of the iron change when it is heated with the sulfur? If so, describe the change.

Does the product react differently to the magnet than the iron? If so, describe the change.

Does the product react differently to the HCl than the sulfur or the iron? If so, describe the change.

Is there evidence that a new material with different properties from the original materials was formed? Cite as much evidence as possible to support your claim.

In your groups, come to consensus about whether a new substance is formed when the iron and sulfur mix and/or when the mixture is heated. Prepare to engage in a full class discussion.

Physical Changes vs. Chemical Reactions

What we observed when we mixed the iron and sulfur together (before heating) is an example of a physical change because there is no new material formed. By contrast, when the mixture of iron and sulfur was heated, a chemical reaction took place because a new substance with different properties was formed.

In your groups, decide which of the changes you think are physical changes and which are chemical reactions.

Change	Physical change or Chemical reaction	Rationale (or what you might do to test idea)
freezing water		
dissolving sugar in water		
baking cake		
melting wax		
burning coal		

For now let's look at how we can use the idea that combining (or separating) substances sometimes happens through a physical change, and sometimes happens through a chemical reaction.

Think about the product of the reaction of iron and sulfur (named iron (II) sulfide) versus the mixture of iron and sulfur. How are the two different?

A substance that cannot be broken down into simpler materials through chemical changes is called an **element** and is, therefore, considered one of the "building blocks" of matter.

A material formed by a combination of two or more elements through a chemical reaction is called a **compound**. The elements that are in the compound do not retain their original characteristic properties.

A substance that can be separated into two or more substances by a physical change is called a **mixture**.

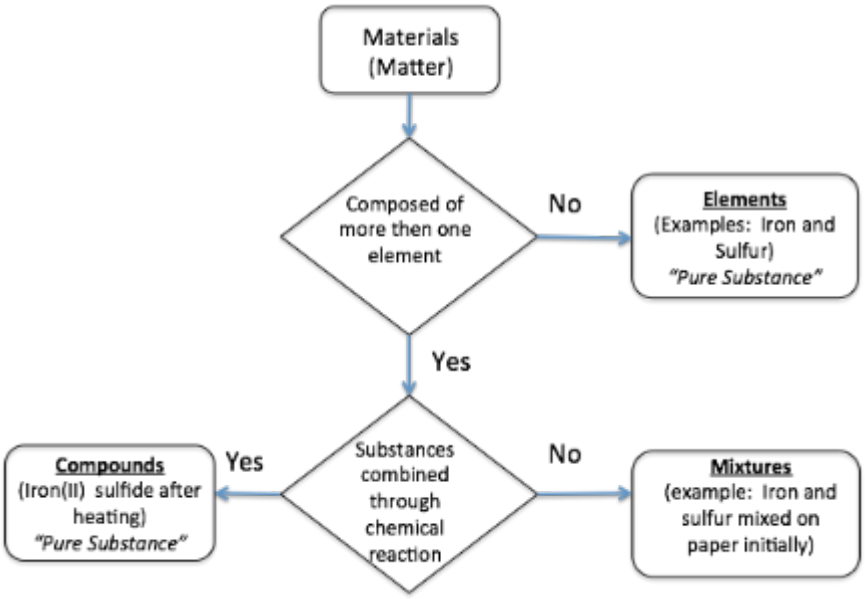
- What are the two elements that you observed in this lesson?
- When did you create a mixture in this activity?
- What was the compound you created in this activity?
- Do you think that you could have a mixture of compounds? Explain.

Summarizing Questions

S1. Think back to your initial ideas about the cake batter and baking. Which step in the process is a physical change and which is a chemical reaction? Support your answer with evidence and rationale.

S2. Here is the list of ingredients for our cake: Flour, sugar, eggs, butter, vanilla extract, baking soda, and salt.

Of these ingredients, name one mixture. Using the flow chart below, explain why you believe that it is a mixture.



Baking soda is sometimes called sodium bicarbonate. It contains sodium, hydrogen, carbon and oxygen. Do you think that baking soda was formed by a physical change or a chemical reaction? Support your answer using the flow chart.

S3. Total™ cereal is fortified[1] with vitamins and minerals. Iron, one of the minerals, is actually metallic iron.

[1] "Fortified" means that these substances are added to the cereal during the processing.

Look at the ingredients on the label and find examples of a mixture, a compound, and an element.

It is possible to remove the iron from the cereal. Propose a method that would enable you to separate out the iron from the cereal.

S4. While making cinnamon rolls, a chef combines cinnamon and sugar to sprinkle over the rolls before baking them.

a) Is this combination of cinnamon and sugar a compound or a mixture? Give evidence to support your rationale.

b) Is it possible to separate the combination of cinnamon and sugar? If yes, provide a possible procedure. If no, explain why not.