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BASIS Lesson Plan

Lesson Name: It's Just a Phase!

Grade Level Connection(s)

NGSS Standards: Grade 2, Physical Science
FOSS CA Edition: Grade 3 Physical Science: Matter and Energy Module

**Note to teachers: Detailed standards connections can be found at the end of this lesson plan.*

Teaser/Overview

Properties of matter are illustrated through a series of demonstrations and hands-on explorations. Students will learn to identify solids, liquids, and gases. Water will be used to demonstrate the three phases. Students will learn about sublimation through a fun experiment with dry ice (solid CO2). Next, they will compare the propensity of several liquids to evaporate. Finally, they will learn about freezing and melting while making ice cream.

Lesson Objectives

- Students will be able to identify the three states of matter (solid, liquid, gas) based on the relative properties of those states.
- Students will understand how to describe the transition from one phase to another (melting, freezing, evaporation, condensation, sublimation)
- Students will learn that matter can change phase when heat/energy is added or removed

Vocabulary Words

- **Solid:** A phase of matter that is characterized by a resistance to change in shape and volume.
- **Liquid:** A phase of matter that is characterized by a resistance to change in volume; a liquid takes the shape of its container
- **Gas:** A phase of matter that can change shape and volume
- **Phase change:** Transformation from one phase of matter to another
- **Melting:** Transformation from a solid to a liquid

- **Freezing:** Transformation from a liquid to a solid
- **Evaporation:** Transformation from a liquid to a gas
- **Condensation:** Transformation from a gas to a liquid
- **Sublimation:** Transformation from a solid to a gas

Materials

Scientist Volunteers will bring:

Ice, in small container
Water (room temperature)
Dry ice, in small container
Tongs, for handling dry ice
Clear plastic cups (3 for each small group)
Balloons (at least 2)
Syringes filled with tap water (1 for each small group)
Isopropyl alcohol (1 vial for each small group)
Pipette, plastic (1 for each small group)
Worksheet copies printed (1 for each small group)
Liquid nitrogen in portable dewar
Large bowl for mixing
Wooden spoon
Half & half, sugar, vanilla extract
Gloves, lab coats, safety goggles

Materials teachers should provide:

Students should have paper and pencils ready.

Classroom Set-Up

A demonstration table is needed in the front and center of the classroom, preferably adjacent to a chalk/white board with chalk or markers. We will start the discussion with the whole class, but please have the students divided into three smaller groups because we will be leading these smaller groups through the hands-on activities after the introduction. Access to a sink for water and clean-up would be helpful. Nametags are always helpful for calling on students.

Classroom Visit

1. Introduction (10 minutes)

Role Model Introduction:
Being a role model for students is an important part of being a BASIS volunteer. Begin your lesson by introducing yourselves! Every team member should take a moment to explain who they are and what they study/do as a scientist. A bonus will be to tell your "story," as if giving an elevator pitch to 8-year-olds: Why did you become a scientist/engineer? What made you interested in your topic? Why should students relate to you, or be interested in you? And remember, you can also weave your story throughout your lesson through examples from your own life, and/or return to it with Q&A at the end.

Topic Introduction:
After you introduce yourselves as role models, take some time to introduce the topic of this lesson: *phases of matter and their transitions*. It may be helpful to keep the suggested take-away in the back of your mind throughout the lesson: **Solids, liquids, and gases can change from one phase to another with either the addition or removal of energy (heat).**

Your topic introduction should follow the outline below. As much as possible, try to frame this information as questions posed to the class, rather than as a lecture. This helps activate students' prior knowledge and facilitate student-guided conversation.

- Today we are going to talk about phases of matter! What does it mean when I say 'matter'? What is that? [The 'stuff' all around us]
- We find matter in three different phases. One of those phases is called a solid. This desk in front of me is a solid. Why? What are there some things that we can describe about it? [It's shape stays the same and its volume (or the space is takes up) stays the same]
- What are some examples of solids? Point to one in the room! [desk, chair, pencil, etc.]
- Can anyone name another phase? If something isn't a solid, what could it be? [A liquid!]
- What is an example of a liquid? [water, juice, oil, etc.]
- What are some things that we can describe about liquids? [They change shape, but they keep the same volume, meaning they take up the same amount of space.]
- Okay, there's one more phase of matter. Does anyone know what it is? [Gas]
- Can anyone point to a gas in the room? [Can point anywhere in space around the room]
- What are some things that describe gases? [Change their shape and change their volume, the space that they take up. For example, when you blow into a balloon, the gas from your lungs is filling the balloon and making it expand.]
- Examples of gases are oxygen, carbon dioxide, helium, etc.

- Today we're going to do some science activities to help us understand the phases of matter and how energy affects the transitions from one phase to another!

Teaching Tip: Say, Write, Show

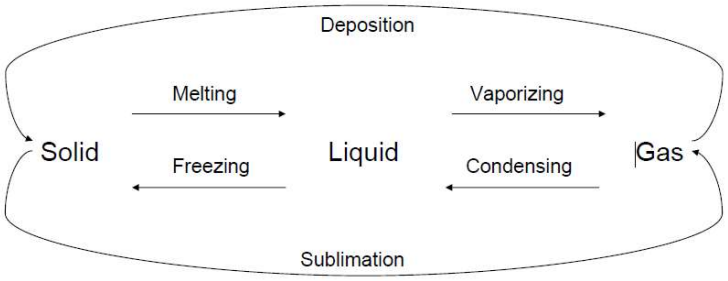
- Bring in photos and props to illustrate the topic intro
- Write new vocabulary words, key terms, and brainstorm lists on the board
- Refer back to the board to engage visual learners and English Language Learners

2. Learning Experience (35 minutes)

Phase Change Introduction:

- Now that we've talked about the different phases (solid, liquid, gas), we're going to talk about how matter transitions from one phase to another phase. A solid can become a liquid or a liquid can become a gas.
- The main thing to remember is that transition from one phase to another requires **energy** – energy either needs to be added or removed.
- Today, we're going to talk about changing the temperature -- heating or cooling a material to achieve a phase change. [We can change the pressure to produce a phase change without changing the temperature, but we won't focus on that today].

Draw the following diagram on the board and have students help you fill it out. Use different colors of markers (ideally blue for cooling and red for warming). Tell students that these arrows show when we either add energy or remove energy.



- Let's start with a familiar example: Ice. What phase is ice? Solid, liquid, or gas? [Solid]
- What happens when you take ice out of the freezer? What happens to it? [It becomes a liquid] What is that called when it goes from a solid to a liquid? [**Melting**] {use red arrow to draw – energy is added}
- Can we go the other way? Can you take liquid water and turn it into ice? How? [Stick some water in the freezer!] What is that called? [**Freezing**] {use blue arrow– energy is removed}
- What happens when we leave out a cup of water? Will that water eventually disappear? What about puddles on the sidewalk after it rains? What happens to those puddles of

water? The water doesn't actually disappear, it changes from the liquid phase to the gas phase. This transition is called **Evaporation**. {use red arrow– energy is added}

- Can we go the other way? Can a gas become a liquid? Have you ever had a cold soda can on a hot day? What happens on the outside? [It gets wet, water gathers on the surface.] Where does that water come from? Is it coming from inside the can? It's actually coming from the air – the air is condensing and transitioning from air to water. This transition from gas to liquid is called **Condensation**. {use blue arrow – energy is removed}
- What do you think about a solid transforming to a gas? Do you think that can ever happen? It's not as common, but yes it does. This transition is called **Sublimation.** {use blue arrow – energy is removed}
- Let's explore all these phase transitions with some experiments!

Students will be split into a number of smaller groups for the following three activities. The groups will not rotate between stations, but the class should be split into smaller groups for the benefit of classroom management and role modeling: students will be able to interact with volunteers in a more personal way, and volunteers will be able to guide a smaller number of students to do the activities and make use of the materials. Remember that all three of these activities are designed to address the take-away in a particular way: **Solids, liquids, and gases can change from one phase to another with either the addition or removal of energy (heat).**

Activity 1: Melting vs Sublimation

1. Engage students in a conversation about ice.
    a. Show students a cup filled with regular ice. What phase is this (solid, liquid, gas)?
    b. Prompt students with some guiding questions: "What will happen if we leave this ice sitting out in the classroom?" "Will it change phase? "What will it become?" [Liquid water] "What is that transition called?" [**Melting**]
2. Do the Sublimation activity
    a. Now we are going to look at a special material called dry ice. (Caution: Dry ice is really cold! It can burn your skin very quickly so we can't touch it with bare hands and we definitely never put it near our mouths or eat it!)
    b. "Is dry ice a solid, liquid, or gas"? [Solid] (Students may observe that they see the solid dry ice as well as vapor/gas) "What do you notice is coming off the dry ice?" [Vapor or gas]
    c. "Does anyone remember the name of the phase transition is? From a solid to a gas?" [Sublimation]
    d. "What happens when we blow into the cup?" Have students pass around the cup and gently blow on it. There should be more vapor that comes up off the dry ice. The speed of sublimation depends on temperature.

e. What happened to all that vapor? Did it just disappear? [No, it's still in the room, but gases can change their shape and the amount of space they take up. So the gas is still there, but now all around the room.]

3. Connect the activity to the big picture
    a. Invite students to reflect on what they noticed with the dry ice. You can also add water to the dry ice to see what will happen. (This will speed up the reaction and you can watch the dry ice bubble in the water – releasing the gas!)
    b. "When you put your hand in the vapor or when that gas touches your face, what does it feel like?" "Is it hot or cold?" [Cold]
    c. "But I told you that dry is so cold that it can actually hurt and burn your hand. So why didn't the gas burn your face?" Remember, that with sublimation, energy is being added (in this case, that energy is heat, either through the heat of our breath or the warmer temperature of the water we added). So the temperature of the gas is cold, but it's not as cold as the solid dry ice!
    d. Emphasize the overall takeaway of the lesson: **Solids, liquids, and gases can change from one phase to another with either the addition or removal of energy (heat).**

Quick Demo: Put a few pieces of regular ice into a balloon. Seal it up. Ask students what they think will happen. Put a few pieces of dry ice into a different balloon. Seal it up. Ask students what they think will happen with this one.

Activity 2: Evaporation of different liquids

1. Engage students in a conversation about evaporation
    a. When it rains, what phase is the water in? Solid, liquid, or gas? [Liquid]
    b. After it rains, what happens to those rain puddles after a while? Do they disappear? What happens to them? [They turn into gas]
    c. What is that transition called? [Evaporation] Energy from the sun heats up those rain puddles and that water turns into gas.
    d. Do you think that all liquids will evaporate in the same amount of time? For example, if we had a puddle of rainwater next to a puddle of milk or soda, would the all evaporate in the same amount of time? Let's do an experiment to figure it out!
2. Do the Evaporation activity
    a. In this experiment, we are going to put one drop of two different liquids on your hand.
    b. Everyone place your hand into the center of the desk area with the back of your hand facing towards the ceiling. The first liquid that I'm going to put on your hand is regular water.
    c. Put one drop on each student's hand. Have them observe what the drop looks like and what it does. Is it evaporating? [Not noticeably]
    d. Alright, the next liquid that I'm going to put on your hand is called isopropyl alcohol. Place one drop on the hand of each student. Have them observe what the drop looks like and what it does. Is it evaporating? [Yes!]

e. Students may notice that it smells like hand sanitizer – great observation! Who has used hand sanitizer before? Do your hands stay wet for very long with hand sanitizer? [No.] But where does it go? Into your skin? [Maybe a small part gets absorbed by your skin, but the isopropyl alcohol in it evaporates into the air!]
f. What does your hand feel like where the isopropyl alcohol liquid used to be? [Cold!]
g. Why do you think it's so cold? Where did the energy go? The energy (heat) from your hand went to the

3. Connect the activity to the big picture
    a. What does your hand feel like where the isopropyl alcohol liquid used to be? [Cold!]
    b. Why do you think it's so cold? Where did that heat or energy from your hand go? The energy (heat) from your hand went into the liquid that was sitting on your hand. For liquid to transition to a gas, it needs heat or energy to make that happen. Energy from the sun helps puddles evaporate and the energy from your hand helped that drop of liquid on your hand evaporate.
    c. Emphasize the overall takeaway of the lesson: **Solids, liquids, and gases can change from one phase to another with either the addition or removal of energy (heat).**

Activity 3: Phase change guess

Given an unknown phase change, how do we decide what type of phase change it is? By defining the phase of the substance before and after the phase change, we can determine what phase change has occurred. If we know the type of phase change, we can also determine if energy/heat was added or removed to make the phase change occur. The students will be presented with example phase change picture cards and they will have to determine what phase change is being described.

3. Wrap Up: Review and Discuss the Learning Experience (10 minutes)

We will reconvene for a final experiment making ice cream with liquid nitrogen. We will make liquid nitrogen in a large bowl in front of the classroom and then distribute portions to the students. We will ask students to reflect on what they have learned and also talk about the phases of matter of ice cream and the different phase transitions that are occurring in front of them!

- What are the three **phases of matter**? [Solid, liquid, gas]
- What did you learn in activity 1? Activity 2? Activity 3?

4. Connections & Close (5 minutes)

Connections to the real world around students:

- Where do you find phase changes in your everyday life?
- When you boil water, make ice cubes, cook food – you are causing a phase change!

- Think of a phase change that you have seen and describe the phase change using the vocabulary we learned today.
- Does this phase change require energy/heat to be added? Or is energy/heat removed? How do you know?

If possible, tie lesson back into your research or role model story.

Close:

- Ask students if they have any questions about science or being a scientist
- Close with a good bye and a thank you, and encourage the kids to keep thinking about the phase changes they see around them every day!
- Don't forget to help clean up!

Follow Up: After the Presentation

Teachers who wish to extend the impact of this lesson may find the following CRS web pages useful:

- http://www.crscience.org/educators/helpfulreports
- http://www.crscience.org/educators/treasuretrove

Standards Connections

NGSS:

- Connections by topic
  Physical Science: 2. Structure and Properties of Matter
- Connections by disciplinary core ideas
  Physical Science: 2-PS1. Matter and Its Interactions
- Connections by scientific & engineering practices
  1. Asking questions and defining problems
  6. Constructing explanations and designing solutions
- Connections by crosscutting concepts
  5. Energy and matter: Flows, cycles, and conservation
  7. Stability and change
- Connections by performance expectation
  2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
  2-PS1-4. Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.

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