THE FRANKLIN INSTITUTE

Be a Chemist!

Be a Cosmetic Chemist

Educator Guide

Big Question:
How can cosmetic chemists design safe personal care products using ingredients found in nature?

GSK Science in the Summer™

In collaboration with GSK

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Be a Chemist! Big Ideas

These are the themes you'll find running through all five *Be a Chemist!* activities.

Chemistry is the "study of stuff"—what things are made of, how they behave, and how they change.

- What chemicals make up the materials in the world around us?
- How are substances alike or different?
- What happens when we mix substances together—do they stay the same or create something new?

All substances in our world are made of chemicals—and chemists help us understand and use them safely and effectively.

- How can we use chemistry to solve problems or invent something new?
- How can we test products to make sure they are safe for us to use?

To learn more about the cosmetic chemist career and the science behind this activity, look for the "Background" section at the end of the activity procedure.

Core Four Strategies

Use the Core Four Strategies as you guide your learners through this activity.

- **Ask questions** to spark curiosity and encourage new ideas
- **Encourage scientific thinking** with chances to observe, make predictions, and test ideas
- **Cultivate rich dialogue** with chances to talk together, share ideas, and use science words
- **Make connections** between learners' experiences, science careers, and this activity

Ask Questions

Encourage Scientific Thinking

Cultivate Rich Dialogue

Make Connections

Be a Cosmetic Chemist

Big Question: How can cosmetic chemists design safe personal care products using ingredients found in nature?

Materials:

Per class:

- Cosmetic chemist career card
- Distilled white vinegar (acetic acid)
- Baking soda (sodium bicarbonate)
- Tablespoon measure
- Funnel (for filling squeeze bottles)
- Bin or bucket for waste (optional)
- Lab notebooks
- Pencils
- Science skills stickers

Per group of 3–4 learners:

- pH test strips (3-4)
- Plastic tray
- Well plates (3-4)
- White paper (3-4 sheets)
- Pipettes (3-4)
- 4 oz squeeze bottles (3)
- Toothpicks (several per group)
- Mortar and pestle (2)
- Dried cochineal shells (2-3)
- Dried butterfly pea flowers (2-3)

Prepare:

1. For each group, prepare a set of liquid materials:
   - Fill one squeeze bottle with water (dihydrogen monoxide).
   - Fill one squeeze bottle with vinegar (acetic acid).
   - Fill the remaining bottles half-full with water. Add 2 tablespoons of baking soda (sodium bicarbonate) to each. Stir until the powdered baking soda is completely dissolved.
   - Clearly label every bottle with both the chemical name and the common name of what's inside.
2. For each group, put 2-3 cochineal shells in one mortar bowl and 2-3 butterfly pea flowers in a second mortar bowl.

Safety Note

In very rare cases, cochineal can trigger a serious allergic reaction. Anyone with a known sensitivity to carmine red or other food dyes should avoid contact with the cochineal shells or liquid made from them. At the start of this lesson, ask your learners if anyone has a known allergy or avoids eating foods with red food coloring.

Engage (10 min)

Describing the career photo out loud assists learners who are blind or low vision, provides vocabulary support for language learners, and helps with visual processing.

Example: "This photo shows a scientist wearing gloves and safety glasses using some kind of syringe or tool. There are some tubes of colored liquid and other lab equipment nearby."

1. Introduce the cosmetic chemist career by showing the group the career card and describing the picture on the card. Ask questions to encourage learners to think about what a cosmetic chemist might do:
   - What do you notice about this picture? What do you think this person is doing?
   - Where do you see chemicals in this picture? Where do you see science tools?
   - What do you think of when you hear the words "cosmetic" or "chemist"? What does the name "cosmetic chemist" make you think of?
   - What do you think a cosmetic chemist might do or study? What makes you think that?
2. Explain that cosmetic chemists create personal care products, like shampoo, lotion, soap, and makeup. They carefully mix ingredients to create products that are safe, work well, and feel good to use. Ask:
   - What kinds of products do you use that a cosmetic chemist might have helped make?
3. **Introduce the storyline like this:**
   - We are a team of cosmetic chemists hired to create colorful dyes for products like skin care, makeup, and face paint.
   - Our job is to make dyes from two natural materials, test how well they work, and determine if they are safe for people to use.
   - How do you think cosmetic chemists make products with different colors or textures?
   - Why do you think it's important that these products are safe to use?

Explore (40 min)

Part 1: Investigating Natural Materials

1. Establish safety guidelines.

Explain that while all the materials in this activity are safe to touch, it's still important to follow basic lab safety rules:

- Don't touch your face and eyes. Some materials might cause irritation if they get into your eyes.
- Wash your hands with soap and water when you're finished.

Continued on next page

- Never taste or put any of the materials in your mouth. These are for experimenting, not eating!
- The plastic tray will be your "lab" space. All the liquids and other materials should stay inside the lab (on the tray).

2. Divide your learners into groups of 3-4. Give each group a tray and a set of mortar bowls. **Don't name the materials inside them yet!**

3. Invite learners to investigate the materials. They can take them out of the bowls for a closer look – but they should stay on the "lab" tray.

- What do you notice?
- 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 sample is the dried shell of an insect called the **cochineal** (kah-chin-EE-ul) from South America. The other is the dried flower of a plant from Asia called the butterfly pea. Invite learners to look at photos of each on page 5 of their lab notebooks.

Some learners may feel uneasy about using insect shells. You can share that cochineal bugs have been used for hundreds of years to make red dye in foods, clothes, and even some cosmetics. The bugs are tiny, and the shells are completely dried and safe to handle. Let learners know it's okay to be curious or a little grossed out—scientists often study surprising things to learn more about the world!

5. Prompt learners to brainstorm how they might turn these natural materials into dyes:

- What is dye like? What does it need to be able to do?
- How could we get color out of the materials?
- What kind of liquid should we add? What makes you think that?

6. Explain that now they will make dye pastes by crushing each material and adding water.

- Pass out the pestles (one for each mortar bowl) and squeeze bottles of water.
- Direct learners to crush materials in the mortar bowls by grinding with the pestles.
- After crushing, use squeeze bottles to add just a few drops of water to each cup and stir with a toothpick to create a paste.

7. Ask learners to observe the color in each cup and record their observations on page 5 of their notebooks. Ask:

- What color did each material make?
- Is it what you predicted? Why or why not?

Part 2: Color Testing

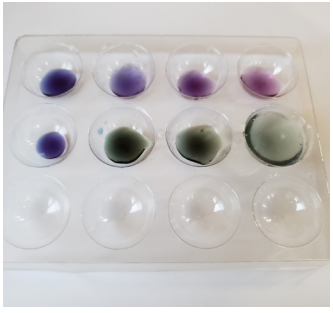
1. Explain that they can now experiment with their dye pastes to see how many colors they can create. Ask:
   - What do you think we could add or change to make the dyes turn different colors?
   - Have we seen anything in past experiments change color? What caused it?

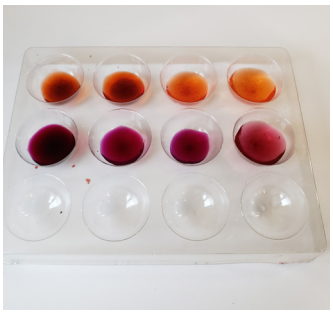
> **Note:** Highlight that people can experience color in different ways. If some learners have challenges with distinguishing or naming colors, remind them that scientists work in teams, and they can rely on the rest of their team for that piece of the work!

2. Distribute the following to each group:
   - 1 squeeze bottle of baking soda solution
   - 1 squeeze bottle of vinegar solution
   - Well plates (one per learner)
   - Pipettes (one per learner)
   - White piece of paper to go under the well plate (one per learner)
   - Several toothpicks (per learner)
3. Guide learners to begin testing the first chemical as follows:
   - Choose the first material (either cochineal or butterfly pea) to test and use a pipette to add some of the liquid from the mortar bowl to the top row of wells of the well plate.
   - If there isn't enough liquid in the mortar bowls, they can add a little more water from the squeeze bottle.
   - Add 1-2 drops of either vinegar or baking soda solution to the first well.
   - Closely observe what happens and record the color change on page 6 of their lab notebook.
   - Learners may use a toothpick to transfer a drop from the well onto the chart in their notebook to document the actual color.

> You may need to pause here to demonstrate proper pipette use. Show learners how to place the pipette tip into the liquid, then gently squeeze and release the bulb to draw the liquid up. Encourage them to practice a few times to get comfortable before continuing with the activity.
>
> If learners have shaky hands or dexterity challenges, you can show them how to support their arm with their opposite arm or by resting it on the table.

4. Encourage learners to try different amounts of chemicals to create different shades.
   - How many different shades or colors can you make?
   - How is the color different when you add baking soda versus vinegar?
5. Then, encourage learners to repeat the process with the second natural material, using the second row of the well plates.

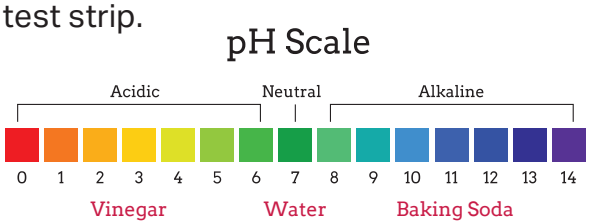




Part 3: Safety Testing

For younger learners, or if you're short on time, you can skip Part 3.

1. Explain that now they will need to find out whether they're safe for use on skin, like in face paints or makeup. To do this, learners will need to test the pH of each mixture with a tool scientists created called a pH test strip.



2. Introduce the pH scale on page 7 of their notebooks and explain:
   - The pH scale measures how acidic or basic a substance is.
   - You may need to clarify that "basic" can have other meanings at other times, but in chemistry it just means "the opposite of acidic."
   - A low number (1-6) means something is acidic. Common acids are vinegar, lemon juice, and many things that taste sour. The test strip shows red or orange colors for acidic things.
   - A high number (8-14) means something is basic. Common bases are baking soda, soap, and things that feel slippery or taste bitter. The test strip shows dark blue, purple, or black colors for basic things.

Tip: The pH test strips are often longer than needed for this test. To reduce waste, you (or learners) can cut or tear the strips in half and use a half-size strip for each test.

   - A middle number (around 7) means it's neutral, like clean water. The test strips show greenish colors for neutral things.
   - Most skin care products are slightly acidic to neutral, with a pH between 4.5 and 7.5. If something is too acidic or too basic, it might irritate your skin.

3. Demonstrate how to use the pH strip by testing it in a cup of clean water. Dip one end of the test strip about halfway into the water and wait a few seconds for the color to develop. Have learners observe and describe the result.
   - What color do you notice?
   - What does it tell you about the pH of the water?

4. Distribute 3-4 pH strips to each group and ask them to predict the pH of colors in their wells based on what chemicals they used. Then direct them to test each color and compare the results to the pH chart.
   - Which ones do you think might be more acidic or more basic?
   - What makes you think that?
   - How did the results match your predictions?
   - Which colors are safe to use? Which ones might need adjusting?

Optional extension: Have learners create test strips on white paper to showcase the different colors they produced.
- Using a pipette or toothpick, they should place a large drop of each color onto a piece of paper.
- Ask them to label or number each drop so they can identify which combination of material and chemical created each color.

Reflect (10 min)

1. Bring the group together to discuss their results and showcase the colors they created.
   - How many colors were they able to create with the dye pastes?
   - Which of the dye and chemical combinations worked the best? Why?
   - Did someone get a color that others don't have? How did they get that color?
   - Was there a difference in how many colors were able to be created using the cochineal dye paste versus the butterfly pea flower dye paste?
   - Were any dyes ruled out as unsafe? How did you determine that?
2. Encourage the group to reflect on how they were like cosmetic chemists during the activity. Refer to the career card and the science skills stickers:
   - What are some things you did today that a cosmetic chemist might do?
   - How did you think like a scientist?
   - What did you do today that made you feel like a scientist? What science skills did you use?
3. Allow time for learners to draw or write their reflections on page 7 of their lab notebooks. Invite them to choose a science skills sticker that reflects a skill they used and add it to their notebooks.

Cleanup

- Liquid waste can be safely poured down the sink.
- Solid waste can be disposed of in the trash.
- Rinse mortars, pestles, and well plates thoroughly with water to remove any colored pigment before reuse.

Background

Cosmetic chemists are scientists who create the products we use for personal care, like shampoo, lotion, lip balm, makeup, and face paint. They mix different ingredients together to make sure these products work well, look and smell nice, and are safe for people to use. For more information, visit the American Chemical Society's page about careers with a focus on personal care: https://www.acs.org/careers/chemical-sciences/fields/personal-care.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 bright 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 comes from a chemical compound called carminic acid. 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).

Butterfly pea (Clitoria ternatea) is a flowering vine native to Southeast Asia. It is used in teas and other beverages because of its color-changing properties. Its color comes from 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).

Be a Cosmetic Chemist Quick Guide

EDUCATORS DO:	EDUCATORS ASK:	LEARNERS DO:
ENGAGE		
Introduce Career • Use career card • Ask discussion questions • Explain what cosmetic chemists do	What do you notice about this picture? What do you think this person is doing? What do you think a cosmetic chemist might do or study?	• Make observations about the image • Make connections to their own experience • Share their ideas
Introduce Story • We are a team of cosmetic chemists hired to create colorful dyes for products like skin care, makeup and face paint • Our job is to make dyes from two natural materials, test how well they work, and determine if they are safe for people to use	How do you think cosmetic chemists make products with different colors or textures? Why do you think it's important that these products are safe to use?	• Imagine being a cosmetic chemist • Share ideas about how chemists create colors
EXPLORE		
Part 1: Investigating Natural Materials • Introduce the cochineal shells and butterfly pea flowers • Distribute dye paste making materials	What do you notice about the materials? What part of nature do you think this comes from? What color ink do you think it might make? What makes you think that?	• Make observations about cochineal shells and butterfly pea flower • Predict what color dye they might make • Create dye pastes

**Quick Guide continues on the following page.*

Be a Cosmetic Chemist Quick Guide

EDUCATORS DO:	EDUCATORS ASK:	LEARNERS DO:
Part 2: Color Testing • Distribute color testing materials • Guide learners as they experiment with making colored dyes by mixing different amounts of baking soda solution and vinegar solution	What do you think we could add or change to make the dyes turn different colors? What did you notice about adding different amounts of vinegar or baking soda? How many different shades or colors can you make?	• Experiment with chemicals to change colors • Test different amounts of chemicals to create different colors
Part 3: Safety Test • Introduce the pH scale • Guide groups to test the safety of their dyes	Which colors are safe to use? Which ones might need adjusting?	• Measure pH of dyes to test for safe use
REFLECT		
Share Group Results	How many colors could you create with the dye pastes? Was there a difference in how many colors you created using the cochineal dye paste versus the butterfly pea flower dye paste? Were any dyes ruled out as unsafe? How did you determine that?	• Share and compare results • Reflect on the process • Draw conclusions
Make Career Connections	What did you do today that made you feel like a cosmetic chemist? How did we think like scientists? What science skills did we use?	• Use skills stickers • Draw/write reflections

Acknowledgments

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Notes