Bay Area Scientists in Schools Presentation Plan

Lesson Name How to Think Like a Scientist
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Grade Level 5 **Standards Connection(s)** Physical science: During chemical reactions atoms rearrange into different products with different properties.

Next Generation Science Standards:

MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Science & Engineering Practices	*Disciplinary Core Ideas*	*Crosscutting Concepts*
Developing and Using Models Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. Develop a model to describe unobservable mechanisms. (**MS-PS1-5**) **Analyzing and Interpreting Data** Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. Analyze and interpret data to determine similarities and differences in findings. (**MS-PS1-2**) **Connections to Nature of Science Scientific Knowledge is Based on Empirical Evidence** Science knowledge is based upon logical and conceptual connections between evidence and explanations. (**MS-PS1-2**)	**PS1.A: Structure and Properties of Matter** Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (**MS-PS1-2**) (Note: This Disciplinary Core Idea is also addressed by MS-PS1-3.) **PS1.B: Chemical Reactions** Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (**MS-PS1-2**), (**MS-PS1-5**) (Note: This Disciplinary Core Idea is also addressed by MS-PS1-3.) The total number of each type of atom is conserved, and thus the mass does not change. (**MS-PS1-5**) Some chemical reactions release energy, others store energy. (**MS-PS1-6**)	**Patterns** Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (**MS-PS1-2**) **Energy and Matter** Matter is conserved because atoms are conserved in physical and chemical processes. (**MS-PS1-5**)

Common Core Standards:
ELA/Literacy:
RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Mathematics:
MP.2 Reason abstractly and quantitatively.
MP.5 Use appropriate tools strategically.
MP.4 Model with mathematics.

FOSS Connections:
Middle School Module: Chemical Interactions Course

Abstract:
Your opportunity to tell teachers and kids what's going to be fun and interesting about your visit!

The way scientists develop hypotheses, design experiments, interpret results, and try to solve new problems will be illustrated through a series of demonstrations showcasing different chemical reactions and physical phenomena. Students will learn to think like scientists to build hypotheses based on their chemical intuition and draw conclusions based on observation of chemical and physical properties.

Activity 1: The presenters will react three different alkali earth metals with water. After two experiments, students will be asked to describe what they observed. Following a brief introduction of reactivity trends in the periodic table, students will be asked to predict the results of the third experiment and subsequently explain their observations in light of the relative reactivity of the three metals.

Discussion 1: Students will be introduced to the scientific method and will discuss how it was applied to the previous experiment.

Activity 2: The presenters will demonstrate how an acid or base can affect the color of an indicator. Students will be asked to describe how a control experiment can help an experimenter interpret results. The class will then design and implement an experiment to determine whether several common household products are acids or bases and then interpret the results of those experiments based on appropriate controls.

Discussion 2: Students will be asked to describe their use of the scientific method in identifying the unknowns and to explain how control experiments were particularly important in the interpretation of their results.

Activity 3: The presenters will briefly describe the concept of paper chromatography, and the method will be used to solve a crime caper. Student detectives will be given a ransom note as a clue and asked design an experiment to identify which suspect holds the guilty pen.

Discussion 3: Students will discuss how one discovery can be applied to solve new problems.

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

- **Scientific Method**: the steps taken by scientists to gain information by making observations, forming a hypothesis, conducting experiments, and interpreting their results
- **Hypothesis**: a tentative explanation that can be tested
- **Experiment**: a test used to prove or disprove a hypothesis

- **Control**: an experiment with a known outcome that is used to interpret other experimental results
- **Result**: the outcome of an experiment
- **Conclusion**: an interpretation of experimental results

Materials:
What you'll bring with you
- Chemicals (sodium, lithium, potassium, hexanes for washing, and isopropyl alcohol to clean spills)
- Glassware
- Safety goggles
- Lab Coat
- Lab Gloves
- Cabbage juice indicator
- Household acids (e.g. lemon juice, vinegar)
- Household bases (e.g. ammonia, baking soda)
- Clear plastic cups or test tubes with rack
- Pasteur pipets
- Plastic funnel
- Periodic table
- Different brands of pens with the same color ink
- Filter paper, one with ransom note
- Chromatography reservoirs
- Candy reward (check with teacher—class rules or allergies)

What students should have ready (pencils, paper, scissors)
- Paper and pencil

Classroom Set-up:
Student grouping, Power/Water, A/V, Light/Dark, set-up/clean-up time needed
- Overhead projector
- Chalkboard or dry erase board at front of room
- Table or work area in front of room
- Water for experiments and clean-up
- Five minutes to set up and clean up

Classroom Visit

1. **Personal Introduction:** ______3_____ Minutes

Who are you? What do you want to share with students and why? How will you connect this with students' interests?
We're a group of students from UC Berkeley who study the chemistry of cells. Your body is made up of trillions of cells that can do amazing things. For example, you can leave a bag of sugar in a room for millions of years and nothing will happen to it. However, if you take the same bag of sugar and feed it to your cells, they can convert it to energy in no time. To understand the complicated chemistry that goes on in the cell, we have to ask complicated questions. We use a technique called the scientific method to help answer these questions.

2. **Topic Introduction:** _______3______ Minutes

Big Idea(s), vocabulary, assessing prior knowledge. What questions will you ask to learn from students?
Today we're hoping to give you a taste of our lives in the lab by teaching you how to think like a scientist.
Every day, we try to answer complicated questions using a method of trial and error. This method is called the scientific method. You've probably used it a lot already without even realizing it. For example, what happens when you eat ice cream too fast or drink a cold slushy really quickly? You get "brain-freeze." How do you know that eating cold food really fast causes this? Well, you've probably eaten hot foods really fast or cold foods more slowly and not experienced the same effect. Through this process of trial and error, you've learned when "brain-freeze" occurs and how to avoid it. We're also going to talk about how we design and interpret experiments and how we use our discoveries to solve new problems.

Right now, we're going to perform a demonstration for you involving a few different chemicals. Pay close attention to what happens. Afterwards, we're going to talk about what you saw and how the scientific method was at work.

3. **Learning Experience(s):** ______35-40__ Minutes
Demonstrations, hands-on activities, images, games, discussion, writing, measuring… What will you do, what will kids do? Describe in order, including instructions to kids.

Activity 1: <u>Using the scientific method to test trends in chemical reactivity</u>. The presenters will react three different alkali earth metals (lithium, sodium, and potassium) with water in order of increasing reactivity. Students will first observe that lithium produces a smaller reaction than sodium, and will be asked to make a hypothesis about how potassium will react. It will be the biggest reaction of the three. Why? Certain elements are more reactive than others. What does this mean? (Refer to the periodic table.) Elements are grouped by the number of free electrons they have. You can think of electrons as the hands of elements. Electrons prefer to hold hands with each other. Elements with an odd number of electrons are more likely to react, or hold hands, with one another. Elements in the first column of the periodic table have one free electron, so they are very reactive. As you go down the column, the elements become bigger and more reactive. Lithium (Li), sodium (Na), and potassium (K) are all in the first column of the periodic table. Based on their order in the column, which is the most reactive element of the three? (Potassium is more reactive than sodium, which is more reactive than lithium.) This was our <u>hypothesis</u> (define on the board). We used an <u>experiment</u> to test this hypothesis (define on board). We observed that potassium produced a bigger bang than sodium, which produced a bigger bang than lithium. This was the <u>result</u> of our experiment (define on board). Based on this result, we can conclude that our hypothesis was correct. This is our <u>conclusion</u> (define on board).   These terms are all used to define the <u>scientific method</u> (define on board). In the next activity, we will take a closer look at how to use the scientific method.

Activity 2: <u>Using the scientific method to identify unknown acids or bases</u>. What are some properties of acids? (Taste sour, associated with citrus fruits, low pH.) What about bases? (Taste bitter, associated with detergents and soaps, high pH.) When doing chemistry, it's often helpful to know whether a chemical is acidic or basic. One way you can do this is by using a special liquid called an indicator that changes color when mixed with acids or bases.

Today, we're going to use an indicator made from cabbage leaves to figure out whether some unknown materials you might find around your house are acidic or basic. You can make this indicator at home by placing a purple cabbage leaf in a plastic bag with water and squishing it around until the water turns purple.

First, we see that when we add an unknown liquid (either acid or base) to our indicator, it changes color. But we can't explain what this color change means unless we first perform a control experiment (define on board). If we take a liquid that we know is an acid, the indicator turns pink, but when we add a known base, and the indicator turns a bluish green. Now we have our controls in place and can use the scientific method to figure out whether our unknowns are acidic or basic. (Come up with a hypothesis.) The class will vote on whether it thinks each household material is an acid or a base. To test this hypothesis, we need to design an experiment. Does anyone have any suggestions? (Add unknowns to indicator, observe color change, record results, and derive a conclusion. Students will observe that the unknowns turn the indicator different colors because they are not all acidic.) One student at a time will add each unknown to the indicator and observe the color change, and the results will be recorded on the board. At the end of the experiment, we will analyze our results using the control experiments to make a conclusion about whether each item was an acid or a base. It's okay that, in some cases, our initial hypotheses may have been incorrect. Because our experiment was well designed, we were able to make a final conclusion anyway.

Activity 3: Designing an experiment using paper chromatography to solve a crime. The ink in every pen is made up of a bunch of different molecules. Since the different molecules have unique properties, water will carry them up a piece of filter paper at different speeds and separate the components in a process known as chromatography. Even if two different kinds of pen contain the same color ink, the actual mixture of molecules may be different. When separated by chromatography, the ink from each kind of pen will show a unique pattern; just like every single one of you has a different fingerprint.

We're going to use this method of chromatography to solve a crime committed right here in this room! The basket of candy we brought was stolen, and our only clue is this ransom note (conveniently written near the bottom of a piece of filter paper). We have seven suspects from the class, each of whom was given one of seven black pens at the beginning of the demonstration. We know that the guilty party has the same pen that wrote the ransom note, but how can we identify the thief?

We could chromatograph the ransom note in a tray of water. Then, samples of ink from all seven pens could also be chromatographed on the same kind of paper. The pattern of separated inks from the ransom note will match only the sample from the guilty pen. By analyzing our evidence, the culprit (the teacher) can be brought to justice, and the class full of detectives can earn their sweet reward!

4. **Wrap-up: Sharing Experiences** ______8______ Minutes

Putting the pieces together – how will students share learning, interpret experience, build vocabulary?

-Summarize the steps of the scientific method (refer to vocabulary on the board)
-Emphasize the application of the scientific method in science and how it leads to new discoveries (tie in classroom activities like the identification of unknown acids and figuring out how atoms will react relative to other kinds of atoms)
-Explain how both new discoveries and the application of discoveries to other problems further scientific understanding and drive technological development.
-Encourage students to try using the scientific method on their own, either when thinking about things in the classroom or in daily life

5. **Close & Connections:** ______5______ Minutes

How can kids learn more? Thanks and good-bye! Clean-up.
If you are interested in learning more about the scientific method, here are some websites you can check out:
http://www.pages.drexel.edu/~bcb25/scimeth/intro1.htm

http://www.sciencebuddies.org/mentoring/project_scientific_method.shtml
http://www.biology4kids.com/files/studies_scimethod.html

You should also feel free to email us with questions!

TOTAL 50 – 60 Minutes

Differentiated Instruction:

English Learners: Repeat directions, if necessary, and physically model how to perform experiments. Write vocabulary words 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: Have students think of/write down other scenarios where they could use the scientific method.

Follow-up Possibilities

ELA Activity:
Write a letter summarizing the steps of the scientific method and give a specific example of how you've used it (or could use it) to answer a question.

Mathematics Activity:
Have students record and graph the pH of common household materials.

Other: