THE FRANKLIN INSTITUTE

Be a Chemist!

Be a Water Chemist

Educator Guide

Big Question:
How can water chemists clean polluted water to make it safe for people and the environment?

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 water 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 Water Chemist

Big Question: How can water chemists clean polluted water to make it safe for people and the environment?

Materials:

Per class:

- Water chemist career card
- Potting soil (approx. 1.5 cups)
- Vegetable oil (approx. 1.5 cups)
- Baking Soda (approx. 1 cup)
- Water
- Coffee filters (1 pack)
- Tissue paper (several sheets)
- Paper towels (1 roll)
- Funnels (5-8)
- Spoons (2-3)
- ¼ measuring cup
- Adult scissors
- Distilled white vinegar (acetic acid)
- Lab notebooks
- Pencils
- Science skills stickers

Per group of 3–4 learners:

- pH test strips (3-4)
- Pipettes (4)
- Well plates (4)
- 9 oz clear plastic cups (2)
- Container with lid, 16-32 oz (1)
- 4 oz squeeze bottles (2)
- Plastic tray (1)

Prepare:

1. Create a "polluted" water sample for each group of 3-4 learners as follows:
   - Mix together approximately ¼ cup of potting soil and ¼ cup vegetable oil in a flat, plastic container to create a thick "sludge."
   - Fill the container half- to ⅔-full with water and add ¼ cup of vinegar.
   - Stir to mix, and place the lid on the container.
   - Label the container "River Sample."
2. Prepare vinegar and baking soda mixtures as follows and set up on a plastic tray (one set per group).
   - Fill half of the squeeze bottles with vinegar.
   - Fill the remaining bottles half-full with water. Add 2 tablespoons of baking soda (sodium bicarbonate) to each. Stir or gently swirl until the powder is completely dissolved.
   - Label the bottles "Vinegar" and "Baking Soda Solution", accordingly.
3. Cut the tissue paper and paper towels into approximately 4-inch squares, preparing enough for 2–3 squares of each material per group.
4. Set out the filtration materials (coffee filters, tissue paper, paper towels, funnels, clear plastic cups) in a designated area that learners can easily access.
5. Fill 2-3 cups about half full with water and set aside, along with 1-2 pH test strips to use for demonstration.

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 group of scientists standing near a river. One of them is holding an open laptop and another one is holding a large tube that is connected to the laptop with a wire. The scientists are looking at something on the laptop screen."

1. Introduce the water 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 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?
2. Explain that a water chemist studies what's in our water to find out if it's clean or polluted. They test for different chemicals in the water to make sure it's safe to drink and healthy for the environment.
   - What type of water do you think a water chemist might test?
   - Why do you think it's important to test the water around us?
   - Why do we need to keep our water clean?

3. **Introduce the storyline like this:**
   - We are a team of water chemists, and it's our job to check the water in local rivers and lakes to make sure it's clean and safe. Clean water is important for the animals that live there—and for people too, since it's used in our homes for drinking and washing.
   - We just received some water samples from a river near a factory. Someone reported that the factory might be leaking pollution—chemicals that don't belong—into the river.
   - Now it's up to us to find out if its water is clean or polluted. If it is polluted, we'll need to test some ways to get it as clean as possible again to help protect the environment.
     - How do you think we might tell if the water is clean and healthy?
     - How could we tell if it isn't clean?
     - What might we look for in the water?
     - What about things we can't see—how can we test for those?

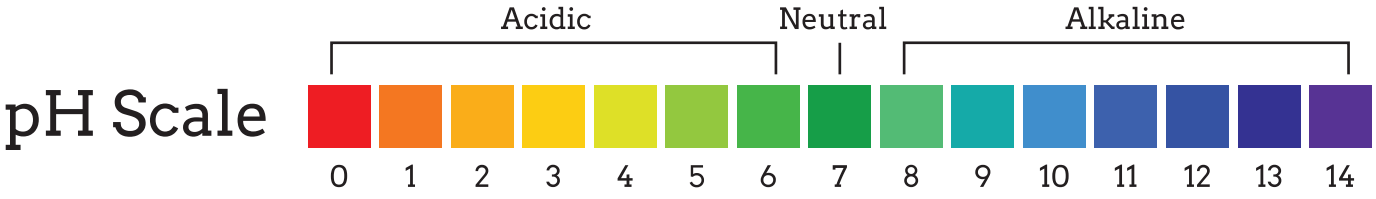
Explore (40 min)

Part 1: Test the Water Sample

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.
- 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).

1. Divide learners into groups of 3-4 and give each group a "River Sample." Ask them to observe the sample closely using their senses. Prompt with questions like:
   - What does the water look like?
   - What does it feel or smell like?
   - How does it compare to clean water?
2. Have learners write or draw what they notice on page 21 of their lab notebooks. Then invite them to share their observations with the whole group. Discuss ways they could clean the water.
3. Explain that there may be pollutants in the water that we can't see, but scientists have invented tools to help us - like pH strips, which measure how acidic or basic a substance is.
4. Introduce the pH scale on page 23 of the lab notebook and explain:
   - The pH scale measures how acidic or basic a substance is. The word "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.
   - A middle number (around 7) means it's neutral, like clean water. The test strips show greenish colors for neutral things.
5. 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, remove it, 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 this water?
6. Distribute 1-2 pH strips to each group and put cups of clean water out where groups can easily access them. Ask them to predict how they think the pH of their polluted sample will compare to the clean water.



8. Guide groups to test both the clean water and their river sample. Instruct them to compare the colors of both test strips to the chart on page 23 of their lab notebook. Ask:
   - Is your polluted water sample neutral, like it should be, or is it too acidic or too basic?
   - How can you tell?
9. Have them label their test strips with a pencil to keep track ("P" for polluted water and "C" for clean water) and set them aside to compare with later.

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.

Part 2: Filter the Water Sample

1. Explain that each group will design and test a system for separating the clean water from the pollution. Introduce the materials station and encourage to brainstorm ideas:
   - Which materials might trap pollution but let water through?
   - Which combinations might work best?
2. Have groups send one member to collect initial materials. Let them know they can come back for additional materials, as needed.

Encourage learners to be mindful of how much material they use. Cleaning up pollution in the water by making a pile of trash instead just creates another problem!

3. Guide groups to choose a design and begin building and testing. Visit each group to ask:
   - What's your plan? What is changing as you test?
   - How does the filtered sample look, feel, and smell?
   - How does your filtered water compare to the original sample?
   - Is it cleaner than before? How do you know?
4. Give groups time to test and change their design. As they improve and retest their designs, encourage deeper thinking:
   - What might filter out even more pollution?
   - Is there a material or idea you haven't tried yet?

Part 3: Restoring pH Balance

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

1. After about 15 minutes, pass out 1-2 new pH strips. Ask learners to predict how they think the pH of their sample might have changed, then test it and observe the results.
   - What color or number does the test strip match? Is it different than your first test?
   - What does that tell you about your cleaning method?
   - Have them label this third strip F for filtered and set it aside with the others.
2. Explain that even clear-looking water can still be unsafe if the pH is not within a healthy range. Our job as water chemists isn't just to clean the water — it's also to help restore the balance so it's safe for animals, plants, and people.
3. Reintroduce the pH scale (on pg. 23) as a reference tool. Tell learners that now they will try to change the pH of their filtered water samples using safe chemicals—just like water chemists might do in a lab or water treatment facility. These chemicals won't remove pollution, but they might help neutralize, or balance out, the acidity to change the water back into a safe pH range.
4. Distribute squeeze bottles of baking soda and vinegar solution, well plates, and pipettes to each group. Introduce the procedure:
   - Use a pipette to add some of their cleaned water sample into one the wells.
   - Choose one chemical (either baking soda or vinegar) and add a few drops to the water sample in the well.
   - Test with the pH strip.
   - Repeat in a new well of the well plate to try a different type or amount of chemical.
5. Ask questions to help learners draw conclusions about their experiments:
   - Which combinations helped move the pH closer to neutral?
   - Was it easier to fix a sample that was too acidic or too basic?
   - How did you decide how much of each solution to add?

Remind learners that it's normal to try many times and not always get it right! Testing, making changes, and trying again is all part of doing science!

Reflect (10 min)

1. Bring the group together to discuss their results:
   - Which materials and design worked best for filtering the water to separate out the pollution?
   - What did you find out about the pH of the water sample?
   - Which chemicals helped make the water less acidic?

1. Encourage the group to reflect on how they were like water chemists during the activity. Refer to the career card and the science skills stickers:
   - What are some things you did today that a water 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?
2. Allow time for learners to draw or write their reflections on page 23 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

- Skim or scoop off any remaining soil and oil from liquid waste before pouring it down the sink to avoid clogging drains.
- All solid waste can be disposed of in the trash.
- Well plates, funnels, and cups should be washed with soapy water to remove leftover oil before reusing.

Background

Water chemists study 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/careers/chemical-sciences/fields/water-chemistry.html

Separating components from a mixture is an important part of chemistry research and practice. Chemists might need to purify a substance by removing contaminants, or collect the desired product of a chemical reaction from a mixture of leftover starting materials and 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 at all 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:** If the substances are more intermingled, they can be separated by filtering through a material that traps some components of the mixture while allowing others to pass through. 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 (like a positive or negative charge) to attract some substances but not others.
- **Distillation** separates a liquid from a mixture 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.

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Be a Water Chemist Quick Guide

EDUCATORS DO:	EDUCATORS ASK:	LEARNERS DO:
ENGAGE		
Introduce Career • Use career card • Ask discussion questions • Explain what water chemists do	What do you notice about this picture? What do you think this person is doing? What do you think a water 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 water chemists, and it's our job to check the water in local rivers and lakes to make sure it's clean and safe • It's our job to find out if water from a local river is polluted and test some ways to get it as clean as possible again to help protect the environment	How do you think we might tell if the water is clean or polluted? What might we look for in the water? What about things we can't see—how can we test for those?	• Imagine being a water chemist • Discuss ideas about how to tell if water is clear or polluted

***Quick Guide continues on the following page.*

Be a Water Chemist Quick Guide

EDUCATORS DO:	EDUCATORS ASK:	LEARNERS DO:
EXPLORE		
Part 1: Testing the Water Sample • Guide learners to make observations about the water sample • Introduce the pH scale	What does the water look like? How does it compare to clean water? Is your polluted water sample neutral, like it should be, or is it too acidic or too basic? How can you tell?	• Make observations about the water sample • Test the pH of the water sample
Part 2: Filtering the Water Sample • Introduce the filtration materials and challenge • Encourage learners to test and change their design	Which materials might trap pollution but let water through? What's your plan? What changing as you test? Is there a material or idea you haven't tried yet?	• Design and test ways to filter the water sample
Part 3: Restoring pH Balance • Reintroduce the pH scale and testing strips • Guide learners to explore changing the pH of the filtered water	Which combinations helped move the pH closer to neutral? Was it easier to fix a sample that was too acidic or too basic? How did you decide how much of each solution to add?	• Test ways to neutralize the sample's pH
REFLECT		
Share Group Results	Which of the materials and design worked best for filtering the water? What did you find out about the pH of the water sample? Which chemicals helped make the water less acidic?	• Share results • Reflect on testing process • Draw conclusions
Make Career Connections	What did you do today that made you feel like a water chemist? How did we think like scientists? What science skills did we use?	• Use skills stickers • Draw/write reflections

Notes