Lesson 11 – Lava Lamps: Experimental Design

Overview

In this lesson, UQUEST scientists will further explore concepts about designing experiments, which were introduced in the experimentation lesson. Designing an experiment allows scientists to test their ideas, theories, and hypotheses. Designing experiments is also key to understanding the scientific process. To facilitate understanding of how to design an experiment, UQUEST scientists will learn about experimental design while reviewing previously learned concepts such as variables.

First, UQUEST scientists will review independent and dependent variables in the context of a lava lamp experiment. UQUEST scientists will discuss how to design an experiment to test which substance can create a faster bubble reaction. To do this, they will manipulate the temperature of the water. After completing the lesson, UQUEST scientists will understand how an experiment can be designed to help answer research questions and test hypotheses. This lesson will be used to discuss acidity how it relates to our bodies and to medicine.

Science Objectives:

UQUEST Scientists will:

- understand how an experiment is designed to help answer research questions and test hypotheses
- understand that the independent variable is manipulated by scientists to produce an outcome in the dependent variable.

Health Messages:

- Chemical reactions are going on inside our body all the time.
- Knowing the function of the medicine you put in your body is important.

Reinforcement of Previous Lessons:

- Hypothesis (Lesson 6) - Hypotheses are used to state what we think the outcome of the experiment will be. They must be made before conducting an experiment
- Independent and dependent variables (Lesson 7) - The components of an experiment, including the independent variable and dependent variables
- Experimentation (Lesson 9) - Experimentation is when the effects of creating different conditions, or manipulating, are observed and/or measured.

Vocabulary:

- **Experimental design**: A plan that includes strategies scientists use to answer their research questions and test their hypotheses.

Materials:

- UQUEST kit
- Dry erase boards
- Empty water or Gatorade bottles
- Oil (vegetable or canola)
- Water
- Food coloring
- Antacid tablets (like Alka seltzer)
- Funnel

Preparation:

At UM:

- Prepare all materials

At OYC:

- Copy page 11B to dry erase board
- Place materials on tables

Introductory Script (~3 mins):

Welcome UQUEST scientists.

Remember the lab notebook is an important tool that scientists use to record their observations and the results of their experiments.

Let's open up your lab notebooks to the second page. Like all scientists, UQUEST scientists pay attention to the world around them. They create an environment that helps them to learn about the world. They listen to each other. They communicate with each other. And they treat each other with respect.

***Let's review the values of a UQUEST scientist. E*ach UQUEST scientist reads OUT LOUD one value.**

1. **Pay attention** when others are talking.
2. **Speak in a low voice**. Do not scream.
3. **Respect each other.** Do not push or shove each other.

****Be sure to praise the students when they do well.****

Relaxation (~2 mins)

Before we begin the lesson, we'd like to start off by doing a relaxation activity. When scientists are relaxed, they do better science.

For today's relaxation activity we will practice belly breathing.

- Guide the UQUEST scientists, through some belly breathing for ~1 minute.

Instructions for UQUEST Guides

1. **Introduction (~10 mins)**
    a. *We previously learned about independent and dependent variables in the elephant toothpaste lesson. We tested how the temperature of the water affected the foam eruption.*
        i. *Remember, an independent variable is the variable that we manipulate (or change) in order to affect another variable. So, in our elephant toothpaste experiment, which variable did we manipulate?*
            1. *We manipulated whether we used hot or cold water. So, the water temperature is the independent variable because we manipulated it.*
        ii. *Remember, a dependent variable is the result that we are measuring. So, in our elephant toothpaste experiment, which variable was the result that we were measuring?*
            1. *We measured the size of the foam eruption. So, the foam eruption is the dependent variable because that was our measured result. The foam eruption depended on the water temperature (hot vs. cold).*
    b. *Today we will keep track of all the parts of our experiment on the dry erase board.*
    c. *You can follow along on page 11B of your lab notebook. You will record this information from the dry erase board as we discuss it.*
        i. UQUEST Guide documents all components of the experimental design as you move along the lesson: research question, variables, hypothesis, materials, steps to test hypothesis
    d. *For today's quest, we will design our very own experiment! Before we do that, let's get some background information on today's experiment.*
    e. **Discuss background information - digestion, stomach acids, and stomach aches**
    f. *How does our stomach digest foods we eat?*
        i. *The human body's organs rely on chemical reactions, like the one we saw today, to work.*
        ii. *Our stomachs have strong acids that can break down food into nutrients that your body can absorb.*
        iii. *Sometimes, certain foods we eat can cause our stomachs to create too much stomach acid. These foods are often high in fat (or oils), like burgers and doughnuts. If we create too much stomach acid, our stomachs can begin to ache. That is what is known as indigestion, or more commonly as a stomachache.*
    g. *Has anyone ever had a stomachache before? Did your parents give you medicine to feel better?*
        i. *Well, they might have given you a medicine called antacid. It's used to neutralize (or balance) our stomach acid when there is too much. It's meant to bring us back to normal.*
        ii. *We may see the antacid medication create a bubble reaction in our stomachs to help neutralize our stomach acid.*

2. **Activity (~25 mins)**
    a. **Note: Scientists will document each part of the experimental design in their lab notebook as we move along the lesson.**
    b. **Reasearch question**
        i. *The research question that we will try to answer today is: will there be a faster reaction when an antacid tablet is placed in cold water or warm water (along with oil)*?
        ii. **Document in lab notebook**
    c. **Introduce experimental design**
        i. *To find the answer to this question, we can design an experiment!*
        ii. *An **experimental design** consists of the strategies and plan you choose to answer your research question and test your hypothesis.*
            1. *In short, **experimental design = plan** for our experiment*
        iii. *For example – in the yoga lesson, the experimental design was to test how two different types of exercise affects our heart rate by doing restorative yoga and power yoga and comparing our heart rate after each exercise.*
    d. **Discuss independent and dependent variables**
        i. *If antacid medication helps our stomachache, what might happen if we put an antacid tablet into a mixture of oil and water (representing our stomachs)?*
            1. *It will create a bubble reaction!*
        ii. *Remember the independent variable is the variable we choose to manipulate (or change) in order to affect another variable. So, in this experiment, which variable will we choose to manipulate in order to affect another variable?*
            1. *We will manipulate whether we use warm water or cold water. So, water temperature is the independent variable because we manipulated it.*
        iii. *And the dependent variable is the result that we are measuring. What will be the result that we are measuring?*
            1. *We will measure the speed of the bubbles in the bottle (scale of 1 -5). So, the speed of the bubbles will be our measured result. The speed of the bubbles will depend on the water temperature*
        iv. **Document in lab notebook**
    e. **Discuss hypothesis.**
        i. *How might the temperature of the water affect the speed of the bubbles?*
            1. *Who has a hypothesis that they would like to share?*
        ii. **Example**: *My hypothesis is that if we place an antacid tablet into our mixture with warm water, then we will see a faster reaction (ex. **5** on the 0-5 scale).*
        iii. **Document in lab notebook**
    f. **Discuss materials**
        i. Empty bottles
        ii. Oil
        iii. Water (cold and warm)
        iv. Food coloring

v. Antacid tablets (like Alka seltzer)
vi. Funnel
vii. **In your lab notebook, circle the materials used in this experiment**

g. Discuss steps to test hypothesis:

i. First, we will fill each empty bottle about ¾ of the way full with oil.
ii. Next, we fill the bottle with water about 2 inches from the top
iii. Then, we add 6-8 drops of food coloring
iv. Then, we will place one antacid tablet in each bottle
v. We will then observe the speed of bubbles in each bottle.
vi. **In your lab notebook, number the steps in the correct order**

h. Review experimental design:

i. All of these parts we wrote on the dry erase board (and on page 11B of your lab notebook page) make up our experimental design! The research question, variables, hypothesis, materials, and steps to test our hypothesis.
ii. We just came up with our plan to answer our research question and test our hypothesis.

i. **Instruct scientists to turn to page 11D in lab notebook.**

i. Place close attention to the bubble reactions. Afterwards, you will rate the speed of the bubbles from 0 (no bubbles) to 5 (a lot of bubbles).

j. Note: one experiment will be performed per group (I.e., 2 bottles per group).

i. Scientists will take turns contributing to the experiment (e.g., pouring oil, water, food coloring etc.)

k. **Perform the experiment**

i. Fill each empty bottle about ¾ of the way full with oil using a funnel.
ii. Fill the rest the way with water until about 2 inches from the top.
iii. Put in 6-8 drops of food coloring into each bottle.
iv. Drop an antacid tablet into each bottle
v. Watch all the bubbles start up and float all around like a lava lamp.
vi. Observe the differences in the reactions in each bottle.

l. Discuss observations

i. How long does it take the tablet to disappear?
ii. How big and fast were the bubbles?
iii. Do you notice other differences in how the reaction happens in the bottle with the warm water vs the bottle with the cold water?
iv. Why do you think you got the results that you did?

m. Provide explanation for results

i. The ingredients in Alka-Seltzer combine with water to form a gas called carbon dioxide. The oil and Alka-Seltzer do not combine in this way though. The gas is lighter than the water and oil, so it bubbles up, taking a bit of colored water with it as it moves through the oil layer. You should have seen those bubbles, looking like colorful blobs, float through the oil layer to the top of the jar.

1. *At the top the bubbles burst (releasing the carbon dioxide gas), and then the colorful blobs sunk back to the bottom (now without carbon dioxide gas). The effect looks like a lava lamp.*

ii. *You may have noticed that the antacid tablet dissolved more quickly in the warm water. This results in lots of rapid bubbling and an energetic lava lamp display.*

iii. *In contrast, the antacid tablet in the cold water dissolved more slowly, resulting in a calmer and longer lasting lava lamp effect.*

1. *For the reaction to occur, the ingredient called bicarbonate in the antacid tablet must come into contact with the hydrogen molecules (i.e. the smallest particles of a substance) in just the right way. The higher the water temperature, the faster the molecules move; the lower the water temperature, the slower they move. The faster they move, the more likely they are to come into contact with each other.*

n. Clean up materials

o. On page 11D of your lab notebook, rate the speed of the bubbles (from 0 to 5) for the bottle with the warm water and for the bottle with the cold water.

3. Documentation (~10 mins)

a. *Now we're going to create a bar graph to present our data on the difference in the number of the bubbles in each bottle.*

b. Instruct scientists to turn to page 11E of lab notebooks.

i. <u>Note:</u> Graph will be done individually on lab notebook because data will differ by scientist.

c. Review title, horizontal and vertical axes, and their respective labels

i. **Title:** How does water temperature affect the bubble reaction?

ii. **X axis:** "Warm water and cold water."

iii. **Y axis:** "Speed of the bubbles"

d. Complete graph

i. Find the number on the Y or vertical axis that represents the speed of the bubbles (0-5) for the one with warm water. Remember you wrote down this number earlier in your lab notebooks.

ii. Repeat for cold water

e. Analyze graph

i. Which bar is taller? What does that mean?

4. Discussion (~10 mins)

a. Now let's discuss what we did today. I will ask some questions, and if you answer, you get a sticker. At the end, the stickers can be traded in for a special prize. Let's GO!

i. **Award sticker for every question answered.**

ii. **Note: below are example questions. You can ask additional questions not listed.**

b. What is an experimental design?

i. An experimental design consists of the strategies and plan you choose to answer your research question and test your hypothesis.

c. ***Today we designed an experiment! What was our plan to test our hypothesis?***

i. *We chose to test our hypothesis by placing an antacid tablet into an oil/water mixture with either cold water or warm water and comparing the speed of the bubbles in each bottle.*

d. *What was your hypothesis?*

e. Was your hypothesis supported by our results?

f. *What was the variable that we manipulated? Our independent variable?*

i. *Water temperature: warm vs. cold*

g. *What variable did we measure? Our dependent variable?*

i. *We measured the speed of the bubbles in the bottles.*

h. How did our experimental design help us test if warm water produced faster bubbles?

i. *Our experimental design helped us to test our hypothesis by allowing us to see how the bubble reaction is different with warm and cold water.*

i. ***How are these chemical reactions affecting us on a day-to-day basis?*** *[Hint: It is inside of us!]*

i. *The chemical reactions are happening in our stomachs when our stomach acid is trying to break down our foods. By knowing what is going on in our bodies, we can make ourselves feel better - like knowing how to treat our stomach aches!*

Wrap-up

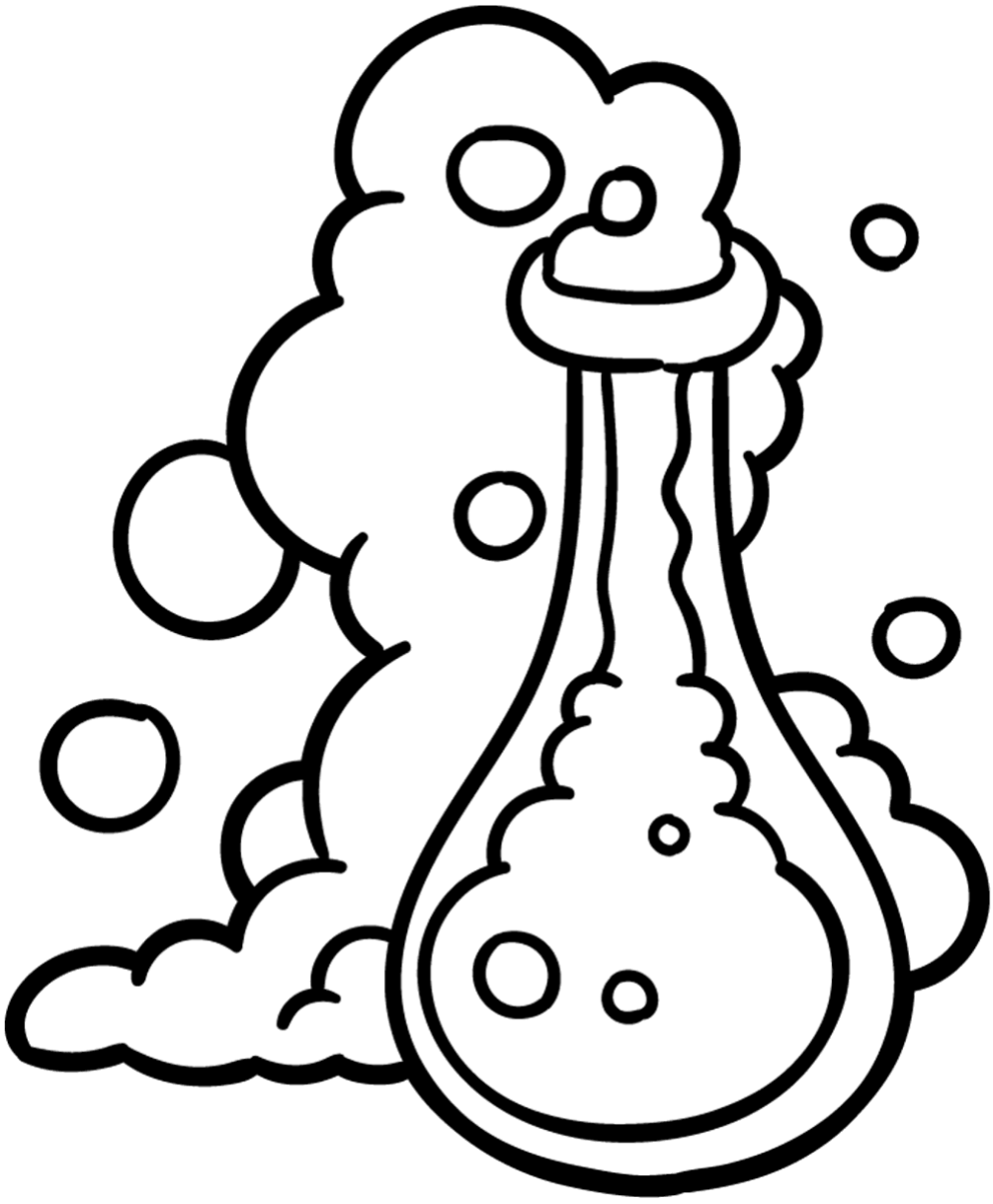
a. *What did you learn today? Write that down on the lines on page 11F.*
b. *How much did you like today's lesson on scale from strongly agree to strongly disagree.*
c. **Award prize at the end based on number of stickers.**

References

Lesson inspired by/adapted from:

- https://www.naturalbeachliving.com/lava-lamp-bottles-science-experiment/
- https://www.sciencebuddies.org/stem-activities/make-a-lava-lamp
- https://www.sciencebuddies.org/stem-activities/how-size-determines-rate

Lesson 11
Lava Lamps



Date: _____

My Experimental Design

What is the research question?

_____

_____

_____

What are the variables?

Independent Variable:_____

Dependent Variable:_____

What is my hypothesis?

Will there be a faster reaction when the antacid tablet is placed in the cold water or the warm water? Circle One.

Date: _____

My Experimental Design

What materials do we use?





What are the steps to test my hypothesis? (Procedures)

Instructions: Number the steps in the correct order

____ Place one whole antacid tablet in each bottle

____ Fill the bottle with water about 2 inches from the top

____ Observe the quantity of bubbles in each bottle

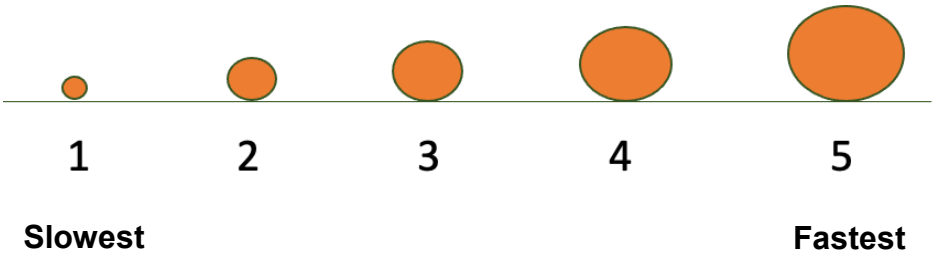
____ Fill each empty bottle about ¾ of the way full with oil

____ Add 10 drops of food coloring

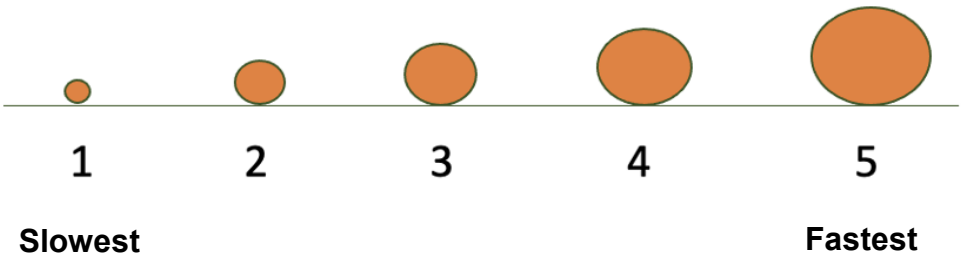
Date: _____

Results

Instructions: Circle your rating of the initial speed of the bubbles in the bottle when the antacid tablet was placed in WARM WATER.

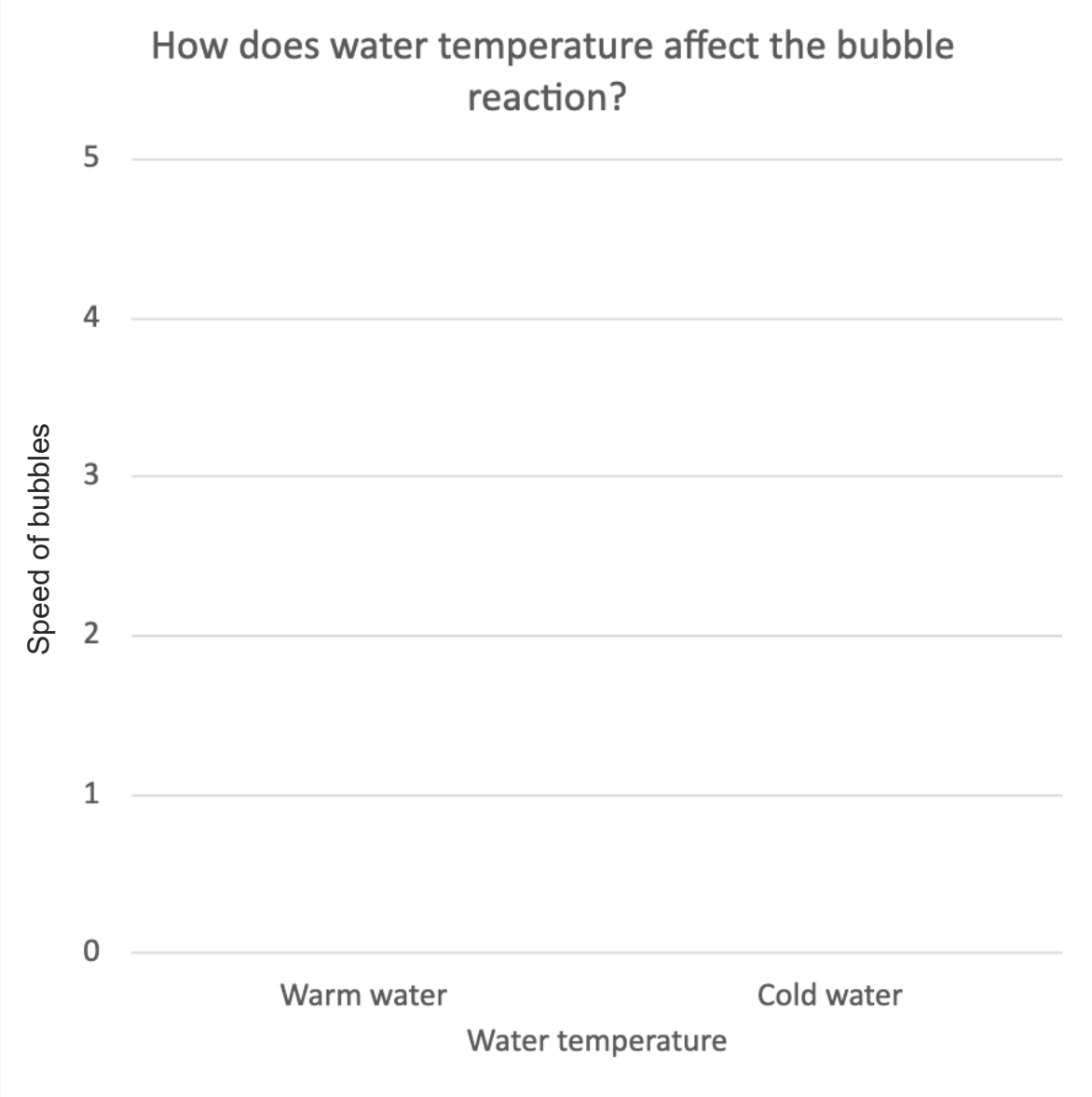


Instructions: Circle your rating of the initial speed of the bubbles in the bottle when the antacid tablet was placed in COLD WATER.



Date: _____

Graphing



Date: _____

Lesson 11

What did I learn today?

_____

_____

_____

I liked this lesson (circle one):

Strongly Agree	Agree	Disagree	Strongly Disagree