Bay Area Scientists in School Presentation Plan

**Lesson Name**  It's just a phase!

**Presenter(s)**  Kevin Metcalf, David Ojala, Melanie Drake, Carly Anderson, Hilda Buss, Lin Louie, Chris Jakobson

**California Standards Connection(s):**  3rd Grade – Physical Science
3-PS-Matter has three states which can change when energy is added or removed.

**Next Generation Science Standards:**  2nd Grade – Physical Science
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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<th>Science &amp; Engineering Practices</th>
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| Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. | PS1.A: Structure and Properties of Matter  
*Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties. (2-PS1-1)*  
*Different properties are suited to different purposes. (2-PS1-2), (2-PS1-3)*  
*A great variety of objects can be built up from a small set of pieces - atoms. (2-PS1-3)* | Patterns  
*Patterns in the natural and human designed world can be observed. (2-PS1-1)* |
| Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. (2-PS1-1) | PS1.B: Chemical Reactions  
*Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not. (2-PS1-4)* | Cause and Effect  
*Events have causes that generate observable patterns. (2-PS1-4)*  
*Simple tests can be designed to gather evidence to support or refute student ideas about causes. (2-PS1-2)* |
| Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. |  |  |
| *Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. (2-PS1-3)* |  |  |
Common Core Standards:

ELA/Literacy:
W.2.8 Recall information from experiences or gather information from provided sources to answer a question.
SL.2.2 Recount or describe key ideas or details from a text read aloud or information presented orally or through other media.

Mathematics:
MP.2 Reason abstractly and quantitatively.
MP.5 Use appropriate tools strategically.

FOSS Connections:
Grade 3 Module: Matter and Energy
Investigation 3: Matter

Teaser:
Properties of matter are illustrated through a series of demonstrations. Students will learn to identify solids, liquids, and gases. Water will be used to demonstrate the three phases. They will learn about sublimation through a fun experiment with dry ice. Next, they will compare the propensity for vaporization (evaporation) for several liquids. Finally, they will learn about freezing and boiling while making ice cream.

Objective:
The students will be able to identify the three states of matter and understand how to describe the transition from one phase to another. In addition, they will learn about the relative properties of each phase.

Vocabulary/Definitions: 3 - 6 important (new) words
1. **Solid**: A phase of matter that is characterized by resistance to changes in shape and volume.
2. **Liquid**: A phase of matter that is characterized by a resistance to change in volume. A liquid can change shape.
3. **Gas**: A phase of matter that can change shape and volume.
4. **Phase change**: Transformation from one phase of matter to another.
5. **Melting**: Transformation of a solid to a liquid.
6. **Freezing**: Transformation of a liquid to a solid.
7. **Boiling**: Transformation of a liquid to a gas.
8. **Condensation**: Transformation of a gas to a liquid.
9. **Sublimation**: Transformation of a solid to a gas.
Materials:

What will you bring with you? Materials for experiments:
1. Ice
2. Water (room temperature)
3. Dry ice
4. 2 large glass beakers
5. Balloons
6. Clear plastic cups
7. Water
8. Food coloring
9. Salt
10. Isopropyl alcohol
11. Poster board/bingo pictures/work sheet
12. Liquid nitrogen in portable dewar
13. Styrofoam bowls and plastic spoons
14. Large bowl for mixing and wooden spoon
15. Milk, heavy cream, vanilla, sugar
16. Gloves

What should students have ready (pencils, paper, scissors)?
Students should have pencils for recording data.

Classroom Set-up:
A demonstration table is needed in the front and center of the classroom, preferably adjacent to a black/white board with chalk or markers.
Access to a sink for water and clean-up would be helpful.

Classroom Visit

1. Personal Introduction: _______ 5 ___ Minutes

We are graduate students in chemical engineering at UC Berkeley, but come from all over the country. Give name and hometown and discuss how each town climate is different from the Bay Area. What is chemical engineering? Why did we choose to become engineers? What kinds of problems do engineers work on?

2. Topic Introduction: _______ 5 ___ Minutes

Introduction to the Properties of Matter. Different materials have different properties. What are some properties of solids? (Object has a defined shape and volume. It resists changes in shape and volume. Molecules are rigidly packed together: ice, dry ice, desk, chair, pencil.) What are some properties of Liquids? (Liquids can flow and change shape. They adopt the shape of the container that
they are in. The molecules are close together, but can freely move around and change position. Because the molecules are close together, you can’t change the volume easily: Water, oil, blood.) What are some properties of Gases? (Gases can flow, change shape, and change volume. A gas has a low density and will readily diffuse. Gases will expand to fill the space around it. Gas molecules are very loosely packed/far apart from each other: Oxygen, carbon dioxide, helium, air.) Today we will discuss some of the properties of solids, liquids, and gases.

Right now, we’re going to study and observe the properties of different materials. Pay close attention to what you see. Afterwards, we’re going to talk about the special features of different types of matter.

3. Learning Experience(s): ______ 30 ______ Minutes

Introduction: Defining the states of matter
1. **Solid:** A phase of matter that is characterized by resistance to changes in shape and volume.

2. **Liquid:** A phase of matter that is characterized by a resistance to change in volume. A liquid can change shape

3. **Gas:** A phase of matter that can change shape and volume.

To transition from one phase to another phase requires energy addition or removal. Most often, we can think of heating or cooling a material to achieve a phase change. However, we can change to pressure to produce a phase change without changing the temperature!

Phase changes
When water changes from one form to another, it is undergoing a phase change. Draw a diagram on the board and let the student’s help you fill it out:

```
     Deposition
         ↑            ↑
   Solid   Melting  Vaporizing
         ↓            ↓
   Freezing  Liquid  Condensing
         ↓            ↓
   Sublimation  Gas  Freezing
```

Questions:  When water goes from liquid to ice, what do you call that? (Freezing)

When water goes from ice to liquid, what do you call that? (Melting)
When liquid water goes to a gas, it is called vaporization. When gas goes to liquid, it is condensation.

What about a solid to a gas? That is a special circumstance where we can observe sublimation. (Gas to solid is deposition).

Bonus: Discuss the temperature for each transition.

The class will now be broken up into small groups of ~4-6 students, with one graduate student per group.

**Experiment 1: Sublimation vs. Melting**

Now we are doing 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 hold it with bare hands or eat it!) Is dry ice a solid, liquid or gas? (Students may observe that they can see the solid (white) dry ice as well as vapor/gas.) Why is it called dry ice? **Quick demonstration:** Put a chunk of frozen water/ice into one beaker. Put a similar chunk into a second beaker. Let sit out for 10-40 minutes. What happens? Ice will melt, dry ice will sublime. Since there is no liquid phase in the dry ice to carbon dioxide transition, we call it dry ice. The dry ice will “disappear” as it forms a gas and diffuses through the room.

Dry ice undergoes a special phase transition called **sublimation**. That means that it goes from a solid to a gas. We can use this property to blow up a balloon. **Quick demonstration:** Put a few chunks of dry ice in a balloon. Seal balloon. What is happening? (The solid carbon dioxide is subliming to form a gas, which occupies a larger volume. This inflates the balloon.) Why does the balloon grow as carbon dioxide forms? (Gases fill up the volume that they are in.) Can we change the shape of the gas in the balloon? (Yes, gases can change shape and volume.) The speed of sublimation depends on temperature. What happens if we put the dry ice in cold water/room temperature water/hot water? (Demonstrate to test hypothesis.) What happens if we put ice (H₂O) in a balloon? Does the balloon inflate? Does the ice melt or sublime?

We know now that dry ice can sublime to a gas. What do you think will happen if we put a small chunk of dry ice in a plastic film canister? (Have students try this.)

**Experiment 2: Evaporation of different liquids**

When energy is added to a liquid to turn it into a gas, it undergoes a phase change called **vaporization**. Different liquids will vaporize at different rates.
Think about boiling water, which is a type of vaporization. Sometimes, your parents might add salt to the water, which increases the temperature of vaporization, making the liquid water hotter. Or, you may have noticed that a recipe has special directions for people who live at high elevations (like in the mountains!). This is because the temperature of vaporization for liquid water is different in the mountains than on the beach.

In this experiment, we will find out how different liquids vaporize into a gas. We can put a little of water, isopropyl alcohol, and salt-water on your hand. The water and salt-water will be pre-mixed with food coloring so that the students can distinguish between the different liquids. Which one vaporizes the fastest? Which liquid vaporizes the slowest? What does vaporization feel like on your hand? Your hand should feel cold, because the liquid is taking energy from your hand (temperature=energy) and using that energy to vaporize the liquid. This is why we sweat! Perspiration on your skin vaporizes, which takes away heat (energy) from your body and cools you off!

**Experiment 3: Phase change game**

Given an unknown phase change, how do we decide what the type of phase change 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 was added or removed to make the phase change occur. The students will be presented example phase changes with picture cards and they will have to determine what phase change is being described in small groups.

4. **Wrap-up: Sharing Experiences**  ______ 15 ______ Minutes

We will reconvene for a final experiment making ice cream with liquid nitrogen. We will make the ice cream 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 ask them what phase changes are occurring as the ice cream is made. We will that the liquid nitrogen is boiling (but it boils at a very cold temperature!) and the cream is freezing. The energy required to boil the nitrogen is removed from the cream, which freezes the cream. We will explain how to make liquid nitrogen.

From Wikipedia:
Liquid nitrogen is produced from “cryogenic distillation of liquefied air. An air compressor is used to compress filtered air to high pressure; the high-pressure gas is cooled back to ambient temperature, and allowed to expand to a low pressure. The expanding air cools greatly (the Joule-Thomson effect), and
oxygen, nitrogen, and argon are separated by further stages of expansion and distillation.

5. Connections & Close: _____ 5 _____ Minutes

Summarize the properties of matter: solids, liquids, gases.
- Emphasize the observations we made to study the properties of the different phases of water and dry ice.
- Discuss how we could observe the differences in density between different solids/liquids.
- Encourage students to study the properties of matter on their own, either when thinking about things in the classroom or in daily life.

Where do you find phase changes in your everyday life? When you boil water, make ice cubes, burn gas in a car, or 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 to be added or removed? How do you know?

Total 50 - 60 Minutes

Differentiated Instruction:
English Learners: Repeat directions, if necessary, and physically model how to perform activities at each station. Write vocabulary, e.g. solid, liquid, on the board and read words aloud. Vocabulary words can also be visually demonstrated using an illustration or action and redefined in very simplistic terms.

Advanced Learners: At each station, have students think of other materials that would behave in a similar manner, i.e. have similar properties, as the matter they are manipulating.

Follow-Up – After Presentation
Suggest students write a letter explaining “How we learned about ______________?”
List or attach examples of activities, websites, connections for additional learning.
Attach worksheets, hand-outs, visuals used in classroom presentation.

Write a letter summarizing the properties of matter and give a specific example of how you can describe a material using the concepts we discussed.

Reading Connections:
- Matter: See It, Touch It, Taste It, Smell It by Darlene Stille – The states of matter (solids, liquids, and gases) are explained and demonstrated. Includes an experiment to try. http://books.google.com/books/about/Matter.html?id=jxLYKx9ul2EC