Bay Area Scientists in Schools Presentation Plan

Lesson Name **States of Matter**
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Standards Connection(s):

CA State Science Standards: 3rd Grade - Physical Science

1. Energy and matter have multiple forms and can be changed from one form to another. As a basis for understanding this concept:
   - 1.e. Students know matter has three forms: solid, liquid, and gas.
   - 1.f. Students know evaporation and melting are changes that occur when the objects are heated.
   - 1.h. Students know all matter is made of small particles called atoms, too small to see with the naked eye.
   - 1.i. Students know people once thought that earth, wind, fire, and water were the basic elements that made up all matter. Science experiments show that there are more than 100 different types of atoms, which are presented on the periodic table of the elements.

5. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:
   - 5.a. Repeat observations to improve accuracy and know that the results of similar scientific investigations seldom turn out exactly the same because of differences in the things being investigated, methods being used, or uncertainty in the observation.
   - 5.b. Differentiate evidence from opinion and know that scientists do not rely on claims or conclusions unless they are backed by observations that can be confirmed.
   - 5.d. Predict the outcome of a simple investigation and compare the result with the prediction.
   - 5.e. Collect data in an investigation and analyze those data to develop a logical conclusion.

Next Generation Science Standards: 2nd Grade

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.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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. Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. **(2-PS1-1)** 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)**	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. **(2-PS1-3)** 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)**	Patterns · Patterns in the natural and human designed world can be observed. **(2-PS1-1)** 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)** Energy and Matter · Objects may break into smaller pieces and be put together into larger pieces, or change shapes. **(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 / Objective: This lesson teaches about the 3 main states of matter in an exciting way! (Bonus: there is a 4th state of matter that we briefly mention at the end of the lesson.) Students will gain an intuitive understanding of the differences between the various states of matter, as well as the concepts of energy and density and how they relate to the various states of matter.

Vocabulary/Definitions: *3 – 6 important (new) words*

- Atoms
- Solids, Liquids, Gases
- Phase shifts
- Temperature
- Energy
- Density
- Plasma (a bonus word at the end of the lesson)

Materials:

What will you bring with you?

Peltier Device Demo Kit.
Solids of different densities.
Liquids of different densities.
Silly putty and play doh

What should students have ready (pencils, paper, scissors)? N/a

Classroom Set-up:

We'll start with a whole-class introduction and then move on to demo stations. The demo stations will be set up on desks around the room and will take minimal time to set up.

Classroom Visit

1. Personal Introduction: **_____5_____ Minutes**

We'll introduce ourselves by saying our name, "grade" (e.g. 19th grade), school, and a quick sentence about what we do, as we think it would interest the students (e.g., I work on robots).

Topic Introduction: **_____10___ Minutes**

Questions to ask (write key words on board while doing this):

- Does anyone what all matter ["stuff"] is made of?
  - Atoms! This will lead nicely to the next question.
- Can anyone tell me what the different states of matter are?
  - 3 states - solids, liquids, and gases
- Can anyone tell me what makes the states different?
  - Explain atomically how the different states differ. The atoms in a solid typically don't move too much and stay in a structured order (or lattice), such as having one "atom" at every point in a grid. Atoms in a liquid can move around each other freely but are still close together. Atoms in a gas are very spaced out and move very quickly.

    - The kids will stand up and pretend to be atoms in solids and liquids as a demonstration of how solids and liquids differ atomically. We won't have them pretend to be gases.
- Which states do you think have the most energy?
    - This can be related to temperatures
    - The more "movement" the atoms have, the more energy they have
- Explain some details about phase shifts
    - As the atoms get hotter, they vibrate more until they break out of their structure (e.g. lattices)

Density and its relationship to different liquids, gases and solids

- What does it mean when something is "dense"?
    - Once this is explained, you can use the students again to demonstrate density (i.e. more students in a smaller area or larger area to show different densities)

2. Learning Experience(s): ____30____Minutes

We will have three demo stations. The students will rotate between each station.

Demo Station 1: Peltier Device Demo Description (Teacher Resource on last page)
Overall Structure: Explain Peltier device as a black box and then ask students what they think will happen if we add and subtract heat from water. etc. Then demonstrate how will add heat to water and boil it (and remove heat from the area around/below it, so it will be cold) and vice versa.
Concepts:
- Conservation of energy
- Heat pump

Note: It's okay to touch the Peltier device when it's cold and have the students touch it when it's cold. Do not touch it when it's hot. We will have a "shield" to help prevent this.

Questions to ask:

- What happens when you add or subtract heat?

Demos to try: Freeze water, boil water, and power LEDS or a motor.

Demo Station 2: Density Demo, Liquids
Overall Structure: The overall learning objective is to have students comprehend that liquids, like solids, which will be more familiar, have different densities. This will be explored by playing with oil/water/other fluid mixtures in water bottles.

- Review the concepts of density just presented in the big group. Try to get the students to explain density in their own words. Focus specifically on liquids

- Work together to name three common liquids:
    - Oil
    - Water
    - Alcohol
    - Other liquid options include: corn syrup, vegetable oil, Dawn dish soap, rubbing alcohol, honey (use food colorings) [see http://www.stevespanglerscience.com/lab/experiments/seven-layer-density-column]
- Discuss what it would mean for liquids to have different densities, see if you can lead them to the idea that the liquids would separate and stack on each other.
- Have the students play with the oil / water mixtures.
- Show a piece of ice in a cup of water and discuss why it is floating.

Questions to ask:

- What does it mean for fluid to have different densities?
- Why do things float more easily in salt water than freshwater? (Salt water is more dense!)
- Hybrid question: Why does ice float? Solid ice is less dense than liquid water. This is unusual because generally solids are more dense than their liquid counterparts.

Demos to try: Oil and Water; mix them up and watch the oil sink/separate from the water!

Add on silly putty/play doh experiment to this demo: non-Newtonian fluid acts a little bit like a solid and a little bit like a liquid.

Demo Station 3: Density Demo, Solids

Overall Structure: different objects: iron wood/petrified wood, tennis ball, baseball, cube of aluminum + steel + plastics, (+ bowling ball?)

Construct a set of cubes such that some have more spherical “molecules” inside of them that others, and some float and others sink

Add: play doh container-- empty container floats, container filled with pennies sinks, shows concept of molecules & density

Questions to ask:

- Place them in ascending density
- Place them in ascending size

Demos to try: Same sized balls/blocks of different materials.

Other Notes/Ideas:

Demo Station 4: Cornstarch Solids/Liquids Example

http://www.sciencebob.com/blog/?p=608

Overall Structure:

Questions to ask: Solids/Liquids -- non-newtonian fluid -- how does it work?
Demos to try: Mix in a Dixie Cup -- stir slowly and it's liquid, pull stick out fast and it gets stuck

Demo Station 5: Floating Bowling Balls / Petrified (Iron) Wood / Stones?
Two main lessons:
(1) A younger lesson for concepts of states of matter
(2) Older middle school lesson that is more data-driven

3. Wrap-up: Sharing Experiences ____5____ Minutes

Ask a question about each demo:

- What is the difference between a solid, liquid, and gas? Which one has the most energy?
- What happens when you take energy/heat out of a gas? What happens when you put energy/heat into a solid?
- What do you know about density? What does it mean when I say something is more dense or less dense? For liquids? For solids? Examples related to home life?

4. Connections & Close: ____5____ Minutes

Continue with concepts from wrap-up questions.
Review over the concepts learned from the introduction and the demos

- What happens when you add or subtract energy from a state of matter? (Peltier demo)
- What does density mean?
  - What will happen in water when you put dense materials together?
- What are some materials that have qualities from both solids and liquids?

(Trick question) Are solids more dense than gas? The answer is usually yes, except in some special cases like water.
Are the any other "weird" materials that students have questions about?
Can anyone guess if the sun is made of liquid or solid? (Trick question again). It's actually made of **plasma**, which is a fourth state of matter! It is even more energetic than gas!

Total <u>50 – 60</u> Minutes

<u>Differentiated Instruction:</u>

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 Possibilities

ELA Activity:
Students answer the following prompt:
"Write a letter to a friend explaining what you learned about changing states of matter."

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

Mathematics Activity:
Have students measure and record the temperature at which certain matter changes states.

Other:
Meltdown (Children's Museum of Houston) – In this activity, learners heat ice and water of the same temperature to get a hands-on look at phase changes. This is an easy and inexpensive way to introduce states of matter and thermodynamics. The activity page includes a fun how-to video for learners and educators.

http://www.cmhoustonblog.org/2010/07/23/meltdown/

What to Do:
1. Cool some water down to about 32° F (0°C) using your freezer or extra ice.
2. Measure around a cup of water and find the weight (you'll see why in a moment).
3. Pour it into a pot on the stove and turn the temperature to high.
4. Time how long it takes to boil.
5. Take the pot off, pour out the water, and let the pot cool down to room temperature.
6. Raise the temperature of some ice to 32° F (0°C) by placing it out at room temperature. Note that some will melt, so you will need to make sure you only use unmelted ice.
7. Measure out equal weight of ice as the water you used earlier. This way, when the ice melts, you have the same amount of water being heated.
8. Pour the ice into the pot on the stove, turn the temperature to high, and time how long it takes for the ice to melt and reach boiling.

What's Happening?
Even though the ice and water are at the same temperature, ice has bonds that hold its molecules in a crystal pattern. In order to break the bonds and melt the ice, extra heat energy is needed. So, even though the temperature doesn't rise, heat is absorbed to melt the ice which is why it will take longer for the ice to first melt and then boil.

For Teachers:

Peltier effect, the cooling of one junction and the heating of the other when electric current is maintained in a circuit of material consisting of two dissimilar conductors; the effect is even stronger in circuits containing dissimilar semiconductors. In a circuit consisting of a battery joined by two pieces of copper wire to a length of bismuth wire, a temperature rise occurs at the junction where the current passes from copper to bismuth, and a temperature drop occurs at the junction where the current passes from bismuth to copper. This effect was discovered in 1834 by the French physicist Jean-Charles-Athanase Peltier.
(Source: Encyclopædia Britannica - http://www.britannica.com/EBchecked/topic/449424/Peltier-effect)