Bay Area Scientists in Schools Presentation Plan

Lesson Name Gak! The science of combining substances
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Grade Level 3rd **Standards Connection(s)** Energy and matter have multiple forms and can be changed from one form to another

Current California Standards
PS-1.g. Students know that when two or more substance are combined, a new substance may be formed with properties that are different from those of the original materials.
I&E5a. Repeat observations to improve accuracy.
I&E5b. Differentiate evidence from opinion.
I&E5c. Use numerical data in describing and comparing objects, events, and measurements.
I&E5d. Predict the outcome of an investigation and compare the result with the prediction.
I&E5e. Collect data and analyze them to develop a conclusion.

Next Generation Science Standards
3-5-ETS1 Engineering Design
3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Science and Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. • Ask questions that can be investigated based on patterns such as cause and effect relationships. (3-PS2-3) • Define a simple problem that can be solved through the development of a new or improved object or tool. (3-PS2-4) **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds	[note: core ideas relevant to 3rd grade physical sciences shift to Stability & Motion under NGSS]	**Patterns** • Patterns of change can be used to make predictions. (3-PS2-2) **Cause and Effect** • Cause and effect relationships are routinely identified. (3-PS2-1) • Cause and effect relationships are routinely identified, tested, and used to explain change. (3-PS2-3) ---------- **Connections to Engineering, Technology, and Applications of Science** Interdependence of Science, Engineering, and Technology • Scientific discoveries about the natural world can often lead to new and improved technologies, which

on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-PS2-1) • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (3-PS2-2) **Connections to Nature of Science** Science Knowledge is Based on Empirical Evidence • Science findings are based on recognizing patterns. (3-PS2-2) Scientific Investigations Use a Variety of Methods • Science investigations use a variety of methods, tools, and techniques. (3-PS2-1)		are developed through the engineering design process. (3-PS2-4)

Common Core Connections:

ELA/Literacy –

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect

RI.3.8 Describe the logical connection between particular sentences and paragraphs in a text (e.g., comparison, cause/effect, first/second/third in a sequence).

W.3.7 Conduct short research projects that build knowledge about a topic.

W.3.8 Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.

SL.3.3 Ask and answer questions about information from a speaker, offering appropriate elaboration and detail.

Mathematics –

MP.2 Reason abstractly and quantitatively.

MP.5 Use appropriate tools strategically.

3.MD.A.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.

FOSS Connections
3rd grade: Matter. Students work with different states of matter, measure mass and volume using metric standards and tools, and solve problems using their knowledge of metric measurement. They develop a set of defining characteristics for states of mater. They read about the difference between opinion and evidence.

Teaser: New scientists! You are given the task of making the best Gak. The head scientists have come up with two recipes but they need your help to find the best one. Using concepts of engineering and science, together we will explore the new materials and learn methods to test for which one has the best properties.

Objective: *As a result of your lesson, what will students learn? What will they be able to do?*
Exploring materials and testing them for applications. Combining materials can produce materials of new properties

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

- Chemical Reaction - when atoms rearrange, causing one or more substances to change into one or more new substances with different properties
- Property – characteristics of a substance (e.g., color, taste, smell, mass, attraction to a magnet)
- Elasticity – how easily a material returns to its original shape after being stretched or bent
- Stiffness – how hard it is to stretch a material
- Shape Memory/Retention – how well an object holds its shape

Materials:
What will you bring with you?

- Glue,
- Borax,
- Paper towels,
- Cups,
- Spoons,
- Water,
- Worksheets,
- rulers,
- paper,
- trash bags,
- goo gone,
- Ziploc bags

What should students have ready?
Pencils

Classroom Set-up: *Student grouping, Power/Water, A/V, Light/Dark, set-up/clean-up time needed*
Students in groups of 4: each group will receive two different gak formulations. Kids need to wash their hands after the experiments.

Classroom Visit

1. **Personal Introduction:** ____5____ **Minutes**

   Hi! We are scientists from UC Berkeley. We study polymers and fluid dynamics. Polymers are chemical things made from long chains of the same molecules. Plastics, for example are polymers. Fluid dynamics is how fluids (like water for example) move!

   Topic Introduction: ____10____ **Minutes**

   Scientists and engineers think a lot about the properties of the materials we're working with. Who can tell me what the word "property" means? What are some examples of properties? (e.g. Physical properties: color, texture, odor, mass, conducts heat, conducts electricity, magnetic, floats or sinks in water, solubility. Chemical properties: burns, rusts, reacts with acids…) *Hold up a classroom object, such as a pencil, and ask the students to identify some of its properties. As students name properties, write them on the board.* How do the properties of a pencil make it right for the job of writing? It's a solid, it's a good size and shape for holding, it leaves a mark on paper. These are all important properties. Some of the other properties – like color – are interesting, but are not as important. The outside color of a pencil doesn't affect how well suited it is to writing.

   Who here has ever played with Gak? What were some of its properties? What did you use it for? What did you like about it?

   As one or more people are explaining Gak properties, have one or more volunteers prepare premeasured cups filled with materials. For each group of 4 prepare:

   1. *Two cups of glue, one with blue food coloring*
   2. *Two cups of Borax solution (label with 'B')*
   3. *One cup of water (label with 'W')*
   4. *Other supplies: paper towels, two spoons, two rulers, worksheets*

   What are the important properties of Gak that make it "Gak-y"? Do you think it should be stretchy, bouncy, etc.? Should it hold its shape? There are 3 properties of Gak that are especially important: *Write vocab words on the board.*

   - One is called **elasticity**. Has anyone heard the word "elasticity" before? Or a word like it? What do you think it means? "Elasticity" is a lot like the word "elastic" – when you bend or stretch a material with high elasticity goes back to its original shape easily, just like how when you stretch a piece of elastic it goes back to its original shape right away. (Silly Bandz have high elasticity!)
   - Another is called **stiffness**. You might have head this word before – can anyone guess what stiffness is? Stiffness is how hard it is to stretch a material. What are some things in the room that are hard to stretch? These are all high in stiffness.
   - The third important property of Gak is called **shape retention**. Can anyone guess what this means? Shape retention means how well an object holds its shape. Solids – like pennies –

are usually very good at holding their shape. Have you ever seen a penny change shape on its own? Liquids, on the other hand, are not very good at holding their shape. What happens if I pour water from a cylindrical (round) cup into a square container? It takes the shape of the container.

Today you are going to be engineers - you will make 2 different types of Gak and compare their properties! We have two different recipes for Gak, and we need to figure out which Gak is highest in elasticity, which is highest in stiffness, and which is highest in shape retention.

Safety:

- Don't eat borax/glue
- Gak will stick to clothing and carpet: BE CAREFUL!

Hand out materials to groups of 4. Start by telling kids you're going to pass out some very fun-looking materials, but they cannot touch them until you say go. You can have them repeat: when do you touch them? "After you say go!" Divide groups into pairs and have one pair prepare the BLUE Gak and the other pair prepare the WHITE Gak. Instruct pairs to take the following supplies. BLUE Gak supplies: 1 cup BLUE glue, 1 cup water, 1 cup Borax solutions. WHITE Gak supplies: 1 cup white glue, 1 cup Borax solution. The BLUE glue is colored blue, just to remind us that that's the one that gets the water.

2. Learning Experience(s): __30____ Minutes

Next, we'll demonstrate up here how to make the Gak while you make Gak in your groups with the materials we provide. Follow along with us while we mix our materials together… wait until I say go! We'll need to mix three substances: glue, water, and a powder called "Borax." (Or two if the Borax is pre-dissolved in water.) Notice how carefully we're measuring the amount of each substance. It's very important for you to measure carefully today because we want to be able to compare two different recipes that use three different measurements. It's just like baking: you want to follow the recipe so your cookies turn out delicious!
Also notice that we're being careful not to spill or drop our substances. Scientists need to make sure they don't damage the room they're working on – or themselves. We never eat any parts of our experiments, and we try never to spill them.

Questions and thoughts to bring up during making of Gak: What do you notice as we're mixing the gak ingredients together? Has anyone heard of a chemical reaction? What happens in a chemical reaction? In a **chemical reaction**, one or more substances change into one or more new substances because the tiny little bits that make up both substances, called ATOMS, are rearranging to make something new – and that new thing has different ***properties***! Remember what we said properties were? As you're making the gaks, think about the properties of the starting materials (glue, Borax, water) and the properties of the gak. Decide whether you think a chemical reaction is occurring. Why or why not?

First, the BLUE Gak pairs will make their gak along with me as I demonstrate. White Gak pairs watch carefully, because you'll be next! Pour all the water from the water cup into the BLUE glue. This is going to dilute the glue, which makes it less glue-y/sticky, and more liquidy. Mix up really well until everything looks uniform. Next, have one person slow pour in all the Borax solution while the other partner continuously stirs with the spoon. Be sure to stir very, very well until the gak is not sticky. You may need to mix with your hands in the cup.

Now the WHITE Gak people will make their gak along with me as I demonstrate. We will not pour water into the glue to dilute it. We will just pour Borax solution directly into our glue. Have one person slow pour in all the Borax solution while the other partner continuously stirs with the spoon. Be sure to stir very, very well until the gak is not sticky. You may need to mix with your hands in the cup. Blue gak pairs, watch carefully to see if the chemical reaction I made looks different from the one you made!

If your Gak is still sticky after you mix it very well, we will come by with more Borax solution.

First, use teacher's technique (or one of your own) to get the class's FULL attention – all hands away from the Gak and in laps (you can make it a little funny – e.g., "alright now that I've got your attention, everyone put their hands up in the air! Everyone! Good! Now… put those hands in your laps! Aha! Perfect. Those hands need to stay PUT on your lap until I say it's time to start the next part of our activity."

Now, we will test the properties of elasticity, stiffness and shape retention of the two Gaks that each group has made. Does everybody remember what those three properties mean? Who can tell me what elasticity/stiffness/shape retention means, and give me an example? *Demonstrate each test, one at a time. Then give students 5 minutes to perform each test on both Gaks and record their results before moving onto the next test. Gak can be divided in half so each student or pair can perform their own tests.*

- **Bounce:** Drop the Gak from the same height and see if they bounce. Record which Gak bounces the highest and possibly measure the approximate height with the ruler.
  More Explanation: When the rubber ball hits the ground it gets compressed, or squished, and because it is very elastic, it quickly returns to its original shape. When it does this, it pushes back on the ground shoots back up into the air.
- **Stretch:** Slowly pull the Gak into a rope until it snaps and measure how long each rope could get before breaking.
  More Explanation: A high stiffness material changes its shape only slightly under loading (pulling). A low stiffness or flexible material changes its shape considerably under the same loading (pulling).
- **Shape retention:** Roll the Gak into a ball observe how well/long it keeps its round shape. Stop counting once the bottom of the ball begins to flatten out.

Have them write down their findings on their data sheets, and then write the results on a table pre-drawn by us on the board. Go over the results (i.e. "Thumbs up if the BLUE Gak

bounced the highest"), discuss the repeatability between groups. Ask them whether or not it makes a difference when different people perform the same experiment.

3. Wrap-up: Sharing Experiences **___10___ Minutes**

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

- Ask for a volunteer or take a classroom poll by raising thumbs/hands to yes/no questions:
  - Who had a favorite Gak? Why?
  - Relate answers to vocabulary words.
- Go over how we mixed things together, tested them, and saw which one gave the best Gak using elasticity, stiffness, shape retention vocabulary words.
- Ask if they think a chemical reaction occurred. Why or why not?
- Give an engineering example of a similar application (e.g. shoe rubber, compare that to elasticity)

4. Connections & Close: **__5___ Minutes**

What else might kids relate this to from their real-life experience? How can they learn more? Thanks and good-bye! Clean-up.

- Talk about processes and applications like baking, comparing shoe rubber vs. rubber band rubber, where similar concepts are applied.
- Mention examples of fields they could work on where they could optimize properties for materials (e.g. rubber for shoes of basketball players, car bumpers).

Total 60 Minutes

Follow-up – After Presentation

Suggest students write a letter explaining "How we learned about Gak!"

What's Happening?

from California Science Center:
http://www.californiasciencecenter.org/FunLab/DoItYourself/Gak/GlobbyGooeyGak.pdf

Q. Why does Gak stretch, even though glue and Borax don't?
A. Mixing materials can cause a chemical reaction. The chemical reaction creates a new material (in this case Gak) different from the two original materials.

Q. How does the chemical reaction work?
A. Glue is made up of long, spaghetti-like molecules that sometimes get tangled together. That's why glue doesn't flow fast like water. Borax reacts with the glue to loosely tie the long molecules together. The molecules of the new material, Gak, look more like a poorly woven rug than a plate of spaghetti. The new material feels and looks different from what you started out with.

Q. Can we find substances like Gak in everyday products?
A. Like the plastic used to make soda bottles or the nylon fabric of a windbreaker, Gak is a kind of polymer—a type of chemical we use in our daily lives. Can you think of a way we could use Gak?