Be a Chemist!

Educator Guide

GSK Science in the Summer™

In partnership with The Franklin Institute
Acknowledgements

Authors: Rachel Castro-Diephouse, Tara Cox, Julia Skolnik, Andrea Foster

Designers: Kelli Cavanaugh, Barbara Chotiner

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Host Organizations: Thank you to the many organizations who host and support GSK Science in the Summer™ programs across the country. GSK Science in the Summer™ reaches thousands of children each summer thanks to your ongoing commitment and invaluable contributions.
Program Goals

The goal of GSK Science in the Summer™ is to increase children's value of and confidence in doing science and pursuing STEM careers, especially for traditionally underrepresented populations in STEM fields including racial/ethnic minorities, low socioeconomic status populations, girls, and low-resourced rural and urban communities. The program aims to do this by providing opportunities for students to:

**Embody science careers.**
Role-play and imagination are important ways that children practice skills and learn to identify with adult careers and occupations. GSK Science in the Summer™ activities invite students to take on the role of different scientists by framing each activity with a storyline that provides real-world context for the phenomena they are investigating through that career.

**Practice authentic science techniques.**
Through role-playing science careers, students engage with authentic science tools and practice laboratory techniques, from measuring and pipetting to collecting and recording data.

**Have fun.**
The GSK Science in the Summer™ program focuses on creating memorable, engaging science experiences, rather than mastering new science knowledge. Creating moments of excitement and connections to students' everyday experience helps build positive attitudes and confidence in science and STEM careers.

**Think scientifically.**
The program's activities encourage students to recognize and develop scientific practices such as asking questions, making observations and predictions, and drawing evidence-based conclusions.
Key Strategies

An important way to build students’ positive attitudes and confidence in doing science is to engage them in experiences that pique curiosity, spark excitement, and help them see themselves as scientists. Use the following strategies to create these experiences in your sessions:

Let children experience science, don’t explain it.

A key goal of this summer program is for students to experience and explore science phenomena in a fun and hands-on way, not to deeply understand the concepts behind them. Whenever possible, invite students to do science rather than hear about it. Avoid providing the “right” answers or giving long explanations of science content. Use the Core Four strategies (see p. 6) to encourage students to ask questions, investigate, and build their own understanding. Focus on and highlight examples of students’ perseverance and creativity, rather than successful results. This models the process of actual scientific research, which is all about discovering answers and explanations that are not yet known!

Reflect on STEM skills and careers.

Use the reflection period at the end of each session to help students make intentional connections between their own actions and the careers they modeled. Provide sufficient time for children to draw or write their reflections in their lab notebooks, and encourage them to be thoughtful in choosing skills stickers that align with their work during the activities.

Adapt to children’s interests.

Modify activities flexibly wherever possible to adapt to students’ questions and interests. If students are excited about a particular activity and wish to extend it, encourage them to do so, even if it means shortening another activity. If children have their own questions or ideas that can be explored with the available materials, invite them to investigate.

Characterize children as scientists.

Maintain each role-play story and students’ roles as scientists consistently throughout each activity to strengthen students’ connections to the careers and science context. Use consistent language that supports the story and highlights connections between children’s actions and science practices: refer to the group as a “research team,” the students as “scientists,” their workspace as the “research lab,” and close the activity with a “research team meeting” that connects the results of their investigations with the larger context of the role-play story.

Engage all children equitably.

Make an effort to ensure that all students feel welcomed and included in the activities. Learn children’s names and use them consistently. Be intentional in choosing students of different genders and racial or ethnic backgrounds to answer questions and assist with tasks, especially those who are not always first to volunteer.
Be a Chemist!

The Be a Chemist! program invites children to play the role of chemists and discover the importance of chemistry in fields as varied as medicine, manufacturing, art, and environmental conservation. The sessions encourage students to practice scientific techniques and explore basic principles of chemistry as they investigate these questions:

- How do substances change and interact with each other?
- How do chemists use these changes and interactions to solve real-world problems?

This curriculum is intended to be presented in two two-hour sessions. Each session is designed to serve a group of approximately 20 children at the same level—either Level 1 (grades 2–3) or Level 2 (grades 4–6)—but materials can be modified to accommodate slightly larger or smaller groups.

The program is designed with the following structure, which can be adapted based on the needs and interests of your group:

**Session 1: Get a Reaction! (2 hours)**
Explore how medicinal chemists and materials chemists use chemical reactions to create new products.

**Session 2: Change It Up! (2 hours)**
Discover how chemists observe and make changes to chemical systems to solve problems like cleaning polluted waterways and inventing new paint colors.

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**Important Safety Notice**

GSK has adopted a set of mandatory safety standards for its programs, one of which requires that eye protection be worn in all laboratories. Therefore, *GSK Science in the Summer*™ provides program participants with safety glasses. A goggle icon will appear next to each activity that requires the use of safety glasses. Please enforce student use of safety glasses when noted in this guide. Where the goggle icon does not appear, wearing them is optional. Use your discretion.

Closed-toed shoes are strongly recommended for all sessions.
Ask Questions
Encourage Scientific Thinking
Cultivate Rich Dialogue
Make Connections
Core Four Strategies
For Building Science and Literacy Skills

1. Ask Questions

Ask questions when exploring science concepts to deepen children’s thinking and engagement.

Why:
• Questions bring out children’s natural curiosity, motivating them to explore and learn.
• Questions allow children to express their ideas through language.

How:
• Ask open-ended questions—questions with multiple possible responses—to help children explain their thinking. Examples: What do you notice? Why do you think that?
• Ask closed-ended questions—questions with one or a few possible responses—to guide children toward a particular area of focus. Examples: What color is the mixture now? Is that liquid acidic or basic? Often follow up with an open-ended question: Why do you think that? How can you tell?

2. Encourage Scientific Thinking

Encourage children to think scientifically by observing, asking questions, making predictions, testing their ideas, and learning from repeated attempts.

Why:
• These practices strengthen critical thinking skills that are crucial for science learning and practice.
• Focusing on the process of science rather than a specific product or outcome frees children to explore and take risks.

How:
• During science explorations, point out occasions when people notice things, guess what will happen, test a new idea, or learn from something that didn’t work.
• Model scientific thinking yourself. If you don’t know the answer to a child’s question, respond with: I don’t know! Let’s find out together!

*Provide opportunities for children to learn new vocabulary words, use them in different contexts, and have meaningful conversations while learning together.*

**Why:**
- Literacy skills develop when children use language in relevant contexts, such as everyday science concepts. Similarly, science learning requires language through describing, questioning, and communicating ideas.
- Rich dialogue during learning allows people to explore new concepts together, and strengthen their ability to express their ideas.

**How:**
- Define and use key vocabulary during the explorations.
- Encourage children to connect their ideas and discoveries back to words and concepts from earlier discussions.
- Encourage children and their caregivers to explain their ideas to each other during their explorations.

4. Make Connections

*Connect learning experiences to children’s everyday lives and interests to make the learning more meaningful and memorable.*

**Why:**
- People understand new information better, and are more motivated to learn, when the topic is connected to their own experiences.
- Highlighting how children behave like scientists during their explorations can help them see themselves as scientists, and potentially increase their future interest in science careers.

**How:**
- Draw connections between children’s everyday experiences and the science activities and science concepts by asking children about their experiences relating to the topic; for example: *Where have you seen something like this before? What kinds of things do you mix together at home?*
- Encourage children to reflect on the ways they were scientists during the workshop. Ask questions like *How did you feel like a scientist today?* or *What did you do today that was like what a chemist does?*
- Introduce children to science role models who reflect their race, ethnicity, gender, and/or cultural background, either in person or through books, photos, articles, or credible websites.
About Chemistry

This section provides some basic information about chemistry, as well as key highlights that appear in each session.

The word “chemistry” often conjures up images of bubbling test tubes, hazardous substances, and complicated formulas; however, chemistry encompasses much more than explosive reactions or color-changing liquids. Chemistry is, simply, the “study of stuff”: the study of the structure and properties of substances and the ways they change and interact with each other. In other words, chemistry explores the following questions:

- What different kinds of “stuff” make up the world? How are they alike and different?
- How do they change? What happens when they are mixed together?
- How can we use them to make new things?

Chemistry is present in nearly every aspect of our daily lives. It explains how soaps clean our dishes and hands, why permanent inks don’t run, and how baking powder makes a cake rise. It made possible the invention of the batteries in our mobile phones, the purification of our drinking water, and the pain-relievers we take for fevers or headaches. Chemists use their understanding of how substances change and interact to solve problems in a wide variety of fields, from creating new medicines, materials, and products to protecting Earth’s ecosystems, solving crimes, or conserving historic artifacts.

Key Ideas

All substances in our world are chemicals, or mixtures of chemicals.

A chemical is simply a substance made of atoms in a particular arrangement. Water, for example, is a chemical made up of two hydrogen atoms connected to an oxygen atom (H₂O). Milk, on the other hand, is a mixture of many different chemicals—water, fats, calcium, proteins, and sugars—each of which has a different structure or arrangement of atoms. Chemists use a system of rules for naming chemicals that describes how the atoms in the chemical are arranged. Many chemicals that we use in our lives have everyday names, but they have chemical names also; for example, the chemical name for baking soda is sodium bicarbonate.

Substances have properties that we can observe and measure.

A property is a feature of the substance that is consistent; in other words, any sample of the substance will have the same feature under the same conditions. These properties are connected to how the atoms of the substance are arranged. Some of these properties we can sense directly, such as color, texture, or smell. Other properties, such as boiling temperature, acidity, or magnetism, cannot be sensed directly, so chemists use tools (such as thermometers) or indirect methods to measure these properties. Understanding the properties of substances, and how they change under different conditions, helps chemists to identify new substances and consider the purposes for which they could be used.

When substances are combined they may interact in different ways: remaining separate, mixing together, or reacting to form a new substance.

How the substances interact depends on the properties and structure of the chemicals involved. Some combinations of substances will remain separate and unchanged (for example, a rock placed in water); some combinations will mix together (such as food coloring in water); and some combinations will react to change or create new substances (such as baking soda and vinegar producing bubbles of gas). Chemists study and use these interactions to create new substances and mixtures as well as to separate desired substances from mixtures of unwanted materials.
**Be a Chemist!**

**Session 1: Get a Reaction!**

How can chemical reactions help us create new products?

How can we control what happens to get the product we want?

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### MATERIALS FOR SESSION 1:

- Medicinal Chemist and Materials Chemist career cards
- Chart paper and markers
- 2-gallon bucket with lid (for liquid waste)
- Meeting Room/Research Lab signs (see Printable Resources)
- Safety poster
- Safety goggles (1 per student)
- Student lab notebooks (1 per student)
- Science skills stickers (1 sheet per student)
- Pencils (1 per student)
- Chemist nametags (1 per student)
- Quart-size plastic containers (5)
- Water rinse bottles (5)
- Clear packing tape
- 100 mL graduated cylinders (1 per 2 students + 3 additional)
- Trays (1 per student + 1 additional)
- Baking soda
- Cream of tartar
- Citric acid
- Powdered sugar
- Distilled white vinegar
- Water
- Baby oil
- Liquid dish soap
- 4 oz. clear cups with lids (1 per student + 18 additional)
- Small wooden craft sticks (1 per student + 18 additional)
- Stirring rods (3)
- Antacid tablets (1 tablet per 3–4 students)
- Well plates (1 per student)
- Pipettes (25)
- 1 L plastic reagent bottles (3)
- 100 mL plastic reagent bottles (25)
- 2" x 4" labels (52)
- Borax
- White school glue
- Cornstarch
- Large bottles of food coloring: red, yellow, blue
- Dropper bottles (15)
- Small paper cups (3–5 per student)
- 1-cup plastic containers with lids (10)
- Plastic spoons (10)
- Rulers (1 per group of 4 students)
- Snack-size ziplock bags (1 per student)
- Five examples of stretchy polymer toys: putty, stretchy toy, sticky slime, fluffy slime, stretchy slime
- (Optional) Slime formula card (see Printable Resources)
Preparation

1. Print out printable resources on p. 56 paper or cardstock.
2. **Choose “Meeting Room” and “Research Lab” spaces**: Post the signs to designate one area of your space (such as a rug, clear floor area, or circle of chairs) to be the group’s “meeting room” where you will gather for group brainstorming and discussions. Designate a separate area (such as tables or desks) as the “research lab” where students will perform experiments and tests. If your space does not permit having separate areas, post one sign at a time in your space, and switch signs as you move through the sections of the activity.
4. Prepare vinegar and citric acid solutions for “Medicine Makers” (see p. 18). Fill and label reagent containers.
5. Prepare borax solution for “Slime Specialists” (see p. 25). Fill and label containers.
6. Fill rinse bottles with water.

Clean-Up

1. Collect liquid waste in the waste bucket during each activity.
2. All liquids and solutions in the waste bucket may be safely washed down the drain, diluted well with water.
3. Rinse well plates, graduated cylinders, trays, and pipettes thoroughly with water and dry with a paper towel to clean them. Soap should only be necessary for containers that held baby oil or glue.
4. Plastic cups, containers, and spoons should be cleaned with water and reused.
5. Containers, bottles, pipettes, and scoops from reagent sets can be reused and refilled when needed. They do not need to be emptied or cleaned after each session unless they become contaminated with other reagents (for example, if a pipette is used for the wrong liquid).
6. Solid glue-borax slime can be disposed of in the trash.
7. To remove slime from fabric or other surfaces, add vinegar to liquefy the slime; then remove with soap and warm water.

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**RECOMMENDED SCHEDULE:**

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INTRODUCTION

Time: 10 minutes

Summary: Students learn about GSK Science in the Summer™, safety guidelines, and the theme of Be a Chemist!

MATERIALS
- Meeting Room/Research Lab signs
- Safety poster
- Safety goggles (1 per student)
- Student lab notebooks (1 per student)
- Pencils (1 per student)
- Chemist nametags (1 per student)
- Markers

Welcome

1. Gather the group in the Meeting Room part of your space. As students join, ask them to write their name on their chemist nametag and wear it in a visible place on their shirt. Introduce yourself and welcome your “chemists” to the program. Explain that GSK Science in the Summer™ comes from The Franklin Institute, a science museum in Philadelphia, and from GSK, a place where scientists work to research and create products for people’s health. Explain that the goals of this program are to have fun doing science together and to experience the roles of real scientists.

2. Orient the group to their surroundings, establish any rules necessary for appropriate use of the space, and provide a brief overview of the schedule including any opportunities for breaks, snacks, etc.

Theme

1. Introduce the title of the program, Be a Chemist, and invite students to share their ideas about chemistry or chemicals:

   ▶ What do you think of when you hear the words “chemistry” or “chemical”?
   ▶ What kinds of things do you think chemists might do?
   ▶ Have you heard of different types of chemists?

2. Explain that they will have the chance to try out being different kinds of chemists in this program. Use some of the students’ responses to the previous questions to highlight some of what they will do, for example:

   - Use chemicals
   - Mix things together
   - Solve problems
   - Do experiments—try things to see what happens

Chemists study different kinds of substances or materials in the world and how they interact with each other. A chemist might:

- Create a new substance
- Find out what an unknown substance is made of
- Study how a substance changes in different conditions
Safety

1. Point out that chemists, like all scientists, need to keep themselves safe while they work.
   - What parts of their bodies do you think chemists need to protect?
   - What could we do to protect that part?

2. As they come up in the discussion, point out the safety precautions students will be using during the program. Bring up any that are not suggested by students:
   - **Eyes**—wear safety goggles when directed
   - **Nose**—waft scents toward nose instead of smelling directly into the container
   - **Mouth**—do not eat or put any substances in the mouth unless specifically told it is safe
   - **Hands**—wear gloves when directed

3. Refer to the safety poster for additional safety guidelines.

4. Distribute safety goggles to the students. Show them how to vent the goggles and adjust the straps to fit comfortably.

5. Introduce the group to the Meeting Room and Research Lab spaces and explain the role of each. Ask them to think about which space is likely to be “goggles-on” and which might be “goggles-off.”

6. Distribute lab notebooks. Point out that it is important for chemists to keep notes about their work and reflect on their experiences. Explain that students will use the lab notebooks to record the results of their experiments and think about how they were like chemists.
**Prepare**

Prepare the following **before the start of the session**, so that students do not see which substances are added to which container:

1. Fill one of the 2-oz. cups with powdered sugar (sucrose). Fill a second cup with baking soda (sodium bicarbonate). In the third cup, mix together equal parts baking soda and cream of tartar (sodium bitartrate). Label the cups with letters as follows. Once the cups have been filled and labeled, they may be stored and re-used for multiple sessions.
   - Sugar: A
   - Baking soda: B
   - Baking soda/cream of tartar: C

2. Fill one graduated cylinder about half-full of baby oil. Fill the second cylinder about half-full of water. Fill the third slightly less than half-full of water and add a generous squirt of dish soap to bring the liquid level up to half-full (or roughly equal to the other two). Label the cylinders with numbers as follows:
   - Plain water: 1
   - Baby oil: 2
   - Water/soap: 3

3. Arrange the cylinders and containers on the tray in the following order:
   - Plain water cylinder (1) with sugar container (A)
   - Baby oil cylinder (2) with baking soda container (B)
   - Water/soap cylinder (3) with baking soda/cream of tartar container (C)

**Note:** Do not label the cylinders or containers with the names of the substances. Instead use numbers and letters (as listed above) to help you keep track of them.
Engage

1. Gather the group together in your Meeting Room. (If you are using the same space for both “areas,” be sure to use the sign and highlight that you are “entering the Meeting Room.”) Explain that each session will begin with “Lab Prep”—a time to practice some science skills that all chemists need in order to do their jobs—to help the group be ready to work in the Research Lab later on.

2. Remind students that one thing they identified that chemists do is mix things together. Invite them to make connections to their own experiences of mixing:
   - What are some things that you like to mix together?
   - What happens when you mix them?
   - Can you think of a time when you mixed things together and they didn’t do what you expected?

3. Highlight examples from student responses of the types of things substances do when mixed, such as:
   - Change color
   - Change texture—get thicker, thinner, lumpier, etc.
   - Dissolve or “disappear”
   - Sink or float but not mix together
   - Make something new—bubbles, foam, clumps of solid

Explore

1. Explain that studying what happens when different things are mixed together is an important part of being a chemist. Point out that to do that, chemists need some important science skills:
   - Observing: using our five senses to notice details
   - Describing: using words or pictures to explain what we observe
   - Predicting: guessing what will happen

2. Show the group the tray with the cylinders and containers and invite students to "warm up their chemist brains" by making some observations about the substances on the tray.
   - What do you notice about the things on this tray?
   - How would you describe the substances in the containers?
   - How do the substances look similar or different to each other?

3. Next ask the group to think about what will happen if you mix the substances together. Point out the first pair (A + 1) and encourage scientific thinking by inviting students to predict what will happen if you add the powder to the liquid.
   - What do you think will happen?
   - What will it look like?
   - What makes you think so?
4. Use the end of a wooden craft stick to add a scoop of the sugar to the graduated cylinder and stir gently with a stirring rod. **Ask questions** that encourage the group to observe and describe the results.
   - **What do you observe about how the powder and the liquid combined?**
   - **What changed, and what stayed the same?**
   - **How would you describe what it looks like now?**
   - **How is it similar to or different from what you predicted?**

5. Ask students to make predictions about the second pair of substances (B + 2). Add a scoop of the baking soda to the cylinder, stir, and invite them to observe and describe the results.
   - **What do you notice about how these two substances combined?**
   - **How is it the same or different from the first set?**

6. Repeat with the third pair (C + 3). Be sure to keep the cylinder on the tray, as the foamy reaction may overflow the cylinder!
   - **What did you observe this time?**
   - **How did it change?**
   - **Where do you think the foam and bubbles came from?**

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**Reflect**

1. **Cultivate rich dialogue** by encouraging the group to reflect on their observations and draw conclusions:
   - Based on our observations, do you think the powders are all the same?
     - What makes you think that?
   - What about the liquids?
   - What was different about the ways the three different combinations behaved?
   - What other things have you mixed or seen before that:
     - Mix together like #1?
     - Stay separate like #2?
     - React like #3 to create bubbles or something else new and different?
Things to Avoid

Experience it, don't explain it! It is not necessary to reveal what the substances are, explain why the combinations behaved differently, or correct inaccuracies in students' conclusions. The goal of the lab prep and reflection is to practice the skills of identifying similarities, differences, and patterns, and drawing conclusions based on available evidence, not develop deep knowledge about the chemical properties of the substances.

Background

Some properties of substances, like color, texture, or state (solid/liquid/gas) we can observe directly with our senses. Many other properties we cannot sense directly, which means that substances that look alike can behave very differently. The three pairs of substances in this activity all looked very similar: a clear liquid and a white, powdery solid. However, the chemical properties of each were different, leading to different results when they were mixed:

Sugar dissolves in water. The sugar molecules are attracted to the water molecules, so the visible sugar crystals begin to break apart and eventually disappear as the individual sugar and water molecules mingle.

Baking soda does not dissolve in baby oil. Baking soda molecules are not attracted to oil molecules, so the baking soda remains clumped together, separate from the oil, and does not “disappear” as the sugar particles did.

Baking soda, cream of tartar, and water create a chemical reaction. Baking soda and cream of tartar react, with the help of water, to create a new substance: carbon dioxide gas. The added soap traps the bubbles of gas to create a foam.

Chemists describe and define many different ways that substances can interact when combined—such as solution, suspension, decomposition, and combustion—but in general they all fall into one of three main categories:

Mix: All the particles of one substance are mingled with the particles of another substance, but the particles stay the same. Dissolving sugar in water or combining nuts, chocolate, and raisins to make trail mix are examples of mixing.

Separate: All the particles of each substance stay clumped together with each other. This can happen because the properties of the substances keep them from interacting in the first place, like oil and water, or a plastic bag floating on the ocean. It can also happen if something happens to a mixture to “un-mix” it, like picking all the chocolate out of the trail mix or letting the sugar water sit until all the water evaporates into the air and the sugar is left behind.

React: The atoms or molecules of the substances combine or change to create something different. Examples of reactions include: baking soda and cream of tartar interacting in water to create bubbles of carbon dioxide gas, glue and borax combining to make slime, or wood burning in a campfire (combining with oxygen in the air to produce heat, light, soot, carbon dioxide, and assorted other byproducts).
**MEDICINE MAKERS**

**Time:** 30–40 minutes

**Summary:** Students model the actions of medicinal chemists as they create a mixture that mimics the action of an antacid tablet.

**Driving Question:** How can observing the properties of a mixture help us know if a chemical reaction is occurring?

**MATERIALS**
- Medicinal Chemist career card
- Antacid tablets (1 tablet per 3–4 students)
- 4 oz. clear cups with lids (1 per student + 15 additional)
- Well plates (1 per student)
- Pipettes (15)
- Baking soda (sodium bicarbonate)
- Powdered sugar (sucrose)
- Cream of tartar (sodium bitartrate)
- Distilled white vinegar
- Citric acid
- Water
- 1 L plastic reagent bottles (2)
- 100 mL plastic reagent bottles (15)
- Trays (1 per student)
- Graduated cylinders (1 per 4 students)
- Liquid dishwashing soap
- 2” x 4” labels (32)
- Permanent marker
- Clear packing tape
- Small craft sticks (15)
- Safety goggles (1 per student)
- Student lab notebooks
- Pencils
- Quart-size containers for liquid waste (1 per table)
- Rinse bottles (1 per table)

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**Prepare**

1. Prepare the vinegar and citric acid solutions:
   - Mix 500 mL of vinegar with 500 mL water in a 1 L bottle. Label the bottle “50% vinegar solution.”
   - Add 1/3 cup (about 80 mL) of citric acid powder to a 1 L bottle and fill with water. Stir or swirl the bottle gently until the citric acid is dissolved. Label the bottle “citric acid solution.”
   - Once prepared, these stock solutions are stable at room temperature and can be used to refill student containers as needed.

2. Fill and label five sets of reagents (one set per group of four students):
   - Fill one 4 oz. cup with each of the three powders and label each with the chemical name (not the common name) and a letter as follows:
     - Baking soda: “sodium bicarbonate (A)”
     - Cream of tartar: “potassium bitartrate (B)”
     - Powdered sugar: “sucrose (C)”
• Fill a 100 mL bottle with each of the three liquids and label each with its chemical name and a number:
  Water: “dihydrogen monoxide (1)"
  Vinegar: “acetic acid solution (2)"
  Citric acid: “citric acid solution (3)"
• Cover the labels on the bottles and containers with a layer of clear packing tape to protect them against spills.
• Use permanent marker to label a pipette for each liquid bottle with the corresponding number (1, 2, or 3).
• Use permanent marker to label a craft stick for each powder container with the corresponding letter (A, B, or C). On the opposite end, mark a line about 0.5 cm (a little less than ¼ in.) from the end.
• Once prepared, the containers, scoops, and pipettes can be refilled and/or reused for multiple sessions.

3. Set up lab stations for each student in the Research Lab area with a tray and pair of goggles. Put out a liquid waste container and rinse bottle for each table group of four lab stations. (If you are using the same space for both “areas,” keep the materials ready but out of the way until it is time to enter the Research Lab.)

Safety
Both the vinegar and citric acid solutions can be mildly irritating to skin and eyes. Students should wear goggles during the “Explore” section of the activity and wash their hands when finished.

Engage
1. In your Meeting Room area, introduce the Medicinal Chemist career by showing the group the career card and asking questions to encourage students to think about what a medicinal chemist might do.
   ▶ What do you notice about this picture? What do you think the person is doing?
   ▶ Where do you see chemicals in this picture? Where do you see science tools?
   ▶ What does the name “medicinal chemist” make you think of?
   ▶ What do you think a medicinal chemist does? What makes you think that?
   ▶ What else do you think a medicinal chemist might do in a day at their job?
2. Explain that for the next activity, students will be medicinal chemists. Introduce the storyline like this:
   We are a team of medicinal chemists who work for a company that makes medicines.
   Our team has been assigned to try to create a new antacid medicine like this one [show a package of antacid tablets].
   ▶ Have you ever seen or heard of this kind of medicine before? What does it do?
   ▶ What can you guess from its name: “ant”-“acid”?
   Our process will have three steps:
   Research: Make some observations about this antacid to see what it looks like and how it works.
   Prototype: Try out some different combinations of chemicals to find a combination that behaves like this antacid does.
   Scale up and test: Decide how much of each ingredient to use, and use a test to determine whether our formula works like this antacid tablet does.
   Let’s head to our Research Lab and start making some observations!
Explore

Gather the group in your Research Lab area. (If you are using the same space for both areas, make it clear to students that you are switching “areas” by changing the sign and drawing their attention to it.) Assign each student to a lab station with a tray for their work area. Ask students to put on their safety goggles and have their lab notebooks ready.

Research

1. Ask students to put on their safety goggles. Distribute one antacid tablet for every four students. Invite each group to pass the tablet around, make observations about it, and write or draw them in their lab notebook.
2. Point out that the instructions on the antacid package say to add the tablet to a glass of water. Encourage scientific thinking by asking students to make predictions about what will happen when the tablet is added to water and share why they think that.
3. Invite each group to break their tablet into pieces, one piece for each person. Fill 4 oz. cups about half full of water and distribute one to each student. Encourage students to add their piece of tablet to the water, observe the results, and add them to their lab notebooks on p. 3.
4. Cultivate rich dialogue by asking the group to describe their observations.
   - What do you notice about how the antacid behaves in water?
   - What could we do to figure out how to make our medicine work like this one?
5. Synthesize student responses to summarize the group’s goal for the prototyping phase, for example:
   - The antacid mixes with water and slowly dissolves away to create a bubbly liquid.
   - For our medicine to work the same way, we need to find a combination of chemicals that will create a bubbly liquid.

Tools and Techniques

1. Distribute the reagent sets to each table. Ask students what tools they see for measuring or adding chemicals. Explain that when mixing chemicals, chemists need to be careful about how much they measure, and how they add it, so that things don’t get mixed together that shouldn’t.
2. Demonstrate the proper techniques for transferring materials for students:
   - All materials and containers should remain on your lab station (tray) while in use.
   - Put the powder container on your lab station. Dip the end of the scoop in the powder up to the line and lift up gently so there is a pile of powder on the end that covers the tip from the line to the end. Hold it steady until ready to add to the new container. Make sure the end of the scoop does not touch the surface of the mixture while dumping the powder into it. Return the scoop to the correct container and put the container back where others can reach it.
   - Put the liquid bottle on your lab station. Squeeze the pipette bulb all the way before putting it in the liquid. Release the bulb while the tip is in the liquid. Squeeze the bulb gently to add just a drop at a time to your mixture. Make sure the tip of the pipette does not touch the surface of the mixture while adding the liquid. Return the pipette to the container and put it back where others can reach it.
   - Highlight the importance of using each scoop or pipette only for its own substance, putting it immediately back in the container, and not mixing them up or using them for stirring.
   - Why do you think that might be important?
   - What might happen if a pipette was used for two different liquids?
3. Ask students to practice using the scoops and pipettes at their tables by filling and emptying them back into the original container. Some students will start with the powders and some with the liquids and then switch. Challenge them to practice good technique by not touching the surface as they empty (even though in this case it doesn’t matter).
Prototyping

1. Explain that the group is now in the prototyping phase of developing the medicine. In this step, they will try mixing different combinations of chemicals to see if any combinations will produce a bubbling liquid like the antacid.

2. Introduce the well plates and demonstrate how to add a scoop of powder or some drops of liquid to a well.

3. Encourage scientific thinking by inviting students to think about how they will design their experiment.
   - How many substances will you mix at a time?
   - If you mix three or four together, how will you know which ones made the reaction?
   - The substances look alike. How will you keep track of which combinations are in each well?

4. Ask students to find p. 3 in their lab notebooks. Point out that there is one square in the grid for each well plate.
   - How could you use this to help you keep track of your combinations?
   - What information do you think you’ll need to write in the square?
   If it doesn’t arise from student ideas, suggest that they could put the letters or numbers of the substances in the box (for example “A + 2”) and then write or draw the results they observe.

5. Encourage students to begin testing different combinations of substances and record their results. As they work, ask questions to encourage observation, prediction, and experimentation.
   - How do the combinations in those two wells look the same, and how are they different?
   - Have you tried each of the powders with each of the liquids? How can you tell?
   - What other kinds of combinations could you try?
   - What do you think will happen if you mix those three substances together? What makes you think that?

Scale-up and Testing

1. While the students are working, prepare a graduated cylinder for the Foam Test by adding a generous squirt of soap and filling to the 30 mL mark with water. Place it on a tray.

2. Explain that the next part of creating a medicine is to figure out the dose—how much of each substance is needed for the medicine to work. If it doesn’t create enough bubbles, it won’t make the person feel better; if it creates too many bubbles, it could make their stomach feel worse! Point out that this is the scaling-up part of the process, where they decide how much of each material to use.
   - How could we find out what is the right amount of bubbles?
   - How could we compare our medicine to the antacid tablet to see if it makes the same amount?

3. Make connections by reminding the group of the cylinder from the warm-up activity that foamed. Explain that they will use a cylinder like that for a Foam Test. Demonstrate by adding half an antacid tablet to the cylinder with the soap. (Keep the cylinder on the tray to catch any foam that overflows.)
   - How much foam did the antacid tablet make?
   - How could we use a test like this to see if our formulas make the same amount of bubbles?
4. Point out that this will be the **testing** part of the process. Help the group agree on a testing procedure based on their ideas; for example:

- Add the test formula's ingredients to a cylinder with a foaming agent.
- If the foam at least reaches the top of the cylinder, the test is successful and the formula has created enough bubbles.

5. **Cultivate rich dialogue** by asking each group of four chemists to decide as a team on a formula to test, including which substances to combine and how many scoops or pipettes of each to add.

6. While they are discussing, prepare a “foam test cylinder” for each group by adding a generous squirt of dish soap to a graduated cylinder and filling to the 30 mL mark with water. When each group has decided on a formula, provide a foam test cylinder and invite them to test their formula. Remind them that the **cylinder must remain on a lab station (tray)** to catch any overflow.

7. **Encourage scientific thinking** by inviting students to notice changes and try new things if they are stuck. Focus on and highlight examples of their perseverance and creativity, rather than just successful results.
   - *Did your formula do what you expected it would? How can you tell?*
   - *Even if it didn't work, what did you learn from it? What could you change for the next test?*
   - *That was a creative idea! What made you decide to try that formula?*

8. Allow groups to adapt and retest their formulas as long as time permits. After each test, they should empty the cylinder into the waste bucket and rinse it with the rinse bottle before adding fresh soap and water for the next test.

**Reflect**

1. Gather the group in the Meeting Room area for a “research team meeting.” Explain that the team needs to share the results of their research with other teams in the company who will work on making their best formulas into a tablet or liquid that people can use. **Cultivate rich dialogue** by asking students to share their results with a neighbor, or with the whole group.
   - *What formulas did you find that worked?*
   - *What did you try that didn't work?*
   - *How did you decide on your final formula?*
   - *Do you think your formula will be safe for people to take? What makes you think that?*

2. Reveal to the group that many substances have more than one name—a chemical name and an everyday name—just like people might have a full name and a nickname that’s easier to use. Explain that many of the substances they tested have two names, and the everyday names are things they may recognize. Hold up containers of each as you reveal their everyday names:
   - Sodium bicarbonate: baking soda
   - Sucrose: sugar (powdered in this case, but table sugar is also sucrose)
   - Potassium bitartrate: cream of tartar (used in baking)
   - Acetic acid: vinegar
   - Citric acid: no common name, but it comes from citrus fruits like oranges and lemons and is what makes them taste sour
   - Dihydrogen monoxide: water

3. **Make connections** by asking about students’ experiences with these substances, and by connecting their ideas to the medicinal chemist storyline:
   - *Where have you seen or used sugar or baking soda before? What about vinegar?*
   - *What do you think now about whether your formula is safe for people? What makes you think that?*
   - *What formula(s) shall we recommend to the next team to start turning into medicines?*
Things to Avoid

1. **Experience it, don't explain it!** It is not necessary to tell students which combinations to try, or in what order. **Ask questions** to help them think about their process, like *Are there any combinations you haven't tried yet?* or *What about mixing two liquids, instead of a liquid and a powder?*, but allow them to choose and explore their own ideas, even if it doesn't lead them to a perfect result.

2. Students may be tempted to mix many substances together at once, or to try several combinations and forget what they added to each. Encourage them to practice careful scientific technique by testing just two substances at a time and writing the combination in the matching grid square in their lab notebook so they will remember what is in each well plate later.

Adapt and Extend

**Level 1 students may need more time and assistance with practicing the pipetting and scooping techniques than Level 2 students.**

1. For Level 1 groups, you could simplify the experiment in one of the following ways:
   - Omit the potassium bitartrate and citric acid so there are four substances to test instead of six.
   - Scaffold the testing by having students start with the three powders and just one of the liquids; then introduce the other liquids one at a time.

2. For Level 2 groups, you could add the following components:
   - Encourage students to devise a systematic plan to ensure they test all the possible combinations, for example: test one powder with each of the three liquids, then test the next powder in the same way, etc.
   - Add a level of complexity to the Foam Test by asking students to fine-tune their formula so that it makes just enough bubbles, but not too many. Challenge them to control the reaction so the foam just reaches the top of the cylinder but does not overflow.
   - Extend the activity by having students identify an "unknown" powder. Explain that you've found a container of one of the three powders in the lab but don’t know which one it is. Challenge them to find a way to identify which powder it is using the materials they have at their lab stations. (Baking soda is a good choice for a first unknown as it is the simplest for students to identify. However, any of the three powders can be distinguished based on how they react with different combinations of the other reagents. Baking soda bubbles with either of the acids, but the other two powders will not. Cream of tartar will bubble if mixed with baking soda and water, but sugar will not.)

3. **Movement activity (especially for Level 1):** Have the group model the behavior of the three mixtures from the "Lab Prep" activity: mixing, separating, and reacting. Designate half the group to be "powder" particles and have them place their hands on their hips. The remaining students are "liquid" particles and keep their arms free. Ask them to spread out and arrange themselves to show what mixing looks like (individual "liquid" and "powder" students are mingled together throughout the group). Remind them of the second cylinder that didn’t mix and invite them to show what separating looks like (all the "liquid" students group together and all the "powder" students group together). To demonstrate the third cylinder, have them "react" by each "liquid" student linking an arm through the arm of a "powder" student and making bubbling noises to indicate the bubbles formed in the reaction. Once they have seen the three actions, do one of both of the following:
   - Challenge them to do the action of the word you call (mix, separate, or react) as quickly as they can. Call out the three words in random order, getting faster and faster as you go. Anyone who does an incorrect action or is the last person in place each round is out.
   - Divide the group in half. Assign each group a combination of substances they tested in the "Medicine Makers" activity, using either the names or the letters/numbers (for example: A + 2). Challenge them to decide together which action represents how that combination reacted (using their lab notebooks for reference) and arrange themselves accordingly. The first group to get into position each time receives a point.
**Background**

**Medicinal chemists** use chemistry to study and create medicines. They might work on discovering new medicines to treat a particular disease or condition, improving the processes by which drugs are made, exploring the effects of different drugs on biological systems, or studying chemicals found in other living organisms to find out if they might have medicinal uses.

For more information, visit the American Chemical Society’s page for medicinal chemistry careers: https://www.acs.org/content/acs/en/careers/college-to-career/chemistry-careers/medicinal-chemistry.html

**Effervescent antacid tablets** contain a mixture of sodium bicarbonate (baking soda) and a powdered acid, like sodium citrate (a form of citric acid). Some also contain aspirin, a pain reliever. The bicarbonate and acid do not interact when dry, but in the presence of water, they react to create carbon dioxide gas (the same substance that makes the bubbles in carbonated drinks). The resulting solution acts as a chemical buffer that helps to neutralize excess stomach acid. There is also some research to suggest that the carbonation plays a role in reducing indigestion and constipation.

In this experiment, there are three acidic substances: citric acid, potassium bitartrate, and acetic acid (vinegar). Combining the baking soda with any of them will result in bubbles as long as water is present. Since the vinegar and citric acid are already dissolved in water, they will react immediately with the bicarbonate; the potassium bitartrate would need an addition of a third ingredient—dihydrogen monoxide (water)—in order to react.

Chemists use an agreed-upon system of rules for naming chemical substances in a way that describes the structure of the atoms or molecules from which they are made. These names are important for identifying individual substances and noting similarities or differences between them. All substances have chemical names, but for many materials we use in our daily lives, we have other names that are easier to use. In a similar way, a person has a full legal name that identifies them individually, but they might use a nickname or just their first name on a daily basis. It is important to highlight that a substance with a long “chemical”-sounding name isn’t necessarily harmful or dangerous—it just may not have an everyday name.

*Note: Chemists do not actually refer to water as dihydrogen monoxide: however, that is one version of its chemical name under the naming system. It is used in this activity to help make the point that all substances are chemicals and can have chemical names.*
SLIME SPECIALISTS

Time: 30-40 minutes

Summary: Students model the actions of materials chemists as they create test formulas for a polymer slime.

Driving Question: How can the amounts and sequence of materials in a chemical reaction affect the properties of the product?

MATERIALS
- Materials Chemist career card
- Borax (sodium tetraborate)
- White school glue (polyvinyl acetate)
- Cornstarch (amylopectin)
- 1 L plastic reagent bottle
- Large bottles of food coloring: red, yellow, blue
- Dropper bottles (15)
- Small paper cups (3–5 per student)
- Pipettes (10)
- 100 mL reagent bottles for borax solution (10)
- 1-cup plastic containers with lids (10)
- 2" x 4" labels
- Permanent marker
- Plastic spoons (10)
- Small wooden craft sticks (1 per student)
- Rulers (1 per group of 4 students)
- Snack-size ziplock bags (1 per student)
- Five examples of stretchy polymer toys: putty, stretchy toy, fluffy slime, sticky slime, stretchy slime
- Trays (1 per student)
- Safety goggles (1 per student)
- Student lab notebooks
- Pencils
- Chart paper
- Markers
- (Optional) slime formula card (see Printable Resources)

Prepare

1. Prepare a saturated sodium tetraborate solution by adding approximately ¼-cup of borax to a 1 L bottle. Fill with warm water and stir until no more will dissolve. Some solid borax should remain at the bottom of the container. Label the bottle “borax solution.” Once prepared, the solution is stable and can be stored for future use.

2. Fill five dropper bottles with each of the three colors of food coloring.

3. Make five sets of reagents (one per group of four students):
   - Add borax solution to a 100 mL bottle and label the bottle with both the scientific and common name: “borax solution (sodium tetraborate).” Label a pipette with “Bo” for borax and place it in the bottle.
   - Add water to a 100 mL bottle and label it “water (dihydrogen monoxide).” Label a pipette with “W” for water and place it in the bottle.
   - Add glue to a 1 c. container and label it with both names: “glue (polyvinyl acetate).” Place a spoon in the container.
   - Add cornstarch to a 1 c. container and label it with both names: “cornstarch (amylopectin).” Place a spoon in the container.
   - Cover the labels on each bottle or container with a layer of clear packing tape to protect against spills.

   Once prepared, reagent bottles and containers can be stored and refilled for multiple sessions.
Safety
Solid borax may irritate the lungs if directly inhaled and can be a mild skin irritant, primarily if skin is exposed repeatedly over long periods. The diluted borax solution used in this experiment is highly unlikely to cause irritation, but students should wear safety goggles during the “Explore” section of the activity and wash their hands after finishing.

Engage
1. Gather the group in your Meeting Room area. Introduce the Materials Chemist career by showing them the career card and asking questions to encourage students to think about what a materials scientist might do.
   - What do you notice about this picture? What do you think the person is doing?
   - Where do you see chemicals in this picture? Where do you see science tools?
   - What does the name “materials chemist” make you think of?
   - What do you think a materials chemist does? What makes you think that?
   - What else do you think a materials chemist might do in a day at their job?
2. Explain that for the next activity students will be materials chemists. Introduce the storyline like this:
   Now we are going to be a team of materials chemists who work for a toy company. The company would like to develop a new toy that is some kind of slime. We’ve been asked to research this material and make suggestions for slime formulas for different kinds of toys.
   - Where have you seen or encountered slime or other stretchy materials before?
   - What does it look and feel like? How does it behave?

Our development process will have several steps:
- **Research:** Observe different existing toys to discover how the materials behave and what makes them different.
- **Prototyping:** Make a first version of slime and see how it compares to the material we want to make.
- **Iteration:** Try different versions of the formula to get closer to the kind of material we want.
- **Scale-up:** Make a larger, final sample to present to the team.

Explore
Research
1. While still in the Meeting Room, divide the group into teams of four chemists. Explain that this will be the research part of the process, where they make observations about how different slime toys behave. Distribute one slime toy to each team. Cultivate rich dialogue by inviting students to discuss in their groups and describe the characteristics of their toy’s material.
   - What is its texture—wet, dry, slimy, rubbery?
   - How well does it hold its shape?
   - How far can you stretch it? Does it stay stretched, break, or bounce back?
2. As a group, compare the characteristics of each toy’s material. Identify criteria that a material would need to meet to be successful for each kind of toy and make a list on chart paper for each. For example:

- **Putty**: Smooth; stretches at least 40 cm; holds its shape for at least 30 seconds before oozing
- **Fluffy slime**: Soft and rubbery; stretches 10–20 cm before breaking
- **Sticky slime**: Wet; fills its container like a liquid; stretches at least 20 cm before breaking
- **Stretch toy**: Dry and sticky; stretches at least 30 cm and bounces back to original shape

3. Post the lists in a location that is visible from the Research Lab. Summarize the team’s lab assignment:
   - Each chemist can decide which type of toy they will try to make with their material. Their material should come as close as possible to matching the list of needs for their toy.
   - Students will need to determine what amounts of substances to mix and in what order to get the type of material they want.

**Tools and Techniques**

1. Move the group to the Research Lab. Ask students to put on safety goggles and find a lab station with a tray.

2. Distribute the reagent sets to each table. Ask students what tools they see for measuring or adding chemicals. Explain that when mixing chemicals, chemists need to be careful about how much they measure, and how they add it, so that substances are not accidently mixed at the wrong time or place.

3. Demonstrate or remind students about the proper techniques for transferring materials:
   - All materials and containers should remain on your lab station (tray) while in use.
   - Pipettes: Put the liquid bottle on your lab station. Squeeze the pipette bulb all the way before putting it in the liquid. Release the bulb while the tip is in the liquid. Squeeze the bulb gently to add just a drop at a time to your mixture. **Make sure the tip of the pipette does not touch the surface of the mixture** while adding the liquid. Return the pipette to the container and put it back where others can reach it.
   - Spoons: Put the container on your lab station. Scoop material out of the container and hold the spoon level. Gently shake or scrape off extra material until it is just level with the edge of the spoon. Empty the material into your container, **making sure the spoon does not touch the surface of the mixture**. Return the spoon to its container and put it back where others can reach it.

4. Invite students to practice measuring level spoonfuls with both the glue and the cornstarch by scooping and returning it to the same container. Remind them to practice careful lab technique by not touching the surface when emptying.
Prototyping

1. Explain that students will start with a sample formula as a prototype, to see how this compares to the type of material they want to make for the slime toy.

2. Briefly explain what each of the reagents is (for example, that borax is a detergent used for cleaning, cornstarch comes from corn and is used in cooking, etc.)

3. Ask them to look at p. 4 in their lab notebooks to find the sample formula. (Optional: hold up the slime formula card for students to see as you review the formula.) Review the formula with the group:
   - Add together one spoonful of glue and one spoonful of water and stir well.
   - Add one pipette-full of borax solution to the mixture and stir again.

4. Distribute paper cups and stirring sticks. Invite each student to make a slime sample using the formula in the lab notebook and following careful lab technique. As they work, encourage scientific thinking by asking them to make observations and predictions.
   - What do you notice about your mixture so far?
   - What do you think will happen when you add the borax? What makes you think that?
   - What do you notice about your mixture now? How is it different from what it was before?
   - How does your sample look similar to your neighbor’s sample? Are there any differences?

5. Cultivate rich dialogue by asking the group to compare their prototype to the lists of needs for each toy material.
   - Does this material meet the needs for any of the toys we described? What makes you think that?
   - How could we find out for sure?

6. Encourage scientific thinking by asking each team of four chemists to test the prototype and see how well it matches the needs of one of the toy materials. For example, one group compares it to the list of criteria the group identified for “slime,” another group compares it to the criteria for “putty,” etc. Distribute rulers as needed for testing stretch length. Invite teams to make observations and predictions, and draw conclusions based on their evidence.
   - What do you notice about this material’s texture?
   - How does it compare to our description of “putty”?
   - How far do you think this material will stretch? Do you think it will break or bounce back? What makes you think that?

7. Cultivate rich dialogue by asking each team to share their conclusions with the group.
   - How does this material match the needs for that toy?
   - Do you think this formula would be the best one for that toy? What makes you think that?
Iteration

1. Invite each student to choose one of the types of toy material to work on. Explain that the next part of the process is iteration: they will now try different versions of the formula and get closer to the kind of material they want to create.

2. Ask questions that help them think about how they might change the slime formula to make it closer to the material they are trying to make. Note: If they feel that the prototype already meets their criteria, challenge them to think about ways to make it even better.
   - What does your material need to do or look like that this slime doesn’t do?
   - Which ingredients do you think might affect how the slime stretches?
   - Might you add more or less of that ingredient? What makes you think so?
   - The cornstarch wasn’t part of the first formula. How do you think it might change the material?
   - What do you think would happen if you added the ingredients in a different order?

3. Encourage students to choose one thing to change about the formula and make a new sample using that formula. Remind them to record the formula they used in their lab notebooks on p. 5. Provide clean cups for the new samples. (Students can reuse the stirring sticks if they wipe off most of the slime residue first.)

4. Point out that students will need to keep track of their samples as they make new versions.
   - What will you do to keep track of which sample came from which recipe?
   - If it doesn’t arise from student ideas, you may want to suggest that students label the cups with numbers (“1” for the first prototype, “2” for the second, etc.) to help them keep track.

5. As students finish their samples, encourage scientific thinking by asking them to test the results against the material criteria to determine if the material is successful. Invite them to consider how they are similar or different, and what they might need to change in order to increase similarities. Remind them to record their formulas and the test results in their lab notebooks on p. 5.

6. Allow students to make second or third iterations on their formula as time permits. Encourage them to continue evaluating each result against the criteria they have chosen.
   - How does this version match what your material needs to do?
   - How could it be even closer or better?
   - What could you try changing to get that result?

Scale-up

1. Explain that it is time to make a larger sample to share with the rest of the research team. Encourage students to choose their formula that most closely matched their toy’s list of criteria and think about how to make a double-size sample.
   - How will you need to change your formula to make twice as much of it?

2. Distribute dropper bottles of food coloring and invite students to add color to their larger batch to show what it might look like as a finished toy. Remind them to use careful dropper technique when adding drops of color to their mixture by not letting the dropper touch their mixture.
   - When in your mixing process do you think you should add the color?
   - What makes you think that?

3. Provide each student with a ziplock bag to hold their finished sample. Write students’ names on their bags to avoid mix-ups.
Reflect

1. Ask the group to bring their finished samples (in securely zipped bags) and their lab notebooks to the Meeting Room for a research team meeting. Divide them into groups based on which type of toy material they tried to reproduce. Cultivate rich dialogue by asking them to compare and discuss the results of their research in their small groups.
   - How are your materials similar? Are there any differences between them?
   - How are your formulas similar or different to one another?

2. Ask a few students from each group to demonstrate how their slime stretches and explain how they arrived at their formula.
   - What formula did you use?
   - How did you get to your final formula? What did you try along the way?

3. Make connections between students’ work and the materials chemist storyline by thanking the research team for discovering different slime materials. Explain that their formulas will be sent to other teams at the toy company who will create names and packaging and figure out how to make large amounts in factories so that it can be sold in toy stores.
   - Which formulas should we recommend for each type of slime toy?

4. If time allows, consider inviting students to write their recommended formulas for each type of slime next to its list of needs on the chart paper.

Things to Avoid

1. Experience it, don’t explain it! It is not necessary to correct students if their initial ideas for how to change their formulas are inaccurate. Encourage them to test the idea and learn from the results. Ask questions to help them draw their own conclusions, such as, If adding more glue made it more stretchy instead of less, what could you try instead?

2. Students may be tempted to make multiple changes to their formulas at once. Highlight the idea that changing only one variable (one piece of the formula) at a time is an important science technique to make clear which change caused a particular effect.

3. Food coloring is strong and can stain fingers and surfaces if overused. Encourage students to practice careful technique and add just a few drops to their slime, rather than an entire dropper-full.

Adapt and Extend

Level 1 students may need more time and assistance than Level 2 students to practice the pipetting and scooping techniques.

1. How do we clean up slime? Challenge students to look for a way dissolve the slime in case it gets stuck in fabric or other materials. Invite them to test different reagents from the Medicine Makers activity by adding them to their slime samples in cups. If possible, provide scrap fabric for a second round of testing:
   - How does the slime change when each substance is added?
   - Are there any that make the slime more liquid? What do you think those substances might have in common?
   - Can you change the mixture back to solid after it has been liquefied?
   - What would you recommend as a method for cleaning slime out of clothing?
2. Movement activity (especially for Level 1): Model the chemical reaction, called **crosslinking**, that forms slime. Designate about ¼ of the group to be borax particles. The remaining students should form groups of two or three by linking arms; these are the glue (polyvinyl acetate) particles. The glue particles move freely around the play area. The borax particles try to freeze glue particles by tagging them. They then link one arm with the end of the glue group and lead the group in looking for a second glue group. Once the borax has connected with two glue groups, the entire group is “crosslinked” and frozen in place. Free borax particles can connect to the free ends of frozen glue groups as well as free ones. Play continues until all the glue groups are crosslinked or there are no free borax particles. Try playing with more or fewer borax particles and notice how it affects the final result.

**Background**

**Materials chemists** study the properties of substances in order to discover new materials and design materials with specific properties for a specific purpose. They might develop paints and coatings that are waterproof, reflective, or heat-absorbing, create materials for medical implants and tools that don’t harm human tissue, or discover new lightweight combinations of metals to build lighter, faster vehicles. While materials science incorporates many different disciplines, including physics and engineering, chemistry is a key component because the properties of a material are related to its chemical structure.

For more information, visit the American Chemical Society’s page on materials science careers: https://www.acs.org/content/acs/en/careers/college-to-career/chemistry-careers/materials-science.html

**Slime**: White glue is a mixture of water and polyvinyl acetate (PVA), which is a type of polymer—long, string-like molecules made up of shorter molecules joined together. (“Poly” means “many”, so PVA is made from many vinyl acetate molecules attached into a long chain.) In the glue solution, the long chains are free to move around and past each other.

When borax solution is added to the glue, the molecules of borate connect the long PVA chains, in effect “tangling” them together, in a reaction called **crosslinking**. This makes them less free to move around and changes the mixture from a liquid to a stiffer, more elastic material. The more borate ions that are present in the solution, the more crosslinking will occur, and the stiffer the substance will be.

The connections between the borate and PVA are relatively weak. Adding an acidic substance, like vinegar or citric acid, breaks the bonds and re-liquefies the glue.

**Cornstarch** is primarily made of a naturally occurring polymer called amylopectin, along with smaller amounts of a related polymer called amylose. Most green plants produce amylose and/or amylopectin as a form of energy storage. These polymers do not react chemically with borate or with PVA in the slime. Instead, the cornstarch particles become trapped in the tangle of crosslinked PVA chains, which makes the mixture stiffer and even more solid.
CLOSING REFLECTION

Time: 10 minutes

Summary: Students will connect the session’s activities with chemistry skills and careers.

MATERIALS

- Medicinal Chemist and Materials Chemist career cards
- Student lab notebooks
- Pencils
- Science skills stickers (1 sheet per student)

Reflect

1. Gather the group in your Meeting Room area. Remind the group that they started the session thinking about three different ways that substances can behave when added together. Cultivate rich dialogue by inviting students to share their experiences.
   - What are some times today when you saw materials react to make something new?
   - What are some times when you saw materials mix together, but not react?
   - What are some times when you saw materials separate or not mix?

2. Show the group the career cards. Ask questions to help the group reflect on their experiences being medicinal chemists and materials chemists in this session.
   - What are some things we did today when we were being medicinal chemists?
   - What kinds of science skills did we use? How did we think scientifically?
   - How do you think it might be like what a real medicinal chemist does?
   - What things did we do today when we were being materials chemists?
   - What kinds of science skills did we use? How did we think scientifically?
   - How do you think it might be like what a real materials chemist does?
   - What did you do today that made you feel like a chemist?

3. Give students time to write or draw their reflections in their lab notebooks. Invite them to choose two stickers that represent science skills they used and add them to the notebook. Encourage students to be thoughtful in their choice and make connections between the skills they chose and the careers they embodied.

4. Encourage students to share with their families about the kinds of chemists they were in this session and the types of research experiments they conducted in their laboratory. Show pages 12–13 in the student lab notebooks where they can explore more about these scientists and look up resources online with their families at home.

Hear from a variety of voices.
Invite a diverse mix of students to share their ideas.
What are some ways that substances can change?
How can we use those changes to solve real-world problems?

MATERIALS:

• Water Chemist and Color Chemist career cards
• 2-gallon liquid waste bucket
• Chemist nametags (1 per student)
• 4 oz. cups (3)
• pH test strips (60–75)
• Water
• pH chart (see Printable Resources)
• Trays (1 per student + 1 additional)
• Potting soil (approx. 1.5 cups)
• Vegetable oil (approx. 1.5 cups)
• Coffee filters
• Tissue paper
• Paper towels
• Cheesecloth
• Small funnels (1 per student)
• Plastic spoons (1 per student)
• Flat, 1 quart plastic containers with lids (5)
• Clear, 50 mL sample containers (2 per student)

• ¼ c. measuring cup (5)
• Liquid dish soap
• 1 L plastic reagent bottles (4)
• 50 mL plastic squeeze bottles (5)
• 100 mL plastic bottles (20)
• Washing soda (soda ash)
• Baking soda
• Distilled white vinegar
• Citric acid
• Pipettes (2 per student + 20 additional)
• Well plates (1 per student)
• Labels (24)
• Quart-size containers for liquid waste (5)
• Rinse bottles (5)
• Dried cochineal shells
  (3–4 shells per 4 students)
• Dried butterfly pea flowers
  (2–3 flowers per 4 students)
• Mortar and pestle sets
  (1 per 4 students)
• Toothpicks (1 per student)
• 8.5” x 11” watercolor paper
  (3 sheets per class)
• Student lab notebooks (from Session 1)
• Science skills stickers (from Session 1)
• Pencils (1 per student)
• (Optional) White paper (printer paper or one-sided scrap paper)
• (Optional) Photos of butterfly pea and cochineal insect (see Printable Resources)
• (Optional) Latex-free gloves for any students with dye allergies
RECOMMENDED SCHEDULE:

Lab Prep: Invisible Change page 35 15 minutes  
Water Watchers page 40 35 minutes  
Break 10 minutes  
Color Creators page 45 40 minutes  
Closing Reflection page 52 10 minutes

Preparation

1. Print out printable resources on p. 56 paper or card stock.  
2. Prepare materials for “Invisible Change” activity (see p. 35)  
3. Prepare vinegar, sodium carbonate, baking soda, and citric acid stock solutions (see p. 41)  
4. Prepare reagent sets for “Water Watchers” activity (see p. 41)  
5. Cut squares of test materials for “Water Watchers” activity (see p. 41)  
6. Cut strips of watercolor paper for “Color Creators” activity (see p. 46)

Clean-Up

1. Collect liquid waste in the waste bucket during each session.  
2. All liquids and solutions in the waste bucket may be safely washed down the drain, diluted well with water.  
3. Solid material such as soil and paper waste from the Water Watchers activity may be disposed of in the trash.  
4. Rinse well plates, graduated cylinders, trays and pipettes thoroughly with water to clean them. Soap should only be necessary for containers that held vegetable oil or potting soil.  
5. Plastic containers, sample cups, and spoons should be cleaned and reused.  
6. Containers, bottles, pipettes, and scoops from reagent sets can be reused and refilled when needed. They do not need to be emptied or cleaned after each session unless they become contaminated with other reagents (for example, if a pipette is used for the wrong liquid).
LAB PREP: INVISIBLE CHANGE

Time: 15 minutes

Summary: Students practice making observations and predictions about three clear liquids and as they explore the property of acidity.

Driving Question: How can we observe changes to a substance’s properties that we can’t see?

Prepare

Prepare the following before students arrive, so that they do not see what is added to each container:

1. Fill three clear cups to the same level with water. Add a generous squirt of vinegar solution to one cup. Add a generous squirt of sodium carbonate solution to a second cup. Test the cups with pH strips to make sure they show visibly different colors on the strips, and add more vinegar or sodium carbonate solution if necessary.

2. Place the cups on a tray in the following order: vinegar, plain water, sodium carbonate. You may want to label the cups with numbers to help you keep track of them. Place a new pH test strip near each cup.

Welcome

1. Gather the group in your Meeting Room area. As students arrive, ask them to write their name on their chemist nametag and wear it in a visible place on their shirt. Introduce yourself and welcome your “chemists” to the second session of the program.

2. Remind students about any rules necessary for appropriate use of the space, and provide a brief overview of the schedule including any opportunities for breaks, snacks, etc.

3. Review safety guidelines for using goggles, handling chemicals, etc.

Engage

1. Remind the group that the session will begin with “Lab Prep”: a time to practice some science skills that all chemists need in order to do their jobs, to help the group be ready to work in the Research Lab later on.

2. Review the main idea from Session 1: one part of chemistry is mixing substances together to make new products. Ask questions to help the group recall their experiences:

   ▶ What things did we mix together in that session?
   ▶ What new products did we try to make?

3. Introduce the main idea of Session 2: another part of chemistry is observing the properties of substances—what different substances are like—and noticing how they change. Observing changes helps chemists understand how a substance will behave under different conditions or figure out if a new product has been created.

MATERIALS

- Chemist nametags (1 per student)
- Markers
- 4 oz. clear cups (3)
- pH test strips (5–6)
- Water
- 100 mL bottle of 50% vinegar solution (from reagent sets for “Water Watchers” activity)
- 100 mL bottle of washing soda/sodium carbonate solution (from reagent sets for “Water Watchers” activity)
- pH chart (see Printable Resources)
- Tray
- An object from the room to make observations about, such as a roll of tape
4. Make connections to students' own experiences of noticing properties and change. Use the example of an object in the room, such as a roll of tape, to focus their thinking:

- What are some ways we could describe this roll of tape?
- What different properties of the tape could we describe? (How big it is, what shape it is, what it feels or smells like, how heavy it is)
- Can you think of any ways this tape could change? Could it change shape? Could it change color?
- What other examples can you think of where you've seen something change? What property of it changed?

Explore:

1. Point out that to learn what substances are like and notice how they change, chemists need the same important science skills the group discussed in the last session. Cultivate rich dialogue by inviting students to identify and describe science skills, such as:
   - Observing: using our five senses to notice details
   - Describing: using words or pictures to explain what we observe
   - Predicting: guessing what will happen

2. Show the group the tray with the cups and test strips, but do not explain what is in the cups or what the test strips are so that students can make predictions. Present the tray so that the vinegar (acidic) cup is to the group's left and the washing soda (basic) cup is to their right, to align with the pH scale you will show them later. Encourage scientific thinking by inviting students to “warm up their chemist brains” for the session by making observations about the substances on the tray.

   - What do you notice about the items on this tray?
   - How would you describe the liquids in the cups?
   - What do you think the strips are made of? What makes you think that?
   - How do the items on the tray look similar or different to each other?

3. Provide the information that the liquids in each of the cups are different water samples (but do not mention the added ingredients). Then ask the group to think about what will happen if you dip one of the strips in the cup. Ask questions that encourage students to make predictions:

   - What do you think will happen?
   - What changes do you think you will observe in the strip? What makes you think that?
   - What properties of the strip might change (color, shape, size)?
   - What changes do you think you will observe in the water? What makes you think that?
4. Dip the end of a strip into the first cup (vinegar). **Cultivate rich dialogue** by inviting the group to describe the results.
   - What do you observe?
   - How did the strip change? What about the water?

5. Ask the group what they predict will happen if you do the same with the second cup (plain water). Dip a fresh strip into the second cup and invite students to describe and compare the results.
   - What changes did you observe?
   - How was it similar to or different from the first cup?

6. Repeat with the third cup (washing soda). **Encourage scientific thinking** by asking the group to compare the results and think about possible conclusions. Leave the three test strips on the tray in front of their respective cups for reference.
   - What was the same about each of the three tests, and what was different?
   - What reasons can you think of that might explain why the strips turned different colors in each cup?
   - Can you think of any ways we might test your ideas?

7. Explain that you will try adding something to each of the cups to see if it changes the results. Hold up the bottle of vinegar solution and explain what it is. **Make connections** by asking students about their previous experiences with vinegar.
   - What do you remember about vinegar?
   - When did we use it before? What did we do with it?
   - Where else have you seen, used, or heard about vinegar?

8. Invite the group to predict what will happen if you add some vinegar to each of the cups and dip another strip in.
   - What changes do you think you will observe in the water?
   - Will the color change? What about the size? What makes you think that?
   - What change do you think you will see in the strip? What makes you think that?

9. Add a generous squirt of vinegar to each cup and test them again, using fresh pH strips. Lay each strip beside the first test strip for comparison.
   - What changes do you observe?
   - How did adding vinegar affect what happened?
   - What do you think this could tell us about the water, or about the strips?

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**Experience it, don’t explain it.**
Avoid correcting or dismissing incorrect assumptions. Instead, look for ways students could test their ideas and draw their own conclusions.
Reflect

1. Point out on the bottle’s label that the chemical name of vinegar (acetic acid) has the word “acid” in it. **Make connections** by asking about students’ experience with the word “acid.”
   - Where have you seen or heard about acids before?
   - What other acids have you heard of?
   - What is an example of a liquid that is very acidic? Something that might be in your kitchen?
   - What kinds of things might acids have in common?

2. Explain that **acidity** (how acidic something is) is one property of liquids that chemists study.
   - Do you think acidity is something we can see with our eyes? What makes you think that?
   - How do you think we could study how acidic something is, if we can’t see acidity?

3. Point out that scientists use tools to help them measure and observe things they can’t see. Explain that the test strips are a tool that helps us measure how acidic a liquid is. **Encourage scientific thinking** by inviting students to draw conclusions about how the test strips work.
   - How do you think this tool works? How might it show us how acidic something is?
   - Which colors do you think mean more acidic? Which colors do you think mean mean less acidic? What makes you think that?

4. Introduce your pH chart. Explain that the color of the test strip tells us how acidic the liquid was. Point out that the opposite of acidic is **basic**. (You may need to clarify that “basic” can have other meanings at other times, but in chemistry it just means “the opposite of acidic.”) Highlight that something right in the middle (the green color) is not acidic or basic but just “in the middle,” or **neutral**.

5. **Make connections** to students’ experience by highlighting some examples of everyday acids and bases, such as:
   - **Acids**: vinegar, lemon or lime juice, many things that taste sour
   - **Bases**: ammonia (the main ingredient in window cleaner), many soaps and detergents, many things that taste bitter and/or feel soapy or slippery

6. Invite the group to draw conclusions about the acidity of each of the three water samples using the information from the test strips.
   - Were each of these samples acidic, basic, or in the middle? How can you tell?
   - What happened when we added the vinegar? How did it change how acidic the water was?

7. Congratulate the group on successfully warming up their chemist’s skills and mention that they will be using acids and bases (and the test strips) in some of their research later on.

Things to Avoid

**Experience it, don’t explain it!** The goal of this activity is for students to have a basic understanding that chemicals can be acidic or basic, not to deeply understand or be able to explain what pH is. Fully understanding pH requires chemical knowledge which is beyond the age level and depth of this program. Instead, this activity lays the groundwork for future learning using the more accessible term of “acidity” and the color scale. As students explore these ideas, they still develop an understanding of how acidity can change and be measured, even without deep knowledge of exactly what pH is or why specific substances are acidic or basic.
Background

Acidity is measured using the **pH scale**. pH stands for “power of hydrogen” and measures the concentration of hydrogen ions (H+) in an aqueous (water-based) solution. The higher the concentration of hydrogen ions a substance produces, the more acidic it is, and the lower its pH value will be. A pH between 0 and 7 is considered acidic; a pH value of 7 is considered neutral (neither acidic nor basic); a pH between 7 and 14 is considered basic, or alkaline. Liquids that do not contain water (such as oils, pure alcohol, or gasoline) do not have a pH value. Solids also do not have a pH value; however, if a solid dissolves in water, we may refer to it as acidic or basic based on its pH when dissolved.

**pH indicators** are chemicals that change color based on the pH of the solution around them. The pH test strips contain a mixture of different pH indicators that each change color at a different pH range. The result is a rainbow series of color changes that can identify the approximate pH of a solution, from red (most acidic) to green (neutral) to purple (most basic).

Adding an acid to a solution makes the solution more acidic (in other words, moves the pH towards the “red” end of the spectrum). Adding a base to a solution makes the solution more basic (moves the pH toward the “purple” end of the spectrum). Mixing an acid and a base together results in neutralization, because the acid and base counteract each other and result in a pH that is closer to neutral.
**WATER WATCHERS**

**Time:** 40 minutes  
**Summary:** Students model the actions of a water chemist as they explore ways to clean and test a sample of polluted water.  
**Driving Question:** How can we change the properties of a mixture by separating or adding components?

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**MATERIALS**

- Water Chemist career card  
- Potting soil (approx. 1.5 cups)  
- Vegetable oil (approx. 1.5 cups)  
- Coffee filters  
- Tissue paper  
- Paper towels  
- Cheesecloth  
- Small funnels (1 per student)  
- Plastic spoons (1 per student)  
- Flat, 1 quart plastic containers with lids (5)  
- Clear 50 mL sample containers (2 per student)  
- ¼-cup measuring cup (5)  
- pH test strips  
- Liquid dish soap  
- 1 L plastic reagent bottles (4)  
- 50 mL plastic squeeze bottles (5)  
- 100 mL plastic bottles (20)  
- Well plates (1 per student)  
- Washing soda (sodium carbonate)  
- Baking soda (sodium bicarbonate)  
- Distilled white vinegar  
- Citric acid  
- Pipettes (1 per student + 20 additional)  
- Safety goggles (1 per student)  
- Student lab notebooks (from Session 1)  
- Pencils (1 per student)  
- Trays (1 per student)  
- Labels (24)  
- Quart-size containers for liquid waste (5)  
- Rinse bottles (5)

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**Prepare**

1. Create a “polluted” water sample for each group of four students as follows:
   - Mix together approximately ¼ c. potting soil and ¼ c. vegetable oil in a flat plastic containers to create a thick “sludge.”
   - Fill the container half to 2/3-full with water and add ¼-cup of vinegar.
   - Stir to mix, and place the lid on the container.
   - Label the sample containers with a “sample name” that includes the name of a river, the name of a factory, and a date. Use the example below or make up your own.

   **Location:** Saddleback River; Samson Steel Factory  
   **Collection Date:** 5/14/20
2. Prepare stock solutions of vinegar, citric acid, washing soda, and baking soda:
   • Mix 500 mL of vinegar with 500 mL water in a 1 L bottle. Label the bottle “50% vinegar solution.”
   • Add 1/3 cup (about 80 mL) of citric acid powder to a 1 L bottle and fill with water. Stir or swirl the bottle gently until the citric acid is dissolved. Label the bottle “citric acid solution.”
   • Add ¼ cup washing soda to a 1 L bottle and fill with warm water. Stir or swirl the bottle gently until the powder is dissolved. Label the bottle “washing soda (sodium carbonate).”
   • Add ¼ cup baking soda to a 1 L bottle and fill with water. Stir or swirl the bottle gently until the powder is dissolved. Label the bottle “baking soda (sodium bicarbonate).”
   • Once prepared, these stock solutions are stable at room temperature and can be used to refill student containers as needed.

3. Create five sets of acid/base reagents (one per group of four students) as follows:
   • Fill a 100 mL bottle with each of the four stock solutions and label them accordingly:
     “vinegar (acetic acid)”
     “citric acid solution”
     “washing soda solution (sodium carbonate)”
     “baking soda solution (sodium bicarbonate)”
   • Use a permanent marker to label a pipette for each bottle with the first letter(s) of each reagent name: “V,” “C,” “WS,” “B.” (Washing soda is designated “WS” to distinguish it from the “W” pipettes used for water in other activities.)

4. Fill five squeeze bottles with liquid dish soap. Label the bottles “dish soap.”

5. Cut the tissue paper, paper towels, and cheesecloth into approximately 10 cm (4 in.) squares, preparing enough for 2–3 squares of each material per student.

6. Designate a supply station in or near your Lab area and set out the filters, tissue paper, paper towels, cheesecloth, funnels, bottles of dish soap, small containers and spoons.

7. Set up a lab station for each student with a tray and safety goggles. Set out a liquid waste container and rinse bottle at each table (or for each group of four students).

8. (Optional): Cut pH test strips into ½- to ¾-inch pieces to make smaller pieces for student use.

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**Safety**

The sodium carbonate, vinegar, and citric acid solutions can be mildly irritating to skin and eyes. Students should wear safety goggles during the “Explore” section of the activity and wash their hands when finished.

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**Engage**

1. Introduce the Water Chemist career by showing them the career card and asking questions to encourage students to think about what a water chemist might do.

   ▶ What do you notice about this picture? What do you think the person is doing?
   ▶ Where do you see chemicals in this picture? Where do you see science tools?
   ▶ What does the name “water chemist” make you think of?
   ▶ What do you think a water chemist does? What makes you think that?
   ▶ What else do you think a water chemist might do in a day at their job?
   ▶ Why do you think observing and making changes to water might be important?
   ▶ What do we use water for?
2. Explain that in this activity students will be water chemists. Introduce the storyline like this:

We are a team of water chemists who work for the government. Our job is to observe the water in our local rivers and lakes to make sure it stays clean and healthy for the creatures that live in it and because it is used for people’s drinking water in their homes.

- How do you think we might tell if the water is clean and healthy?
- How could we tell if it isn’t clean?
- What properties might we look for?
- What about properties of the water that we can’t see?

We’ve received some water samples collected from the [Name] River. The samples were collected from the part of the river near the [Name] Factory, because someone has reported that the factory might be leaking pollution—chemicals that don’t belong—into the river.

Our job is to find out whether the water is clean or polluted with chemicals that don’t belong. If it is polluted, we’ll need to test some ways to get the water as clean as possible again, so that we can tell the government how to solve the problem.

Let’s go into the lab and see what we can find out!

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**Explore**

**Observation**

1. Invite the students to the Research Lab. Ask students to find a lab station and put on their lab goggles. Give each group of four chemists a water sample container.

2. Invite students to open the container and make observations about the water sample. Ask them to find p. 7 in their lab notebooks and use it to write or draw their observations. **Cultivate rich dialogue** by asking them to share and discuss their observations with the rest of their group.

- Do you think this sample is clean?
- How can you tell? What do you observe that makes you think that?

**Filtration**

1. Challenge students to think about how to clean their water samples. Introduce the materials at the supply station and invite groups to brainstorm ways they could use the materials to separate, or filter, the water from the “pollution sludge,” such as scooping with the spoon or pouring through the coffee filter. **Encourage scientific thinking** by suggesting that each chemist in a group test a different idea or material for removing the sludge.

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**Ask students to be mindful of how much material they use. Cleaning up pollution by making a pile of trash instead just creates another problem!**
2. Provide a measuring cup to each group to use in scooping the sample from the container. As students work, **ask questions** that encourage them to make observations and predictions and to help them deepen their explorations. **Cultivate rich dialogue** by encouraging groups to work together and share what they’ve tried with each other. Remind students to record their tests and results in their lab notebook.

- **What do you notice about your water sample after you used the spoon?**
- **Is there any pollution left in your water? What do you think you could try to get out the stuff that’s left?**
- **What do you think will happen when you pour the sample through the cheesecloth?**

3. Gather the group back in the **Meeting Room** for a brief team meeting. **Cultivate rich dialogue** by asking the group to discuss their results.

- **What solutions did you find for removing the sludge?**
- **Do you think your sample is clean now?**
- **What about the properties of water that we can’t see?**

### Acidity

1. Reintroduce the pH chart from the lab prep activity and ask students to find the same chart on p. 8–9 in their lab notebooks. Explain that for water to be clean and healthy for the creatures that use and live in it, it should be close to the “green” part of the chart—not acidic, not basic, but neutral.

- **How could we find out if our water samples are acidic, basic, or neutral?**

2. Ask the group to return to their lab stations in the **Research Lab**. Ask students to put on their safety goggles. Distribute test strips and invite students to test their cleaned samples from the previous tests.

- **What was the acidity of your water?**
- **What do you think you could do to get the water back to a “green” indicator?**

3. Distribute a set of reagent bottles to each table. Ask students to recall what good pipette technique looks like:

- **How do you get liquid into the pipette?**
- **How do you get it out?**
- **Where should the bottle be when you are using it?**
- **Where should the tip of the pipette be when you are squeezing the liquid out?**
- **What should you do with the pipette and bottle when you are finished?**

4. Invite students to use the chemicals in the bottles to try to change the acidity of their sample to “green.” Distribute well plates and encourage students to pipette small amounts of their cleaned sample into the wells for testing. Distribute pH test strips as needed. Encourage groups to work together, for example by each starting with a different chemical.

5. As students experiment, **encourage scientific thinking** by asking them to make observations and predictions and draw conclusions about their results. Remind them to record what they try and what results they observe in their lab notebooks.

- **What happened to the acidity when you added the baking soda? How can you tell?**
- **What do you think would happen if you added more?**
- **How much washing soda have you added so far? How much more do you think you will need to add to get it to “green”?**

6. Before returning to the **Meeting Room**, ask students to dispose of any liquid waste in their waste container and clean their well plates by rinsing each well with the rinse bottle. (They will need the well plates again in the next activity).
Reflect

1. Gather the group in your Meeting Room for a research team meeting. Encourage them to bring along their lab notebooks.

2. Cultivate rich dialogue by inviting teams to share their research findings with the group.
   - What did you find out about the acidity of the water sample?
   - What solutions did you find that could make the water less acidic?

3. Make connections between students’ experiments and the storyline by explaining that the team needs to report back to the government about the results of their research.
   - Was the sample from the [Name] Factory polluted? What evidence do we have to show it?
   - What suggestions should we give them for how to clean it up?

Things to Avoid

1. Experience it, don’t explain it! It is not necessary to direct students toward a particular method of filtering the sample or to correct wrong assumptions about how materials will behave. Encourage students to try their ideas, think critically about the results, and discover for themselves whether their process made the sample cleaner.

2. Distribute pH strips to groups a few at a time as needed, to avoid waste or overuse.

3. Reusing pH strips will result in inaccurate readings because the second sample liquid will mix with the liquid still on the strip from the first test. Used strips may still indicate large changes if the second sample is much more acidic or basic than the first, but they shouldn’t be used for careful measurement.

Adapt and Extend

1. For Level 2 students: Ask students to think about how to adapt and apply the process they developed to the actual situation of polluted water draining from a pipe at the factory into the river. Challenge groups to design and create a diagram or model for a proposed cleaning system:
   - How could we filter and neutralize all the water that comes out of that pipe?
   - What would the filter look like? Where should it be located?
   - How and where would we add chemicals to neutralize the acid?
   - What kinds of problems might we encounter? Are there any parts of our plan that might create new problems?
   - Are there any other ways we could solve this problem?

2. Movement activity (especially for Level 1): Reinforce acid/base concepts with a pH-themed game. Mark out a play area with masking tape or cones, big enough for the group to stand in a single-file line across the middle. Designate one end of the area the “acid” side, and the other end the “base” side. The group stands in a line across the center of the space, at “neutral” (halfway between acid and base). One person, the Chemist, calls out the number of drops of acid or base they are adding, for example “three small drops of acid” or “five giant drops of base,” and everyone in the group must take that many steps toward the appropriate end of the play area. If the chemist calls out “Neutral!” everyone must run to line up again in the center as fast as possible. Anyone who goes in the wrong direction or goes over the edge of the play area at any point is out. The last person remaining becomes the Chemist for the next round.
Background

**Water chemistry** is the study of how water interacts with and affects Earth’s systems, from ecosystems and geology to human-built systems like cities and manufacturing processes. A water chemist might study how changing levels of chemicals in ocean water affect plants and animals, take and test samples from lakes and rivers to monitor the quality of the water, work at a water filtration plant to ensure that a city’s drinking water is safe, or develop processes for cleaning up polluted water environments.

For more information, visit the American Chemical Society’s page on water chemistry careers: https://www.acs.org/content/acs/en/careers/college-to-career/chemistry-careers/water-chemists.html

**Separating components from a mixture** is an important part of chemistry research and practice. It is often necessary to purify a substance by removing contaminants, or to collect the desired product of a chemical reaction from a mixture of leftover starting materials and unwanted byproducts. There are many techniques for separating mixtures, depending on the properties of the components. They include:

- **Physical separation**: If the substances don’t mix and remain in separate layers, such as oil floating on water, they can be separated by skimming or pouring off one substance, leaving the other behind.

- **Filtration** involves passing the mixture through a material that traps some components of the mixture while allowing others to pass through. Some are based on particle size; for example, the fibers of paper towel or filter paper create a mesh that lets water molecules through but traps larger particles like dirt or coffee grounds. Other filters might rely on chemical properties of the substance, like attracting only positively charged particles and not neutral or negative ones.

- **Distillation** separates a liquid from substances dissolved in it by boiling away the liquid and collecting its vapor in a separate container, leaving the unwanted substances behind.

- **Chemical reactions** can also help to change components of a mixture into a form that is easier to separate. For example, if a contaminant is dissolved in water, a substance can be added to the water that reacts with the contaminant to form a solid that sinks to the bottom. It can then be removed by filtration or some other technique.
MATERIALS:
- Color Chemist career card
- Dried cochineal shells (3–4 shells per 4 students)
- Dried butterfly pea flowers (2–3 flowers per 4 students)
- Mortar and pestle sets (1 per 4 students)
- Well plates (1 per student)
- Acid/base reagent bottles and pipettes (prepared in previous activity): citric acid solution, vinegar solution, baking soda solution, washing soda solution
- 100 mL water bottles and pipettes (from “Slime Specialists” activity)
- Pipettes (1 per student)
- Toothpicks (1 per student)
- 8.5" x 11" watercolor paper (3 sheets per class)
- Quart-size containers for liquid waste (5)
- Rinse bottles (5)
- Trays (1 per student)
- Safety goggles (1 per student)
- Student lab notebooks
- Pencils
- (Optional) White paper (printer paper or one-sided scrap paper)
- (Optional) printed of butterfly pea and cochineal insect (see Printable Resources)
- (Optional) latex-free gloves for students with known red dye allergies

Prepare
1. Create a set of reagent bottles for each group that includes:
   - Vinegar solution
   - Citric acid solution
   - Washing soda solution
   - Baking soda solution
   - Water
   - An appropriately labeled pipette for each
2. Prepare a mortar and pestle set for each group by placing 3–4 cochineal shells in half of the mortars and 2–3 butterfly pea flowers in the other half.
3. Cut watercolor paper widthwise into approximately 1" strips.
4. (Optional): Cut pH test strips into ½- to ¾-inch pieces to make smaller pieces for student use.
Safety
The vinegar, citric acid, and washing soda solutions may be mildly irritating to skin and eyes. Students should wear safety goggles during the “Explore” section of the activity and wash their hands when finished.

Allergy Note: Carmine red, the pigment made from cochineal shells, can, in rare cases, cause an allergic skin reaction. Anyone with a known allergy to carmine red or red dyes in general should wear gloves and avoid skin contact with the shells or pigment.

Engage
1. Gather the group in your Meeting Room area. Introduce the Color Chemist career by showing them the career card and asking questions to encourage students to think about what a color chemist might do.
   ▶ What do you notice about this picture? What do you think the person is doing?
   ▶ Where do you see chemicals in this picture? Where do you see science tools?
   ▶ What does the name “color chemist” make you think of?
   ▶ What do you think a color chemist does? What makes you think that?
   ▶ What else do you think a color chemist might do in a day at their job?
   ▶ Why do you think creating colored substances is useful? What things do we make or use that have color in them?

2. Explain that in this activity students will be color chemists. Introduce the storyline like this:
   We are a team of color chemists working for a company that makes paints and inks for artists.
   The company wants to create a new set of watercolor paints called “Nature Inks” that are made from things found in nature.
   ▶ What kinds of things in nature can you think of that have color?
   ▶ Which ones do you think might be easier to make a paint from, and which might be harder? What makes you think that?
   ▶ How do you think we might go about making a paint from a flower or other piece of a plant?

   The company’s Exploration Team has found two natural sources that we might be able to make colored paints from. Our job is to find a way to make a paint from these objects, and then to see if we can change the paint to create as many different colors for the paint set as possible.
   Let’s go to the lab and see what we can find out about the properties of these natural products, and how we can change them!

Explore
Research
1. Invite students to move to the Research Lab. Ask students to find a lab station and put on their safety goggles.
2. Explain that in the research part of the process, they will try to find out more about two natural products and the colors they create. Give each team of four chemists a pestle and a mortar with either 3–4 cochineal shells or 2–3 butterfly pea flowers, but do not explain what the samples are.
3. Encourage scientific thinking by inviting students to make observations about the objects in their mortars. After a few minutes, have each team trade mortars with another team to observe the second type of material.
   ▶ What part of nature do you think this comes from?
   ▶ What color ink do you think it might make? What makes you think that?
4. Reveal that one object is the dried shell of an insect called the **cochineal** (kah-chin-EE-ul) from South America and that the other is the dried flower of a plant from Asia called the butterfly pea (Optional: show the image cards for students to see as you discuss them). Ask the group for their ideas about how to turn these objects into a watercolor paint.

- **What properties does paint have? (Is it solid or liquid?) What does it need to be able to do?**
- **How could we get the color out of the objects?**
- **What kind of liquid should we add? What makes you think that?**

**Tools and Techniques**

1. Demonstrate effective technique for using a mortar and pestle:
   - Hold the mortar steady with one hand.
   - Hold the pestle upright in the other hand with the wide end in the mortar bowl.
   - Press down on the object firmly, and grind it using a sideways or circular motion to most effectively crush the object.
   - Do not pound up-and-down—it doesn’t work as well and could cause the object to fly out of the mortar, or damage the mortar.

2. Invite groups to take turns using the mortar and pestle to grind their samples. Distribute the water bottles and suggest that they could add a small amount of water (about half a pipette-full) to the mortar bowl as they grind. (Note: Groups may discover that cochineal shells crush fairly easily into a powder, but the butterfly pea flowers release their pigment best when softened and crushed in water. In both cases, the water will help to make the pigment color clearly visible.)

3. **Ask questions** that encourage students to notice changes throughout the process.
   - **What do you notice about your sample? How is it changing?**
   - **What color liquid is it creating? How does that compare to what you predicted?**

**Testing**

1. Gather the group back in the **Meeting Room** area for a brief research meeting. **Cultivate rich dialogue** by asking the Cochineal teams and the Butterfly Flower teams to report to each other about their results.
   - **What color paint did you create from your sample?**
   - **What process worked best for getting the color out of your sample?**

2. Remind the group that the second part of the research team’s job is to try to change the paints to create as many different colors as possible.
   - **What do you think we could try that might change the color of these paints?**
   - **Have we seen anything else in our other chemistry research that changed color? What made it change colors?**
3. If it doesn’t arise from student ideas, make connections by reminding the group about the pH test strips and the way they showed different colors when more or less acidic liquids were added. Invite students to return to their lab stations and see if they can change the color of their paints by making them more or less acidic.

4. Remind students to put their safety goggles back on in the Research Lab. Explain that this is the testing part of the process, where they will see how many different colors they can create from the natural products.

5. Distribute a set of reagent bottles to each group of four students. Ask each group to divide into two teams of two chemists and work in pairs (rather than individually) for the next phase of testing. Provide a well plate and clean pipette to each pair.

6. Ask the group to recall scientific pipette technique:
   - How do you get liquid into the pipette?
   - How do you get it out?
   - Where should the bottle be when you are using it?
   - Where should the tip of the pipette be when you are squeezing the liquid out?
   - What should you do with the pipette and bottle when you are finished?

7. Encourage scientific thinking by inviting pairs to discuss how to design their experiment. Remind them that it is helpful for scientists to change only one thing at a time to measure what causes a change in reaction. Point out pages 10–11 in their lab notebooks as a place to record their results.
   - How could you use the well plate to test the paint with different chemicals?
   - How will you keep track of which combination is in each well?
   - How many drops of each liquid will you start with?
   - How will you record your results?

Note: One method for recording the colors might be to use a toothpick to transfer a small drop of the paint color into the appropriate square in the lab notebook grid and write the formula (number of drops of each substance used) in the square with it.

8. Encourage groups to add 3–4 pipettes-full of water to their mortars and stir it with a toothpick to create a larger volume of paint before beginning their tests. Invite each pair to pipette paint from the mortar into their well plates for testing.

   Note: if the well plates are transparent, placing a white sheet of paper underneath them will make the colors in the wells easier to see and identify.

9. As pairs test their samples, ask questions that invite them to make observations and predictions and try new things. Encourage them to explore their ideas and draw their own conclusions.
   - How many drops of baking soda did you add? What change did you notice?
   - What do you think would happen if you added only 5 drops instead of 10? Try it in a new well and see what happens.
   - How do you think you could make a color that is in between those two colors?
   - Could you make a lighter version of that color? How would you do it?
10. When students have fully explored making changes to their initial paint, have each group trade mortars and pestles with a group that had the other sample material (so that the groups with the cochineal paint receive butterfly flower paint and vice versa).

11. Give each pair of students a clean well plate and invite them to test the second paint as they did the first. If needed, they could grind an additional flower or shell and add water to create more liquid. **Encourage scientific thinking** with questions that invite students to observe, compare, and test new ideas.

   ▶ What changes do you notice with this paint?
   ▶ How is it similar or different to the first sample you tested?
   ▶ What else could you try to create more colors?

12. Distribute strips of watercolor paper and invite students to make a “sample chart” by adding a drop of each color they created. Encourage them to number or label each color so they can compare it to their notes and remember how they created it.

**Reflect**

1. Gather the group in the **Meeting Room** area for a research team meeting, and ask students to bring their sample charts along. **Cultivate rich dialogue** by inviting students to compare their sample charts with someone from a different group.

   ▶ What is similar about the colors you found? What is different?
   ▶ How many different colors did we find in our group?
   ▶ What chemicals did you add to create each color?
   ▶ Did any chemicals produce similar results?

2. Reflect as a group on their outcomes in creating paints for the “Nature’s Inks” paint set. **Ask questions** to encourage reflection and discussion.

   ▶ How many different colors were we able to make from these two natural sources?
   ▶ Are there any colors you think a paint set should have that we weren’t able to make?
   ▶ Can you think of any items from nature that might make a paint that color?
   ▶ What suggestions could we give the Exploration Team about what colors we’re still looking for and what natural products might have them?
Things to Avoid

1. **Experience it, don't explain it!** It is not necessary for students to be able to explain why adding an acid or base produces a particular result. Encourage them to explore and draw their own conclusions, but focus on the process of testing and creating changes rather than the underlying concepts.

2. Students may try to add too much of their color samples as they record them in lab notebooks or sample charts, which will lead to soggy pages. Highlight the importance of adding a very small amount by using a toothpick to transfer drops of color, or by carefully squeezing a single drop from a pipette.

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Adapt and Extend

1. For Level 2 students:
   - Encourage students to be systematic in their experimental design, for example: do four tests of baking soda (1 drop, 5 drops, 10 drops, 20 drops), and then repeat with each of the other chemicals, using the same numbers of drops each time.
   - Challenge students to fine-tune their formulas and create as many different shades and "in-between" colors as they can. Adding one drop at a time, how many drops does it take to see a visible color difference? What is the maximum number of drops after which the color no longer changes?

2. Extend the investigation by allowing students to mix the cochineal and butterfly pea liquids together. What color combinations can they create just by mixing? How does the mixture change when each of the other chemicals is added? How is it similar or different to the individual inks?

3. Invite students to paint with the colors they create on a larger piece of watercolor paper to create a work of art.

4. Become the Exploration Team. Gather plant material from your nearby area (making sure it is safe and permissible to pick) and try creating paint from those materials.

5. Turmeric creates a pH-sensitive ink when mixed with rubbing alcohol, but does not dissolve readily in water. Test this paint to create different colors, or test other plant materials with alcohol instead of water. **Note:** Turmeric can stain skin and surfaces, so use with caution. Stains can often be removed with a mixture of rubbing alcohol and dish detergent.
Background

**Color chemists** study and create colored pigments and dyes. Pigments and dyes are used to color everything from paints and ink pens to toys and clothing to cosmetics and food products. A color chemist might create new pigments for lipsticks that use fewer harmful materials, improve the performance of a clothing dye so that it doesn’t fade after washing, or develop a new process for manufacturing a paint pigment that produces less waste. Some color chemists study historical paintings and artifacts to analyze the pigments that were used to make them, determine when and where they were made, or repair damage without affecting the rest of the piece. For more information, visit the American Chemical Society’s page about careers with dyes, pigments, and inks: https://www.acs.org/content/acs/en/careers/college-to-career/chemistry-careers/dyes-pigments-ink.html

**Cochineal insects** (*Dactylopius coccus*) are small insects native to Central and South America that live on and eat cacti. The dried shells of the insects create a brilliant red pigment called carmine (also known as crimson lake or natural red #4) that humans have used to create dyes and paints for hundreds of years. In modern times, synthetic dyes have taken the place of carmine for some uses, but it is still frequently used in cosmetics and food products.

The color of cochineal pigment is due to the presence of a chemical compound called carminic acid. The structure of carminic acid changes depending on the acidity of its surroundings, which affects its color as well. In neutral conditions (around pH 7), carminic acid is red. Adding acid changes the color gradually to a yellowish orange (around pH 4). Adding a base changes its color to a burgundy or reddish-purple (around pH 12). Carmine dye is made by reacting the carminic acid with a fixative that stabilizes the red color and reduces its sensitivity to pH.

**Butterfly pea** (*Clitoria ternatea*) is a flowering vine native to Southeast Asia. It is a popular component of teas and other beverages because of its color-changing properties. Its color is due to the presence of several compounds called delphinidins, which are part of a larger group of chemicals called anthocyanins. Other anthocyanins are responsible for the red, blue, and purple colors of many plants and foods, such as blueberries, red cabbage, raspberries, eggplant, and most blue or purple flowers. The delphinidins in the butterfly pea flower are a deep cobalt blue in neutral solutions (around pH 7). When acid is added, they gradually change to purple and eventually a magenta pink (around pH 4). If a base is added, they turn gradually to green and then yellow (around pH 9).
CLOSING REFLECTION

Time: 10 minutes
Summary: Students will connect the session’s activities with chemistry skills and careers.

MATERIALS
• Water Chemist and Color Chemist career cards
• Student lab notebooks
• Pencils (1 per student)
• Science skills stickers (from Session 1)

Reflect
1. Gather the group in your Meeting Room area. Remind the group that they started the session by thinking about properties of substances—what they are like—and how the properties can change. Cultivate rich dialogue by inviting students to share their experiences.
   ▶ What are some times today when you noticed or tested what a substance was like?
   ▶ What are some of the properties you observed?
   ▶ What are some times today when you made or noticed changes?
   ▶ Which properties of the substances changed? Which ones stayed the same?
   ▶ What are some ways we made changes to a substance to solve a problem?
2. Show the group the career cards. Ask questions that help the group reflect on their experiences being water chemists and color chemists.
   ▶ What are some things we did today when we were being water chemists?
   ▶ What kinds of science skills did we use? How did we think scientifically?
   ▶ How do you think it might be like what a real water chemist does?
   ▶ What things did we do today when we were being color chemists?
   ▶ What kinds of science skills did we use? How did we think scientifically?
   ▶ How do you think it might be like what a real color chemist does?
   ▶ What did you do today that made you feel like a chemist?
3. Give students time to write or draw their reflections in their lab notebooks. Invite them to choose two stickers that represent science skills they used and add them to the notebook. Ask students to be thoughtful in their choice and make connections between the skill they chose and the career they embodied.
4. Encourage students to share with their families about the kinds of chemists they were today and the types of research experiments they conducted in their laboratory. Point out the resource page in their lab notebooks and invite them.

Hear from a variety of voices. Ask students to talk first with a partner, and then share their partner’s idea with the group.
Concluding the Program

1. Thank the students for doing a fantastic job as chemists! Encourage them to consider being a chemist one day, and to continue learning about all kinds of science at home, in school, and in places like museums and libraries.

2. Share details of any family events planned in conjunction with GSK Science in the Summer™, including dates, registration, and flyers.

3. Thank GSK, The Franklin Institute, and your host site for offering the program. If time permits, encourage students to draw a picture or write a thank-you note to share what they enjoyed and learned through the program.
**Consumable**

- Chart paper
- Student lab notebooks (1 per student)
- Science skills stickers (1 sheet per student)
- Chemist nametags (2 per student)
- Clear packing tape
- Baking soda
- Cream of tartar
- Citric acid
- Powdered sugar
- Distilled white vinegar
- Baby oil (clear)
- Liquid dishwashing soap (clear)
- Effervescent antacid tablets (1 tablet per 3–4 students)
- Borax
- White school glue
- Cornstarch
- Large bottles of food coloring: red, yellow, blue
- Small paper cups (3–5 per student)
- Snack-size ziplock bags (1 per student)
- pH test strips
- Potting soil
- Vegetable oil
- Coffee filters
- Tissue paper
- Paper towels
- Cheesecloth
- Washing soda (soda ash)
- Dried cochineal shells (3–4 shells per 4 students)
- Dried butterfly pea flowers (2–3 flowers per 4 students)
- 8.5" x 11" watercolor paper (3 sheets per class)
- Toothpicks (1 per student)
- Latex-free gloves, size XS (for students with dye allergies)

**Non-consumable**

- Chart markers
- Permanent marker
- Career cards (4)
- 2-gallon bucket with lid (for liquid waste)
- Safety poster (1)
- Safety goggles (1 per student)
- Pencils (1 per student)
- Quart-size plastic containers (5)
- Water rinse bottles (5)
- 100 mL graduated cylinders (13)
- Trays (21)
- 4 oz. clear cups with lids (41)
- Small wooden craft sticks (40)
- Stirring rods (3)
- Well plates (20)
- Pipettes (85)
- 1 L plastic reagent bottles (7)
- 100 mL plastic reagent bottles (45)
- 2" x 4" labels (76)
- Dropper bottles (15)
- 1-cup plastic containers with lids (10)
- Plastic spoons (30)
- Rulers (5)
- Five examples of stretchy polymer toys: putty, stretchy toy, fluffy slime, stretchy slime, sticky slime
- Small funnels (1 per student)
- Flat, 1 quart plastic containers with lids (5)
- Clear, 50 mL sample containers (2 per student)
- ¼-cup measuring cups (5)
- 50 mL plastic squeeze bottles (5)
- Mortar and pestle sets (1 per 4 students)
Printable Resources

- Quick Guides
  - Session 1
  - Session 2
- Meeting Room/Lab signs
- Slime formula card
- pH scale chart
- Cochineal insect image
- Butterfly pea image
### Session 1: Get a Reaction!

#### Quick Guide

**PROGRAM INTRODUCTION (10 MINUTES)**

<table>
<thead>
<tr>
<th>SECTION</th>
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</table>
| Welcome | • Make name tags  
 • Gather in Meeting Room  
 • Introduce yourself and program  
 • Orient to space and rules | | What do you think of when you hear the word “chemistry?”  
 What things do you think a chemist does? |
| Theme | • Introduce title & topic  
 • Introduce goals: have fun, be chemists | What body parts do chemists need to protect?  
 Which areas of our space will be “goggles on” areas?  
 Which will be “goggles off?” |
| Safety | • Review safety measures: goggles, gloves, wafting no tasting, close-toed shoes  
 • Safety poster  
 • Distribute & fit safety goggles  
 • Introduce Meeting Room & Lab areas  
 • Distribute lab notebooks & pencils | |
**Session 1: Get a Reaction!**  
*Quick Guide*

**LAB PREP: WILL IT MIX? (10 MINUTES)**

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<th>SECTION</th>
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</table>
| **Engage** | • Gather in Meeting Room  
• Introduce Lab Prep  
• Connect to student mixing experiences  
• Highlight examples of changes when things are mixed | What are some things you have mixed together?  
What happened when you mixed them? |
| **Explore** | • Introduce chemist skills: observing, predicting, describing  
• Students observe 3 liquid cylinders & powders  
• Students predict how the first pair will react  
• Add 1 scoop of powder to cylinder; students describe results  
• Repeat with second and third substance pairs | How would you describe the substances in the containers?  
What do you think will happen?  
What makes you think so?  
What do you notice that changed, and what looks like it stayed the same?  
How is it similar or different to what you predicted? |
| **Reflect** | • Students draw conclusions and make connections | Do you think all three powders are the same?  
What makes you think that?  
What other things have you seen that mixed, separated, or reacted? |
## Session 1: Get a Reaction!
### Quick Guide

### MEDICINE MAKERS (40 MINUTES)

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</table>
| **Engage** | - Gather in **Meeting Room**  
- Introduce **Medicinal Chemist card**  
- Introduce box of antacid tablets and storyline of creating an antacid medicine  
- Introduce process: research, prototype, scale up and test | **What do you think a medicinal chemist does?**  
**Have you ever seen or heard of an antacid?**  
**What could we do to figure out how to make a medicine that works like this one?** |
| **Explore** | - Gather in **Lab; goggles on**  
- Students observe tablet  
- Students observe tablet piece in water  
- Students record and share observations  
- Summarize goal: create a mixture that creates bubbles like the antacid | **What do you notice about how the tablet looks and feels?**  
**What do you think will happen when you put it in water?** |
| **Explore** | - Demonstrate pipetting and scooping techniques  
- Students practice each technique | **Why do you think it’s important to use each pipette only for its own liquid?** |

*CONTINUED*
What substances will you combine, and how much of each will you use?

What made you decide on that formula?

Was your formula successful? How can you tell?

What could you change for the next test?

MEDICINE MAKERS continued

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<th>SECTION</th>
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</thead>
</table>
| **Explore** | - Distribute well plates  
- Students write plan for testing substance combinations  
- Introduce test grid in notebooks  
- Students test and record observations  
- Ask questions to encourage critical thinking  
- Prepare demo cylinder for Foam Test | How many substances will you mix at a time?  
How will you keep track of which mixture is in each well?  
What other combinations could you try? | |
| **Explore** | - Explain & demonstrate Foam Test  
- Teams decide on test formulas  
- Prepare Foam Test cylinders for each team  
- Teams test formulas  
- Teams adapt and retest formulas  
- Ask questions to encourage critical thinking | What substances will you combine, and how much of each will you use?  
What made you decide on that formula?  
Was your formula successful? How can you tell?  
What could you change for the next test? | |
| **Reflect** | - Gather in Meeting Room with lab notebooks  
- Discuss teams’ results  
- Discuss common names of substances  
- Connect results to storyline | What formulas did you find that worked?  
Which formulas didn’t work?  
Where have you seen or used baking soda before? | |

**GSK Science in the Summer™**  
In partnership with The Franklin Institute
### Session 1: Get a Reaction!

**Quick Guide**

#### SLIME SPECIALISTS (40 MINUTES)

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<td><strong>Engage</strong></td>
<td>• Gather in Meeting Room</td>
<td>What do you think a materials chemist does?</td>
</tr>
<tr>
<td></td>
<td>• Introduce Materials Chemist card</td>
<td>Where have you seen slime before?</td>
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<tr>
<td></td>
<td>• Introduce storyline about creating slime for toy company</td>
<td>What does slime look and feel like?</td>
</tr>
<tr>
<td></td>
<td>• Introduce process: research, prototyping, iteration, scale-up</td>
<td>How does it behave?</td>
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<tr>
<td><strong>Explore</strong></td>
<td>• Student teams explore slime toys</td>
<td>What is the material's texture?</td>
</tr>
<tr>
<td><strong>Research</strong></td>
<td>• Discuss and list needs for each slime type</td>
<td>How far can you stretch it?</td>
</tr>
<tr>
<td></td>
<td>• Summarize goal: create a material that best meets the needs for one type of slime toy</td>
<td>Does it stay, break, or bounce back?</td>
</tr>
<tr>
<td><strong>Explore</strong></td>
<td>• Gather in Lab; goggles on</td>
<td>What do you remember about how to use a pipette?</td>
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<tr>
<td><strong>Tools and Techniques</strong></td>
<td>• Review pipetting technique</td>
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<td>• Demonstrate spoon technique</td>
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<tr>
<td></td>
<td>• Students practice spoon technique</td>
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<tr>
<td><strong>Explore</strong></td>
<td>• Review sample formula from lab notebook</td>
<td>Does this material meet the needs for any of our toy materials?</td>
</tr>
<tr>
<td><strong>Prototyping</strong></td>
<td>• Students mix sample slime and record observations</td>
<td>How could we find out for sure?</td>
</tr>
<tr>
<td></td>
<td>• Teams test sample against one set of toy material needs</td>
<td>How far do you think this material will stretch?</td>
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<tr>
<td></td>
<td>• Teams share test results with group</td>
<td>Do you think this formula is the best one for that toy?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What makes you think that?</td>
</tr>
</tbody>
</table>

**CONTINUED >**
### SLIME SPECIALISTS continued

<table>
<thead>
<tr>
<th>SECTION</th>
<th>DO</th>
<th>ASK</th>
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</thead>
<tbody>
<tr>
<td><strong>Explore</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Iteration</strong></td>
<td>• Students each choose a type of toy material to create</td>
<td>What does your material need to do or look like that this slime doesn’t?</td>
</tr>
<tr>
<td></td>
<td>• Students make one change to formula and record observations</td>
<td>Which ingredients might affect that property?</td>
</tr>
<tr>
<td></td>
<td>• Students test new formula against material needs list</td>
<td>What might happen if you added the ingredients in a different order?</td>
</tr>
<tr>
<td></td>
<td>• Students make and test further iterations on formula</td>
<td>How does this version match your material’s needs?</td>
</tr>
<tr>
<td></td>
<td>• Ask questions to encourage critical thinking</td>
<td></td>
</tr>
<tr>
<td><strong>Explore</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Scale-up</strong></td>
<td>• Students make a double-size sample of best formula</td>
<td>How will you need to change your formula to make twice as much of it?</td>
</tr>
<tr>
<td></td>
<td>• Provide food coloring for adding to final samples</td>
<td>Where in the process should you add the color?</td>
</tr>
<tr>
<td></td>
<td>• Provide bags for storing finished samples</td>
<td>What makes you think that?</td>
</tr>
<tr>
<td><strong>Reflect</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Gather in <strong>Meeting Room</strong> with lab notebooks and samples</td>
<td>How are your materials similar or different?</td>
</tr>
<tr>
<td></td>
<td>• Group students by material type to compare results</td>
<td>How are your formulas similar or different?</td>
</tr>
<tr>
<td></td>
<td>• Connect student results to storyline</td>
<td>Which formulas shall we recommend for each type of slime toy?</td>
</tr>
<tr>
<td>SECTION</td>
<td>DO</td>
<td>ASK</td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Reflect</td>
<td>• Gather in Meeting Room</td>
<td>What are some times today when you materials react, separate, or mix?</td>
</tr>
<tr>
<td></td>
<td>• Discuss experiences with reacting, separating, and mixing</td>
<td>What are some things we did today when we were being medicinal or materials chemists?</td>
</tr>
<tr>
<td></td>
<td>• Reflect on experiences taking the roles of medicinal and materials chemists</td>
<td>How do you think it might be like what a real medicinal or materials chemist does?</td>
</tr>
<tr>
<td></td>
<td>• Students draw or write reflections in notebooks</td>
<td>What did you do today that made you feel like a chemist?</td>
</tr>
<tr>
<td></td>
<td>• Students add skills stickers to notebook</td>
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</tbody>
</table>
Session 1: Get a Reaction!
Quick Guide

### INTRODUCTION (5 MINUTES)

<table>
<thead>
<tr>
<th>SECTION</th>
<th>DO</th>
<th>ASK</th>
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</thead>
</table>
| Welcome | • Make name tags  
• Gather in Meeting Room  
• Re-orient to space, rules, and schedule |  |
| Safety 🕒 | • Review safety measures  
• Safety poster  
• Distribute goggles, lab notebooks, and pencils | What body parts do chemists need to protect?  
Which areas of our space will be “goggles on” areas?  
Which will be “goggles off?” |
Session 1: Get a Reaction!
Quick Guide

LAB PREP: INVISIBLE CHANGE (10 MINUTES)

<table>
<thead>
<tr>
<th>SECTION</th>
<th>DO</th>
<th>ASK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage</td>
<td>Gather in Meeting Room</td>
<td>What things did we mix together last session, and what new products did we make?</td>
</tr>
<tr>
<td></td>
<td>Review Session 1 idea: mixing substances to create new products</td>
<td>What different properties of this roll of tape could we describe?</td>
</tr>
<tr>
<td></td>
<td>Introduce Session 2 idea: observing properties and change</td>
<td>Which properties of this tape could change? How?</td>
</tr>
<tr>
<td></td>
<td>Connect to student experiences of properties using classroom object (tape roll)</td>
<td>Where else have you seen something change? What property changed?</td>
</tr>
<tr>
<td>Explore</td>
<td>Review chemist skills: observing, predicting, describing</td>
<td>What do you notice about the items on this tray?</td>
</tr>
<tr>
<td></td>
<td>Students make observations about 3 liquid cups and paper strips</td>
<td>What properties of the strip might change when it is dipped in the water?</td>
</tr>
<tr>
<td></td>
<td>Introduce liquid as water; students predict effect when strip is dipped in first cup</td>
<td>What could explain why the strips turned different colors from each cup?</td>
</tr>
<tr>
<td></td>
<td>Dip strip; students observe results</td>
<td>How did adding vinegar affect what happened?</td>
</tr>
<tr>
<td></td>
<td>Repeat with remaining cups</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Students predict effect of adding vinegar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Add vinegar to each cup and re-test</td>
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</tbody>
</table>

CONTINUED >
## LAB PREP: INVISIBLE CHANGE continued

<table>
<thead>
<tr>
<th>SECTION</th>
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</thead>
</table>
| Reflect | • Connect to experiences with acids  
• Introduce acidity as a property we can’t see  
• Introduce strips as tools for measuring acidity  
• Introduce acidity (pH) chart  
• Highlight everyday examples of acids and bases  
• Students draw conclusions about 3 water samples | Where have you seen or heard of acids before?  
How can we study how acidic something is, if we can’t see acidity?  
How do the strips show us how acidic something is?  
Which colors mean more acidic? What makes you think that?  
Was this water acidic, basic, or in the middle? How can you tell? |
## Session 1: Get a Reaction!
### Quick Guide

### WATER WATCHERS (35 MINUTES)

<table>
<thead>
<tr>
<th>SECTION</th>
<th>DO</th>
<th>ASK</th>
</tr>
</thead>
</table>
| **Engage** | • Gather in **Meeting Room**  
• Introduce Water Chemist career  
• Introduce storyline of cleaning contaminated river water | **What do you think a water chemist does?**  
**Why do you think observing and making changes to water might be important?**  
**What properties of water might we look at to tell if it is clean and healthy?** |
| **Explore** | **Observation**  
• Gather in **Lab; goggles on**  
• Give teams a water sample  
• Students make, record, and discuss observations  
• Summarize goal: find ways to make the water as clean as we can | **Do you think this water sample is clean? What makes you think that?** |
| **Explore** | **Filtration**  
• Introduce supply station materials  
• Students create and test methods for cleaning  
• Ask questions to encourage critical thinking  
• Students record tests and results  
• Gather in **Meeting Room**  
• Students share and discuss research findings so far | **What do you notice about your sample now?**  
**What could you do to get out the material that is left?**  
**What do you think will happen when you pour the sample through the cheesecloth?**  
**What solutions did you find for cleaning out the “sludge”?**  
**What about pollution that we can’t see?** |

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<thead>
<tr>
<th>SECTION</th>
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<th>ASK</th>
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<tbody>
<tr>
<td><strong>Explore</strong>&lt;br&gt;Acidity&lt;br&gt;гад&lt;br&gt;</td>
<td>• Review acidity and pH chart&lt;br&gt;• Summarize next goal: test cleaned sample and find ways to make it close to “green” (neutral)&lt;br&gt;• Return to Lab; goggles on&lt;br&gt;• Students test cleaned samples with pH strips&lt;br&gt;• Review pipette technique&lt;br&gt;• Students use reagents and well plates to test ways to neutralize the sample&lt;br&gt;• Students record results in notebook&lt;br&gt;• Ask questions to encourage critical thinking</td>
<td>What do you remember about how to use a pipette?&lt;br&gt;What happened to the acidity when you added the baking soda? How can you tell?&lt;br&gt;How much more do you think you will need to add to get it to “green?”</td>
</tr>
<tr>
<td><strong>Reflect</strong></td>
<td>• Gather in Meeting Room with notebooks&lt;br&gt;• Share research findings&lt;br&gt;• Connect student results to storyline</td>
<td>What did you find out about the acidity of your sample?&lt;br&gt;Was the factory water sample polluted? What evidence do we have?&lt;br&gt;What solutions could we give for how to clean it up?</td>
</tr>
</tbody>
</table>
### Session 1: Get a Reaction!

**Quick Guide**

**COLOR CREATORS** *(40 MINUTES)*

<table>
<thead>
<tr>
<th>SECTION</th>
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<th>ASK</th>
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</table>
| **Engage** | • Gather in Meeting Room  
• Introduce Color Chemist card  
• Introduce storyline of creating colors for Nature Inks at paint company  
• Summarize the goal: test two natural products for color and change them to create as many colors as possible | What do you think a color chemist does?  
Why do you think creating colored substances is useful?  
How might we try to make paint from a flower or piece of plant? |
| **Explore**  
Research  
🔍 | • Gather in Lab; goggles on  
• Students observe whole cochineal and flower samples  
• Students predict what colors they might create | What part of nature do you think this comes from?  
What color do you think it might create?  
How could we get the color out and turn it into paint? |
| **Explore**  
Tools and Techniques | • Demonstrate mortar/pestle technique  
• Teams grind one sample type  
• Students add water by pipette as needed | What do you notice about your sample? How is it changing? |

CONTINUED >
### COLOR CREATORS continued

<table>
<thead>
<tr>
<th>SECTION</th>
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<th>ASK</th>
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</thead>
<tbody>
<tr>
<td><strong>Explore</strong></td>
<td>• Gather in <strong>Meeting Room</strong></td>
<td>What color ink did your sample create?</td>
</tr>
<tr>
<td></td>
<td>• Discuss research findings</td>
<td>What could we do to change the color of these inks?</td>
</tr>
<tr>
<td></td>
<td>• Connect to pH strips and acid-base color changes</td>
<td>Have we seen anything else in our research that changed colors?</td>
</tr>
<tr>
<td></td>
<td>• Return to <strong>Lab; goggles on</strong></td>
<td>What change did you notice from 10 drops of baking soda? What if you added only 5 drops?</td>
</tr>
<tr>
<td></td>
<td>• Review pipette technique</td>
<td>How could you make a color that is in between those two colors?</td>
</tr>
<tr>
<td></td>
<td>• Pairs pipette sample liquid into a well plate</td>
<td>How could you make a lighter version of that color?</td>
</tr>
<tr>
<td></td>
<td>• Pairs add acid or base reagents to create color changes</td>
<td>How does your second sample compare to the first one?</td>
</tr>
<tr>
<td></td>
<td>• Students record results in notebook</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Teams switch sample materials and repeat with second sample type</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Ask questions to encourage critical thinking</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Students create color “sample chart” on watercolor paper strip</td>
<td></td>
</tr>
<tr>
<td><strong>Reflect</strong></td>
<td>• Gather in <strong>Meeting Room</strong> with notebooks</td>
<td>How many different colors did you find between you?</td>
</tr>
<tr>
<td></td>
<td>• Students share research findings with a new partner</td>
<td>What chemicals did you use to create them?</td>
</tr>
<tr>
<td></td>
<td>• Connect student results to storyline</td>
<td>What suggestions could we give about colors we’re still missing and where to look for them in nature?</td>
</tr>
</tbody>
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*GSK Science in the Summer™*  
In partnership with The Franklin Institute
Session 1: Get a Reaction!
Quick Guide

CLOSING REFLECTION (10 MINUTES)

<table>
<thead>
<tr>
<th>SECTION</th>
<th>DO</th>
<th>ASK</th>
</tr>
</thead>
</table>
| Reflect | • Gather in Meeting Room  
• Discuss experiences exploring properties and change  
• Reflect on experiences with water and color chemist careers  
• Students draw or write reflections in notebooks  
• Students add skills stickers to notebook | What are some times today when you tested what a material was like?  
What are some ways we made changes to a substance to solve a problem?  
What are some things we did today when we were being water chemists?  
How do you think it might be like what a real water chemist does?  
What did you do today that made you feel like a chemist? |
| Conclude | • Encourage group to consider chemistry careers and keep learning about science at home and in school  
• Encourage use of lab notebook at home with families  
• Share details of any family events  
• Thank GSK, Franklin Institute, and host site |  

Meeting Room

GSK Science in the Summer™
In partnership with The Franklin Institute
Research Lab

GSK Science in the Summer

In partnership with The Franklin Institute
Slime Formula

1 Spoonful of Glue + 1 Spoonful of Water

Mix Well

+ 1 Pipette-full of Borax Solution

Mix Again
pH Scale

1  2  3  4  5  6  7  8  9  10  11  12  13  14

- **acidic**
  - [vinegar]

- **neutral**
  - [water]

- **basic**
  - [baking soda]
Cochineal Insect
Butterfly Pea Plant