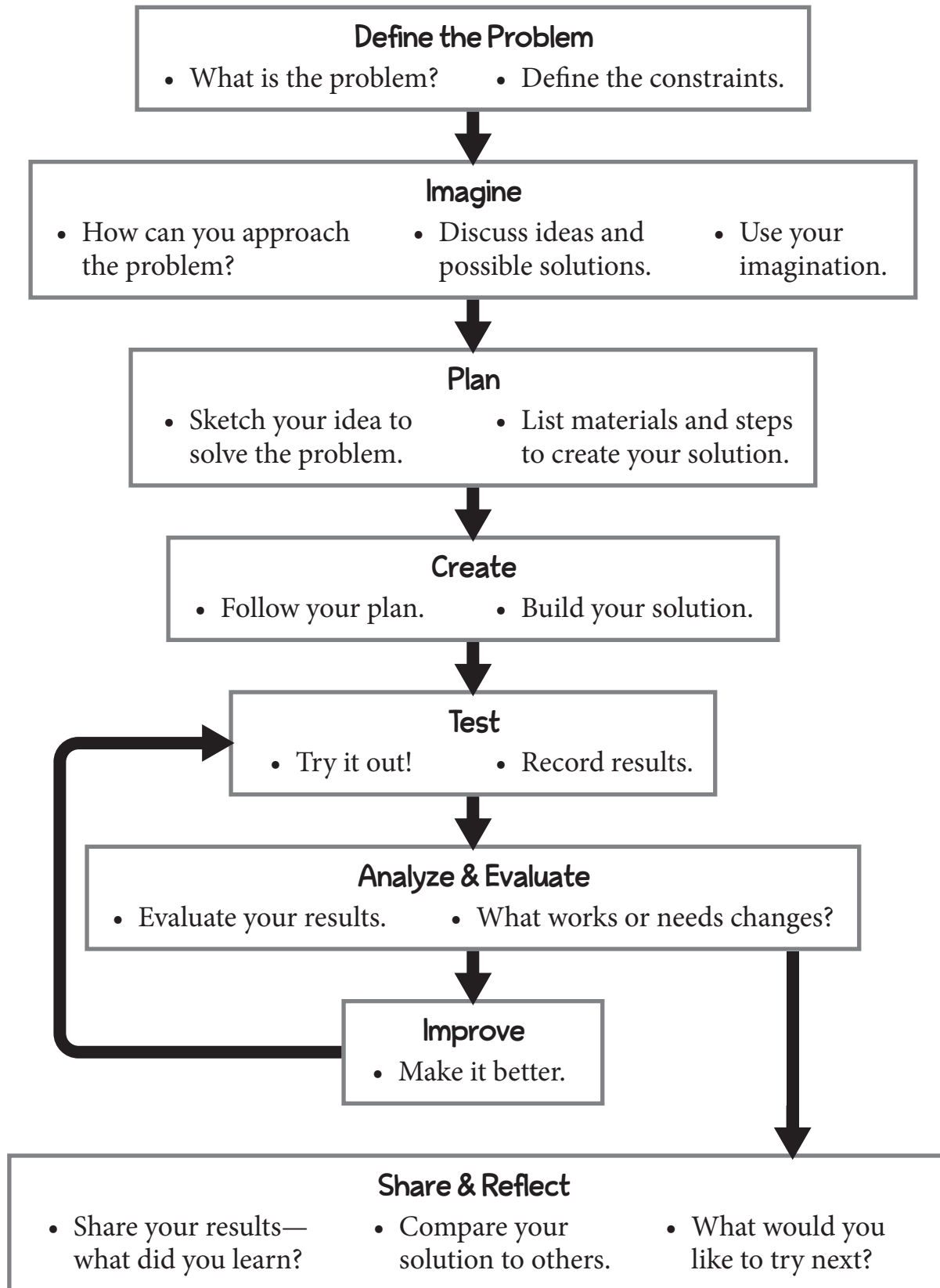




# Engineering Design Process

—a series of steps used by engineers to solve a problem—



# The Bubble Solution Investigation

## Objectives

Students will learn about surface tension through a series of hands-on activities. Students will then use the scientific process to find the best bubble-solution additive for making long-lasting bubbles.

## STEM Focus

**Life Science:** When two or more different substances are mixed, a new substance with different properties may be formed.

**Science Inquiry:** Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

**Science and Engineering Practices:** Ask questions and define problems; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; construct explanations.

**Crosscutting Concepts:** Cause and effect; energy and matter; scale, proportion, and quantity; stability and change

## Setup for Introduction and Mini Challenge

- ▶ Search “surface tension swimmer” online to find images that show swimmers as they stretch the surface of the water to create what looks like a glass bubble just before they break the surface tension.
- ▶ Set up two stations each for the three surface-tension activities, for a total of six stations. (See *Surface Tension Activity Cards* for materials needed.) Include copies of the Activity Cards at each station—one for each group (or student).
- ▶ Be sure that each student has his or her own straw so that students aren’t sharing germs.

## Setup for Main Challenge

- ▶ Make the bubble solution ahead of time. Gently mix  $\frac{2}{3}$  cup of dish soap into one gallon of warm water. Distilled water works best, but tap water will do if it isn’t too hard.
- ▶ Each group will need three cups, each labeled *Bubble Solution*. Pour one cup of basic bubble solution into each cup.
- ▶ For each group, premeasure additives into three smaller, labeled cups: one with 1 T. of glycerin, one with 1 T. of corn syrup, and one with 2 T. of sugar.

## Materials

### Introduction and Mini Challenge

- *Water Molecules* (page 54)
- *Surface Tension Activity Cards* (page 53)
- photo of swimmer (See Setup.)
- black pepper
- dish soap
- paper clips
- pennies
- plastic bowls, cups, and plates
- straws
- timer
- toothpicks
- water

### Main Challenge

- *Bubble Solutions Test* (pages 55–56)
- *Reflections—Bubble Solution Investigation* (page 57)
- dish soap
- glycerin
- light corn syrup
- paper towels
- plastic cups
- straws and pipe cleaners
- sugar
- water (distilled and tap)

## Time Frame

The Introduction and Mini Challenge should take about 45 minutes.

The first part of the Main Challenge will take about 40 minutes. The second part of the investigation should take about 45 minutes. Bubbles should be made the day before the activity.

Follow up with the Writing Reflection as time allows.

## Vocabulary

additive	mean
cohesion	reproducibility
conclusion	surface
control	surface tension



# The Bubble Solution Investigation



This challenge is best presented after the Seed Growth challenge, which introduces students to variables and scientific investigation.

## Introduction

1. Show students a photo of a swimmer as he or she stretches the **surface** (*top or outer layer*) of the water to create what looks like a glass bubble. Ask students:
  - What do you think is going on in the picture of the swimmer? (*Allow time for discussion.*)
2. Tell students that they will do three quick, hands-on activities, each for five minutes, to learn about the phenomenon that they see in the photo.

## Mini Challenge

1. Divide students into six groups—one for each station. Have each group move to a station and perform the activity at that station.
2. After 5 minutes, signal students to move to another station with an activity they have not yet completed. After 5 more minutes, signal again and have students move to their last activity station.
3. Have each group share with the class their results for each activity. As a class, discuss students' theories about why water behaves the way that it does.
4. Share the *Water Molecules* information sheet with the class. Take time to discuss the meaning of surface tension and review the graphics. Ask:
  - Does this information change your theories about water behavior? If so, how?
5. Ask students to focus on the pepper and penny activities. Ask:
  - What do you think soap does to water molecules?
6. Give students a few minutes to discuss this question in their groups. Then, have one member each group share their ideas with the class. (*Students will probably agree that soap breaks or lessens the surface tension of the water.*)

➡ Provide time for students to add soap molecules to the information sheet.

## Explain the Science

The soap molecules get between the water molecules at the surface and increase the distance between the water molecules. This decreases the pull that the water molecules have on each other, lowering the surface tension of the solution.

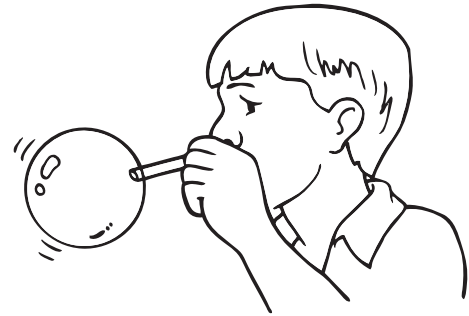
Tell students that this will play a part in the next investigation.

# The Bubble Solution Investigation

## Main Challenge

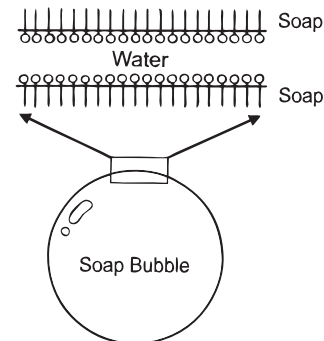
### Part 1—Blowing Bubbles

1. Provide each group with a small cup of water, a straw for each student, and some paper towels.
2. Tell students to dip the end of their straw into the water, lift it up, and try to blow a bubble on the end. Ask:
  - Can you explain why the water won't form a bubble?  
(*The surface tension of the water is too strong—it can't stretch, so it breaks.*)
3. Ask students how they could reduce the surface tension of the water. That's right—soap!
4. Show students the bubble solution you prepared earlier (the day before, if possible) and explain that you have added soap to the water. Provide each group with a small amount of pre-mixed bubble solution (about ½ inch deep in a small cup) and have them try blowing bubbles by dipping the ends of their straws in the solution, lifting the straw up, and blowing through it. They will need to blow gently at first.



### Explain the Science

Each bubble is formed by inner and outer layers of soap, with the water layer in the middle. The soap reduces the surface tension of the water, allowing it to stretch. Bubbles will eventually pop when the water is stretched too far, or if the water evaporates. It will also pop if the bubble comes in contact with something dry that breaks the surface tension.



5. Tell students that, in this investigation, they will add different substances to the bubble solution to see which one makes the largest bubbles. Ask students,
  - How would you measure a bubble floating in the air? (*They should conclude that it would be very difficult!*)
6. Have students try to blow a bubble on the dry surface of the table by dipping a straw into the bubble solution and blowing a bubble right onto the table. (*The bubble should pop very quickly.*)
7. Next, have students wet the surface of the table—they can just wet their fingers with a little bit of water and rub it on the table. Have them try blowing a bubble on the wet table. They should be able to blow a fairly large bubble.
8. Once their bubble pops, ask if they can measure the size of the bubble. (*They should see an outline of the bubble on the table that they can measure with a ruler.*)

# The Bubble Solution Investigation

## Main Challenge (cont.)

### Part 2—Preparing for the Tests

1. Tell students that you will give them three different substances that may make it possible for them to blow bigger bubbles. Explain that each **additive** (*added substance*) works in the same way—it slows the evaporation of the water so that the bubbles will last longer, allowing time to make them bigger before they pop. Students will test each substance to find which additive works best.

⇒ Write the word *additive* and its definition on the board.

2. Give each group three separate, labeled cups, each containing one cup of basic bubble solution.
3. Next, give each group three smaller, labeled cups containing the premeasured additives:
  - **Cup 1**—1 tablespoon of glycerin (available at drug stores)
  - **Cup 2**—1 tablespoon of corn syrup
  - **Cup 3**—2 tablespoons of sugar
4. Allow students to inspect the additives closely. They can touch each one with the tip of a finger and feel the textures. Remind students not to put any substances in their mouths.
5. Have students pour each additive into a different cup of bubble solution. Stir each mixture gently.
6. Give each group a copy of the *Bubble Solutions Test* recording sheets. Read through it together, and work with students to fill it in.

⇒ Have students fill in the investigation specifics as shown below.

**The question we will try to answer is:** Which bubble solution additive will make the biggest bubble?

**Hypothesis** (*what we think will happen*): Have students write what they predict the outcome will be. For example, “We think the glycerin will make the biggest bubbles.”

**Independent variable** (*the thing we will change*): The additive to the solution will change.

**Dependent variable** (*the thing we will measure*): The size of the bubbles will be measured.

**We will measure our dependent variable by:** We will measure the outline of the bubble on the table. (*Decide as a class whether to measure in inches or centimeters.*)

**Reminder:** Caution students to wipe away each outline after it has been measured and to slightly wet the table again to prepare for the next bubble.

**Controlled variables** (*everything else*): Ask students what other variables they can think of.

### Examples

- the strength of the blow
- the surface the bubbles are blown on
- the straw
- the temperature of the solution

# The Bubble Solution Investigation

## Main Challenge (*cont.*)

7. Explain that to really know which additive made the difference, everything else about how they create the bubbles must be the same. Also, they will test plain soap and water as a **control** to which they can compare the different additives.

**Materials:** Have students list all the materials they will use.

**Procedure:** Have students write out a step-by-step procedure for the investigation. Remind them that the aim of the procedure is **reproducibility**—another scientist reading this should be able to replicate the test.

## Part 3—Testing Bubble Additives

1. Give students time to perform their tests and to record their data. Keep plenty of paper towels handy!
2. Students should calculate the **mean** (*average*) bubble size for each additive and graph their data using the blank bar graph on their recording sheet.
3. Students should write their **conclusions** based on the analysis of their data. Remind them to state whether the results proved their hypothesis correct or incorrect.
4. Have each group present their hypothesis, data, and conclusions to the class.
5. As a class, discuss the results. Try to determine how successful each additive was versus the control, and which additive created the biggest bubbles.
6. Encourage students to cite evidence in their answers, such as, “More groups found that the glycerin made the biggest bubbles, so glycerin worked best.”
7. Just for fun, challenge students to test their best solution by blowing a bubble within a bubble. The secret is wetting the straw so that it will go inside a bubble without breaking it. See how many bubbles-within-bubbles they can make!

## Writing Reflection

- ⇒ Have students complete the *Reflections—Bubble Solution Investigation* writing reflection individually.

## Extensions

- Have students test different dependent variables, such as the longest-lasting bubble or the greatest number of connected bubbles.
- Have students engineer and test different bubble wands from materials such as straws, pipe cleaners, and string. They can try to make lots of small bubbles, really huge bubbles, or bubbles stacked into different formations.

# Surface Tension Activity Cards

## Activity 1–Will it Float?

### Materials

- 1 cup of water
- paper clip
- toothpick
- penny

1. Bend one end of a paper clip up slightly so that you can hold it.

2. Very gently lay the paper clip on the surface of the water.

→ Can you get the paper clip to float?      **Yes**      **No**

3. Next, gently lay the toothpick on the surface of the water.

→ Can you float the toothpick?      **Yes**      **No**

4. Finally, try to gently lay the penny on the surface of the water.

→ Can you float the penny?      **Yes**      **No**



## Activity 2–Penny Dome

### Materials

- 1 cup of water (labeled *plain water*)
- 1 cup of soapy water (labeled *soapy water*)
- pennies
- plate
- straw

1. Place a penny on the plate.

2. Dip one end of a straw about ¼ inch into the water, and place your thumb over the other end. This will keep a drop of water in the straw.

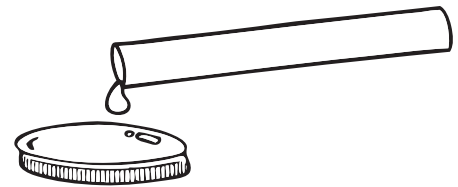
3. Next, keeping your thumb over the straw, move the straw so that the end with the water is just above the penny.

4. Release your thumb, and let the water drop onto the penny.

→ How many drops can you add before the water runs off the penny? \_\_\_\_\_ drops

5. Dry the penny off, and repeat the activity with soapy water.

→ How many drops could you add this time? \_\_\_\_\_ drops



## Activity 3–Pepper Party

### Materials

- bowl of water
- pepper
- dish soap (1 tsp. in cup)

1. Shake pepper onto the surface of the water, just enough so that there is an even coating.

2. Touch your finger gently to the surface of the water in the center of the bowl.

→ What happens? \_\_\_\_\_

3. Put a tiny bit of soap on your finger, and dip it into the center of the water again.

→ What happens? \_\_\_\_\_

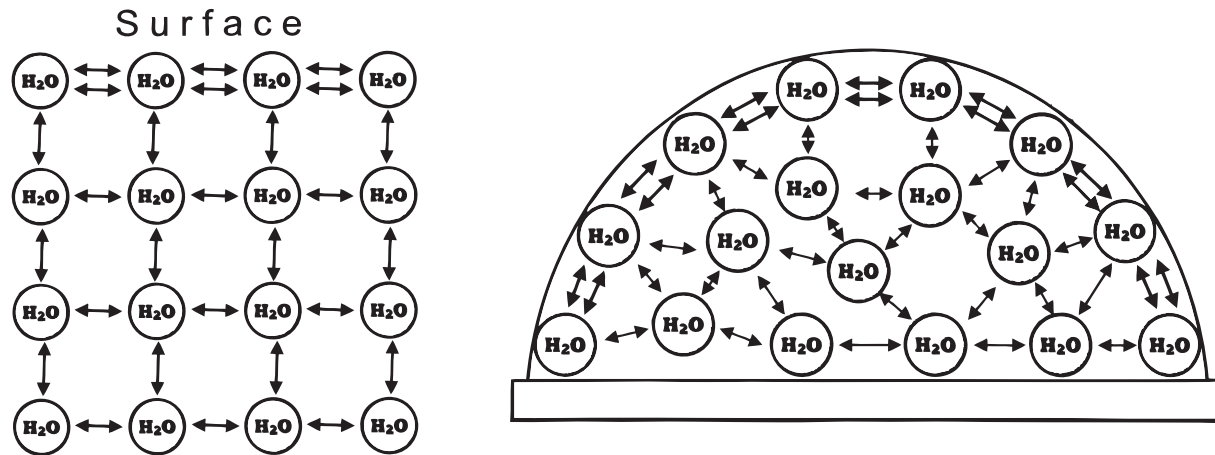


Name \_\_\_\_\_

Date \_\_\_\_\_

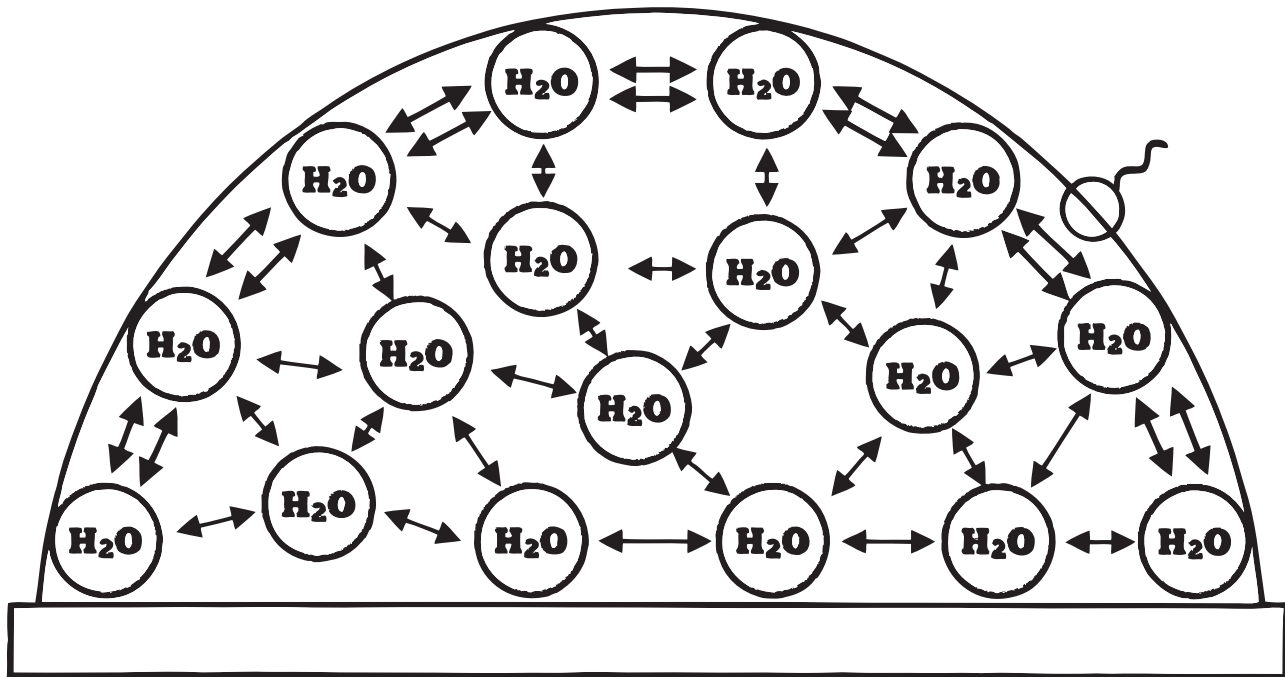
# Water Molecules

Water molecules attract each other and stick together—they love their neighbors. This attraction is called **cohesion**. The water molecules on the surface don't have as many "neighbor" water molecules to stick to, so they stick to each other with more strength. This causes **surface tension**.



Surface tension forms a sort of skin on the water, which keeps the pepper and the paper clip from sinking, and forms a dome of water on the coin. This is the same phenomenon that we saw in the photo of the swimmer.

**Directions:** Add soap molecules in between the water molecules at the surface of the water molecule diagram. The first one has been done for you.



Name \_\_\_\_\_

Date \_\_\_\_\_

# Bubble Solutions Test

**Directions:** Use the scientific process to test bubble solution additives. Record your information below.

1. The **question** we will try to answer is: \_\_\_\_\_

\_\_\_\_\_

2. **Hypothesis** (*what we think will happen*): \_\_\_\_\_

\_\_\_\_\_

3. **Independent variable** (*the thing we will change*): \_\_\_\_\_

\_\_\_\_\_

4. **Dependent variable** (*the thing we will measure*): \_\_\_\_\_

\_\_\_\_\_

5. We will measure our **dependent variable** by:

\_\_\_\_\_

6. **Controlled variables** (*everything else*):

\_\_\_\_\_

\_\_\_\_\_

7. **Materials:**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

8. **Procedure:**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Name \_\_\_\_\_

Date \_\_\_\_\_

# Bubble Solutions Test *(cont.)*

9. **Data:** Record your data in the table. Test the control solution and each additive five times.

Additive	Size of Bubble	Average Bubble Sizes				
Control: soap and water	1.					
	2.					
	3.					
	4.					
	5.					
Glycerin	1.					
	2.					
	3.					
	4.					
	5.					
Corn Syrup	1.					
	2.					
	3.					
	4.					
	5.					
Sugar	1.					
	2.					
	3.					
	4.					
	5.					
		Control	Glycerin	Corn Syrup	Sugar	

10. Calculate the **mean** (*average*) bubble size for the control and for each additive.

→ Control (*soap and water*): \_\_\_\_\_

→ Corn Syrup: \_\_\_\_\_

→ Glycerin: \_\_\_\_\_

→ Sugar: \_\_\_\_\_

11. Graph your average bubble sizes on the graph on the right side above.

12. **Conclusion:** Analyze your results. Which additive produced the largest bubbles? \_\_\_\_\_

How do you know?

# Reflections—Bubble Solution Investigation

1. What was your question about the bubble solution?

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2. What was your hypothesis?

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3. How did you test your hypothesis?

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4. What were your results?

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5. What did you learn from this experiment?

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6. What was the hardest part?

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7. What was your favorite part?

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8. What surprised you the most?

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