

Be a Chemist!

Be a Medicinal Chemist

Educator Guide



Big Question:

How can medicinal chemists design and control chemical reactions to create new products?

Table of Contents

Use the list below to help you navigate this guide!

03 *Be a Chemist!* Big Ideas

Find this year's main themes and the Core Four facilitation strategies.

04 **Be a Medicinal Chemist**

Find detailed instructions for facilitating this activity.

10 **Be a Medicinal Chemist Quick Guide**

*Find a summary of the content, as well as a QR code to the *Be a Chemist!* webpage.*

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 medicinal 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 Medicinal Chemist



Big Question: How can medicinal chemists design and control chemical reactions to create new products?



Materials:

Per class:

- Medicinal chemist career card
- Antacid tablets (1 box)
- Baking soda (sodium bicarbonate)
- Powdered sugar (sucrose)
- Cream of tartar (potassium bitartrate)
- Bottle of distilled white vinegar (acetic acid)
- Liquid dish soap
- Funnel (for filling squeeze bottles)
- Pen or marker (1)
- Water
- Bin or bucket for waste (optional)
- Lab notebooks
- Pencils
- Science skills stickers

Per group of 3–4 learners:

- 4 oz containers with lids (3)
- 4 oz clear plastic cups (2-4)
- 4 oz plastic squeeze bottles (2)
- Well plates (4)
- Craft sticks (4)
- Plastic tray (1)
- Mortar & pestle (optional, for Part 3)



Prepare:

1. Create a set of materials for each group of 3-4 learners:
 - a. In 4 oz containers with lids:
 - Fill one container about 1/3 to half full of baking soda (sodium bicarbonate)
 - Fill one container about 1/3 to half full of powdered sugar (sucrose)
 - Fill one container about 1/3 to half full of cream of tartar (potassium bitartrate)
 - b. In 4 oz squeeze bottles:
 - Fill one with distilled white vinegar (acetic acid)
 - Fill one with water (dihydrogen monoxide)
 - c. Label all containers and bottles clearly with the chemical and common names of the materials inside.
 - d. Once prepared, containers and squeeze bottles can be used for multiple sessions and refilled as needed.
2. Make craft stick scoops by drawing a line about ¼ inches from the end of the stick (about the width of a pencil). Make sure the line is dark and easy to see.
3. For Part 3: create a mixture of water with a squirt of dish soap in 4 oz clear plastic cups (2-4 per group). **Mix gently to avoid creating bubbles.**



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 safety glasses and gloves standing by a counter full of bottles and lab tools. They are holding a glass container in one hand and using a pipette to put some clear liquid into a different container on the counter."

1. Introduce the medicinal 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 medicinal 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 "medicinal" or "chemical"? What does the name "medicinal chemist" make you think of?
 - ❓ What do you think a medicinal chemist might do or study? What makes you think that?
2. Explain that a medicinal chemist studies chemicals to help create new medicines. They design and test substances to find out how they affect the body and how they can be used to treat diseases or help people feel better.
 - ❓ What types of medicines have you heard of?
 - ❓ Why do you think people need different medicines for different illnesses?
 - ❓ What do you think medicinal chemists need to learn or know to do their job?

3. Introduce the storyline like this:

- Imagine we are a team of medicinal chemists working 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? What does it do?
 - ❓ What can you guess from its name "ant"- "acid"?
 - ❓ How could we figure out how to make a medicine that works the same way as this one?

Explore (40 min)

Part 1: Research Tablet Reaction

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 the group into teams of 3-4. Each group should receive the following:

- Plastic tray
- Antacid tablet
- 4 oz plastic cup
- Squeeze bottle of water

2. Ask learners to carefully remove the antacid tablet from its package and observe it closely. They can write or draw what they notice on page 17 of their lab notebook. Use guiding questions to prompt observations, such as:

- ❓ What do you notice about the tablet?
- ❓ What does it look like?
- ❓ How does it feel?

3. Next, have learners break the tablet into four pieces. Ask them to place one piece into a 4 oz clear plastic cup and use the squeeze bottle to add a few drops of water. Encourage them to observe closely and describe any changes they notice right away.
4. Direct learners to keep adding water until the tablet piece is completely submerged. Encourage them to observe what happens next. Use guiding questions to prompt observations, such as:
 - ❓ How does the tablet change?
 - ❓ How does the water change?
 - ❓ What else do you notice?
5. Invite the group to record their observations in their lab notebook.



Part 2: Test Chemical Combinations

1. Explain that next it's time to test some different chemicals to find the combination that looks and behaves most like the antacid tablet they studied.

2. Distribute well plates (one per learner), a set of chemicals, and craft stick scoops to each group. Introduce the four chemicals they will be testing (vinegar, powdered sugar, baking soda, and cream of tartar) and ask:

❓ **Have you heard of these chemicals before?**

❓ **What might they be used for?**

3. Explain that they should start by choosing two chemicals to test together. Direct them to add a small amount of each chemical (a few drops or one small scoop) to the first well of the well plate.

- Demonstrate how to use the craft stick to scoop up a small amount of powder on the end with the marked line.
- Demonstrate how to squeeze the bottle gently, so only a few drops come out.
- Remind them to make sure the scoop or squeeze bottle tip doesn't touch any material that is already in the well plate to prevent contamination.

4. Direct learners to observe what happens and record their findings on page 18 of the lab notebook. Ask them:

❓ **Did the materials mix or change?**

❓ **What happens when you add water to them, like you did with the antacid tablet?**

To help younger learners stay organized, have everyone test the same chemical combinations simultaneously. This way, they won't get confused or forget which ones they've already tried.

5. Guide them to try different combinations of chemicals in each well and record the results in their notebook. As they explore, ask them to consider:

❓ **How well does each combination of chemicals match how the tablet looked and behaved?**

❓ **Is there a combination of two chemicals that behaves most like the tablet? What about a combination of three chemicals?**

❓ **Have you tried every possible chemical combination? How can you tell?**

6. When the group is finished testing all of the combinations, have them decide which combination of the chemicals they tested is the best choice for making a bubbling antacid tablet. Ask:

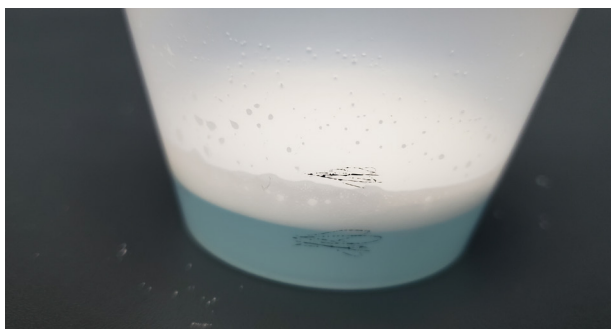
❓ **Why do you think it is the best choice?**

❓ **How does it compare to the antacid tablet you observed earlier?**

Part 3: Fine-Tune the Dose

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

1. Explain that for medicines, the dose, or amount of chemicals, is very important! Next they will need to figure out how much of each chemical is needed to create the same amount of bubbling as the antacid tablet.
 - ❓ **How will we know if the amount of bubbling is the same?**
 - ❓ **What could help us see the amount of bubbles the medicine makes?**
2. Introduce the dish soap and guide learners to think about how it could trap the bubbles from the reaction by making a foam. The amount of foam could show whether the reaction had more or less bubbling.
3. Explain that first they will need to find out how much foam the antacid tablet makes. Pass out the soapy water cups and introduce the procedure:
 - Take one of the pieces of tablet left from Part 1 ($\frac{1}{4}$ tablet) and crush it in the mortar and pestle until it becomes a fine powder—to make it similar to the powders in their other tests.
 - Add the powder to one of the soapy water cups and observe what happens.
 - Once the foam reaction has stopped, make a pencil mark on the outside of the cup at the highest point the foam reached.
4. Then guide learners to use the combination of chemicals they identified in Part 2 to try to match the foam height created by the tablet piece:
 - Predict how much of each chemical (baking soda, cream of tartar, etc.) they should use to get the same amount of foam as the crushed tablet.
 - Add those amounts to a second cup of soapy water.
 - Observe the reaction and mark the highest level of the foam.
 - Compare to the level on the original cup. Is it higher, lower, or the same?
5. As time allows, encourage groups to adjust their amounts and repeat the test as needed to match their dose as closely as possible to the tablet. For each test they should either rinse the cup thoroughly or use a clean cup.



Remind learners that it's normal to try many times before getting it right! Testing, making changes, and trying again are all part of doing science!

Optional extension: Once learners have a formula that matches $\frac{1}{4}$ of a tablet, encourage them to estimate the quantities needed to simulate a full tablet. Ask:

- ❓ **If one tablet piece equals $\frac{1}{4}$, how many pieces make a full tablet?**
- ❓ **How much of each ingredient would you need to scale up your formula to equal four pieces (a whole tablet)?**

Reflect (10 min)

1. Bring the group together to discuss their results:
 - ② Which of the chemical combinations worked the best? Why?
 - ② Which chemical combinations didn't work at all? Why do you think that happened?
2. Encourage the group to reflect on how they were like medicinal chemists during the activity. Refer to the career card and the science skills stickers:
 - ② What are some things you did today that a medical chemist might do?
 - ② How did you think like a scientist?
 - ② 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 19 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

- All liquid mixtures can be safely poured down the drain.
- Unused dry ingredients can be stored and reused for future sessions.
- Well plates and cups can be rinsed thoroughly with water and reused as needed.

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/careers/chemical-sciences/fields/medicinal-chemistry-pharmaceuticals.html>

Effervescent (bubbling) 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 mixture 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.

Chemists use a standard system of rules for naming chemical substances in a way that describes the arrangement of the atoms or molecules they're made from. 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 don't really refer to water as dihydrogen monoxide—they call it water like everyone else! However, that is its formal name in the standard naming system, and it's used in this activity to help make the point that all substances are chemicals and can have chemical names.

Acknowledgments

Authors: Tara L. Cox, Rachel Castro-Diephouse

Designers: Madeleine Bennett, Madelyn Lobb, James Bailey, Zeph David, Audrey Lee

Accessibility: Thanks to All Kinds Accessibility Consulting for auditing these resources and supporting the ongoing work of increasing inclusion and access to Science in the Summer™.

Sponsor: This program is made possible with the generous support of GSK and the contributions of their dedicated team.

Educators and Host Organizations: Thank you to the many organizations and their educators who host 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.

scienceinthesummer.fi.edu/be-a-chemist



Be a Medicinal Chemist Quick Guide

EDUCATORS DO:	EDUCATORS ASK:	LEARNERS DO:
ENGAGE		
<p>Introduce Career</p> <ul style="list-style-type: none"> • Use career card • Ask discussion questions • Explain what materials chemists do 	<p>What do you notice about this picture?</p> <p>What do you think this person is doing?</p> <p>What do you think a medicinal chemist might do or study?</p>	<ul style="list-style-type: none"> • Make observations about the image • Make connections to their own experience • Share their ideas
<p>Introduce Story</p> <ul style="list-style-type: none"> • Imagine we are a team of medicinal chemists working for a company that makes medicines • Our team has been assigned to try to create a new antacid medicine 	<p>Have you ever seen or heard of this kind of medicine? What does it do?</p> <p>What can you guess from its name "ant"- "acid"?</p> <p>How could we figure out how to make a medicine that works the same way as this one?</p>	<ul style="list-style-type: none"> • Imagine being a medicinal chemist • Discuss what they know about antacid

**Quick Guide continues on the following page.

Be a Medicinal Chemist Quick Guide



EDUCATORS DO:	EDUCATORS ASK:	LEARNERS DO:
EXPLORE		
<p>Part 1: Research Tablet Reaction</p> <ul style="list-style-type: none"> Introduce antacid tablets Distribute testing materials 	<p>What do you notice about the tablet?</p> <p>How does the tablet change?</p> <p>How does the water change?</p>	<ul style="list-style-type: none"> Make observations about antacid tablet Add water to tablet and observe results
<p>Part 2: Test Chemical Combinations</p> <ul style="list-style-type: none"> Guide learners test different chemicals to find the combination that looks and behaves most like the antacid 	<p>What happens when you mix the materials?</p> <p>How well does each combination of chemicals match how the tablet looked and behaved?</p> <p>Is there a combination of two chemicals that behave most like the tablet?</p>	<ul style="list-style-type: none"> Test different chemical reaction Make observations about how similar they are to the antacid reaction
<p>Part 3: Fine-Tune the Dose</p> <ul style="list-style-type: none"> Guide learners to recreate a chemical reaction that makes the same amount of foam as the antacid tablet 	<p>How much of each ingredient would you need to scale up your formula?</p>	<ul style="list-style-type: none"> Recreate the antacid reaction with a new formula
REFLECT		
<p>Share Group Results</p>	<p>Which of the chemical combinations worked the best? Why?</p> <p>Which chemical combinations didn't work at all?</p> <p>Why do you think that happened?</p>	<ul style="list-style-type: none"> Share results Reflect on the process Draw conclusions
<p>Make Career Connections</p>	<p>What did you do today that made you feel like a medicinal chemist?</p> <p>How did we think like scientists?</p> <p>What science skills did we use?</p>	<ul style="list-style-type: none"> Use skills stickers Draw/write reflections

