Bay Area Scientists in Schools Presentation Plan

Lesson Name: States of Matter: from sublime suds to ice cream science!
Presenter(s): Francis group – Kristen, Allie, Amy, Mike, Troy, Praveena and Leah

Grade Level: 3rd Grade – Physical Science

California Standards Connection(s)

3-PS-Matter has three states which can change when energy is added or removed.

Next Generation Science Standards:

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

Abstract: Today we are going to be discussing solids, liquids and gases and how they can all be turned into each different state under special conditions. Under extreme temperatures, almost any solid, liquid or gas can be turned into something else. We are going to be exploring what happens when you take some gases and turn them into either a solid or a liquid. Then we will see how you can use these two special substances to rapidly change the properties of almost anything else! We will have three different stations to explore these different properties, one station will look at what happens when a solid turns directly to a gas, another station will look into the different properties of solids and how rapidly freezing objects effects their physical properties and the final station will look at a substance that is not entirely a solid or a liquid, but somewhere in between and how we can make this special substance.

Vocabulary/Definitions:

Review words: solid, liquid, gas. Ask: Can anyone name something that is a solid/liquid/gas? (many possibilities). Explain: A solid is something that does not change it's shape or size no matter where you put it, an example is a rock. A liquid is something can freely move and change shape to be in the shape of whatever container it is put in, an example is orange juice. A gas is something that never has a defined shape or size, an example is perfume, if you spray the liquid it becomes a gas and then the smell will fill this entire room and maybe even spread out into the hallway.

- <u>freezing</u>: freezing is the process where a liquid turns into a solid. Ask: Has anybody frozen something? (ice, popsicles, etc.)
- <u>condensing</u>: condensing is the process where a gas changes to a liquid. Ask: Has anybody seen something condense? (foggy mirror after shower, cold drink, etc.)
- <u>melting</u>: melting is the process where a solid turns into a liquid. Ask: What have you seen melt? (ice cream, ice, snow, etc.)

- boiling (or evaporation): boiling is the process where a liquid changes to a gas. Ask: Has anyone ever boiled something? (any sort of food...)
- sublimation: the process where a solid turns to a gas without ever being a liquid in between

Ask: can anyone figure out which of these processes are opposites of each other? (freezing and melting or boiling and condensing)

Materials:

We'll bring:

- Bowl
- Ice cream mix
- Liquid nitrogen
- Paper cups and plastic spoons
- Ice cubes
- Carton of ice cream with ice crystals in it and cooler to keep it cold
- Dry ice
- Soap solution
- Leaky Faucet setup
- duct tape
- cryo gloves
- tub for water so students can wash their hands after holding soap bubbles
- TOWELS (cloth, paper, etc)
- 100 mL and 400 mL beaker
- Smaller dewar for demonstration
- Tongs
- Cold gloves
- Rubber bands
- Carrot or Onion or Orange
- Marshmallows
- Flowers
- Balloons

Classroom Set-up:

After the introductions students will be divided into three groups and will then rotate through three different phase transition stations. If possible, it would be best to have the three stations set up with a table (or several desks pushed together) as far away as possible from each other so that the students can really only focus on the station at which they are learning. It should probably take about 5-10 minutes to both move the desks or tables to and from the three stations. The only other set up request we have is that either the door to the classroom or some windows be open for the duration of the demonstration so that the room does not fill up with too much nitrogen.

Classroom Visit

1. Personal Introduction: **5 Minutes**

We are a group of college graduates that are now in graduate school and have gone on to study chemistry and biology in more detail. All of us are working to make new materials that can help people around the world. Some of the things we are working to make are ways to purify water, deliver medicine exactly to your sicknesses, and take the light from the sun and turn it into energy. Here today we have (introduce ourselves by first name).

Topic Introduction: **10 Minutes**

As chemists we often take advantage of the different states of matter and how they can change back and forth between all of the different states. Ask: Does anybody know what the three different states/phases of matter are? (solid, liquid gas)

Discuss vocab words now

2. Learning Experience(s): **35 Minutes**

We're going to divide the class into three and have them rotate through three demo stations (10 min each)

Demo 1: Ice Cream Science

Ask: Is ice cream a solid, liquid or gas? How do you know? What is ice cream made of?

Look: Let's look at frozen water… can you scoop that with a spoon? (look at some ice cubes)

Ask: What do you think might make ice cream softer than frozen water?

Explain: Ice cream, although mostly frozen, also has to include a small amount of unfrozen (liquid) water to make it easy to scoop.

Look: Let's look at an ice cream carton with ice crystals in it.

Ask: Has this ever happened to some ice cream in your freezer? How does it taste when this happens? (not good!)

Explain: To prevent these ice crystals from forming we need to have special chemicals, which is usually fat and sugar from cream. It's a balance because we need water in liquid form to keep ice cream soft enough to scoop but we don't want to let it freeze or else ice crystals will form.

Explain: Some people want to have healthier ice cream without all of the fat that keeps it soft. Recently, certain brands of ice cream have used science to answer this problem – what can we add to ice cream to prevent water from freezing that is not fat or sugar? Scientists found this special ingredient from a fish that lives in the arctic. Let's figure out what the secret ingredient could be!

Ask What is the temperature like in the arctic? (Cold)

Ask: What would happen if the blood in a fish froze? (they wouldn't survive)

Explain: So, fish have a special protein in their blood that prevents ice crystals from forming. Now to keep your ice cream soft, they just make the same chemical that fish use!)

Ask: Now, want to make some ice cream?

Explain: Usually ice is used to cool ice cream so it takes a while to churn slowly but we can use something colder than ice so that it goes quickly, liquid nitrogen! (then we'll make liquid nitrogen ice cream – kids will just watch since liquid nitrogen can be dangerous and we'll pass it out)

Demo 2: Sublime suds

Show the students dry ice. Prevent them from touching it.

Ask: Do you know what this is? (dry ice) Have you ever seen it before? Where?

Ask: Does anyone know what state of matter carbon dioxide is usually found in? (gas – give examples, e.g., exhaust from your car)

Ask: How do you think you make carbon dioxide solid? (make it really cold)

Explain: Correct. Solid carbon dioxide is VERY cold. That's why we can only touch it with these special gloves.

Ask: So, what do you think will happen if we mixed dry ice with water? (allow them to answer)

Demonstrate and explain: The heat from the water is causing the carbon dioxide to change phase from solid directly to gas. This is called "sublimation". It refers to the process of changing from solid directly to gas. (Only if someone asks, note differences between water's 3 phase changes under normal conditions, and carbon dioxide's 2 phase changes. Water can sublimate directly from ice to vapor as well, but only under very extreme conditions).

Ask: We can capture gas in bubbles. What do you think would happen to a bubble of carbon dioxide when we make it? (ask around, pretend like we don't know). Using our sophisticated bubble maker, we're going to see whether it sinks or floats in air.

Make bubbles, and we'll know. Let children play with bubbles.

Demo 3: Liquid Nitrogen

Ask: What is the coldest thing you can think of? (Ice is 32F/ dry ice is -109 F)

Explain: Today, we have liquid nitrogen with us and its temperature is really, really cold – 320 F—much colder than ice or the dry ice at the other station.

Ask: First of all, who knows where we can find nitrogen? (Air)

Explain: The air we breathe is about 80% nitrogen gas. So what we have here is Liquid air. It took a really powerful refrigerator to make air so cold that it turns into a liquid.

Segue: Now that we know what liquid nitrogen is, we are going to use it to make other things cold.

We'll have some fruits, flowers, rubber bands, and balloons.* ***All nitrogen handling will be done by us exclusively.* *Frozen materials may be passed around once at RT.**

Ask: What do you think will happen when we put this into the liquid nitrogen? (Dip balloon- Inflated balloon gets much smaller).

Explain: Gas inside the balloon "shrinks" when you make it cold (avoid confusing pressure explanation).

Look: Let's keep it outside for a while, and see what happens to it

Segue: In the meanwhile, let us look at some flowers and fruits.

Ask: How does a flower (rose) or orange feel when you touch it? (Soft). Pass some around. Now let us see what happens when we dip them in Liquid Nitrogen. Let us find out. (Dip flowers and Fruits)

Look: Now touch the flower and orange and see how it feels

Explain: The flowers and fruits froze.

Ask: What liquid do you think is present in fruits and flowers which make them freeze when they get cold? (Water)

Explain: Fruits and Flowers have a lot of water in them, which freezes into ice when it gets really cold.
That is why they turn so hard—just like ice. Now let us see how hard they get (throw the frozen orange to shatter)

Explain: We can also use a frozen banana (instead of a hammer) to put a nail in the wall.

Ask: What will happen to a rubber band? (No longer stretchy, turns brittle).

Segue: Because liquid nitrogen is so cold, it can be used to make some things in a special way.

Ask: Has anyone heard of Dippin' Dots?

Explain: Dippin' Dots are a type of ice cream that comes in tiny round balls instead of the normal large scoops. Liquid nitrogen is used to freeze the ice cream mixture when it is being made, which means there is less air in it. Because the ice cream mixture has less air, it doesn't puff up like normal ice cream, and can be made into these tiny round "dots."

Tie in, or allude to ice cream station, depending on whether they've been there already.

3. Wrap-up: Sharing Experiences and Building Connections 4 Minutes

So today we explored the three states of matter (what are they again?) and the transformations that can occur between them. What transformations did you observe today? (solid to gas, liquid to solid, liquid to gas, etc). What changed in the objects you saw undergoing these transformations? Why do you think these changes occurred? How did we force the changes in matter? (extreme temperature, etc). Did anything surprise you as you watched and learned about these transformations? Can you think of any other transformations between states of matter that we see or experience every day?

4. Close: 1 Minutes

Thanks so much for letting us come and share with you today!

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.

Ice Cream Mix Recipe

Mix together ahead of time and then refrigerate until it's time to make:

- 1 lb strawberries
- 3/4 cup sugar
- 3/4 tsp fresh lemon juice
- 1/8 tsp salt
- 2 cups heavy cream

Prepare by mashing strawberries with sugar, lemon juice, and salt for 5-10 min, then blend together with cream

States of Matter: Sublime Suds and Ice Cream Science!

Fill in the blanks using words from the Word Bank.

When a **solid** turns into a **liquid** it is _____.

When a **liquid** turns into a **gas** it is _____.

When a **gas** turns into a **liquid** it is _____.

When a **liquid** turns into a **solid** it is _____.

Word Bank

- freezing
- melting
- condensing
- boiling/evaporating
- sublimating

BONUS: When a **solid** turns into a **gas**, without becoming a liquid first, it is _____.

For each activity in today's presentation by the scientists, circle the state changes that you observed from the lists below.

Sublime Suds	Liquid Nitrogen	Ice Cream Science
Freezing	Freezing	Freezing
Melting	Melting	Melting
Condensing	Condensing	Condensing
Boiling/Evaporating	Boiling/Evaporating	Boiling/Evaporating
Sublimating	Sublimating	Sublimating

Follow-up – After Presentation

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
- Ice Cream by Jules Older – Filled with cartoon-like illustrations and fun facts, this informative book explains all about ice cream: how people used to make it before ice cream factories and refrigeration, and how we make ice cream today. http://www.amazon.com/exec/obidos/ASIN/0881061123/qid=1015653756/sr=1-1/ref=sr_1_1/103-0688263-4257414
- Ice Cream Treats: The Inside Scoop by Paul Fleisher – In this book, you can learn all about them. Find out what ice cream is made of and read about the history of ice cream. Then, take a trip to the ice cream factory to watch treats being made! Meet the factory workers and learn about the machines that turn milk, cream, and sugar into a batch of newly packaged ice cream bars. The book includes recipes so that you can make your own ice cream at home. http://www.amazon.com/Ice-Cream-Treats-Inside-Carolrhoda/dp/1575052687
- 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

Make ice cream without liquid nitrogen (see next page):
http://teachnet.com/lessonplans/science/plastic-bag-ice-cream-recipe/

Make Ice Cream in a Plastic Bag

(Source: http://teachnet.com/lessonplans/science/plastic-bag-ice-cream-recipe/)

Yes, it sounds dangerous and the potential for messes seems highly likely, but you'll be surprised at the good, "clean" fun you'll enjoy with your students when you make ice cream. The key to success is to plan smart and follow our simple instructions. The lesson possibilities for this one are nearly endless. Your class can explore the history of ice cream and dairy products, the chemistry of ice, salt and exothermic reactions, or use it an exercise in the scientific method: what if you make the following recipe without salt?

This recipe is enough for one student, so that each student can make their own.

1/2 cup milk
1/2 teaspoon vanilla
1 tablespoon sugar
4 cups crushed ice
4 tablespoons salt
2 quart size Zip-loc bags
1 gallon size Zip-loc freezer bag
a hand towel or gloves to keep fingers from freezing as well!

Mix the milk, vanilla and sugar together in one of the quart size bags. Seal tightly, allowing as little air to remain in the bag as possible. Too much air left inside may force the bag open during shaking. Place this bag inside the other quart size bag, again leaving as little air inside as possible and sealing well. By double-bagging, the risk of salt and ice leaking into the ice cream is minimized. Put the two bags inside the gallon size bag and fill the bag with ice, then sprinkle salt on top. Again let all the air escape and seal the bag. Wrap the bag in the towel or put your gloves on, and shake and massage the bag, making sure the ice surrounds the cream mixture. Five to eight minutes is adequate time for the mixture to freeze into ice cream.

Tips

Freezer bags work best because they are thicker and less likely to develop small holes, allowing the bags to leak. You can get away with using regular Zip-loc bags for the smaller quart sizes, because you are double-bagging. Especially if you plan to do this indoors, we strongly recommend using gallon size freezer bags.

Coffee Can Ice Cream

An alternative to the baggie method is to use coffee cans. The recipe is the same, and may be doubled or tripled because the coffee can can hold more liquid than the baggies. Put the mixture in a standard size coffee can and seal with the plastic lid, then place that can inside a larger "economy size" can (usually available from the teachers' lounge or office). Pack the large can with ice and salt, and seal with the lid. Students can roll the can back and forth on the ground (outside – the condensation will drip) until the ice cream is set. The time required to set the mixture will vary depending on the number of servings in the can.

What does the salt do?
Just like we use salt on icy roads in the winter, salt mixed with ice in this case also causes the ice to melt. When salt comes into contact with ice, the freezing point of the ice is lowered. Water will normally freeze at 32 degrees F. A 10% salt solution freezes at 20 degrees F, and a 20% solution freezes at 2 degrees F. By lowering the temperature at which ice is frozen, we are able to create an environment in which the milk mixture can freeze at a temperature below 32 degrees F into ice cream.

Who invented ice cream?
Legend has it that the Roman emperor, Nero, discovered ice cream. Runners brought snow from the mountains to make the first ice cream. In 1846, Nancy Johnson invented the hand-cranked ice cream churn and ice cream surged in popularity. Then, in 1904, ice cream cones were invented at the St. Louis World Exposition. An ice cream vendor ran out of dishes and improvised by rolling up some waffles to make cones.