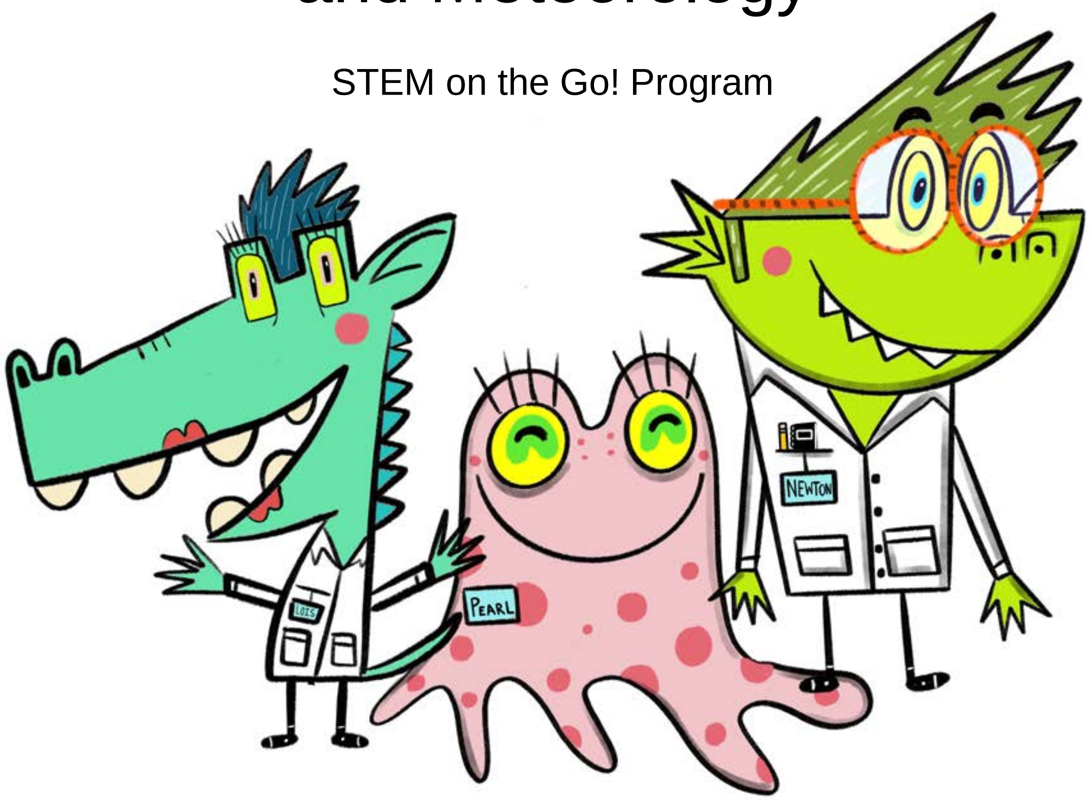
TEACHER'S HANDBOOK

# Earth Science Kit

## Adventures with Lois, Newton, and Pearl

## Exploring Geology, Oceanography, and Meteorology

STEM on the Go! Program

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**Earth Science– The study of Earth and its atmosphere.**

## Geology

Geology is the study of Earth and the features of its surface.

### Lesson 1 – Rocks & Minerals

Ages 6-11

“Weathering & Erosion” video

Students will explore how solid rock breaks apart into smaller pieces through a process called weathering. In the activity, students will model the process of weathering that occurs when rocks tumble and crash into each other.

### Lesson 2 – Volcanoes

Ages 12-14

“Can you make your own lava?” video

Students will investigate how differences in lava types can explain the differences in the shape and eruption patterns among volcanoes. In the activity, students will experiment with “lava” of different thicknesses to solve the mystery.

### Lesson 3 – Earthquakes: Shake it!

Ages 15-19

Students design and build their own model buildings made of toothpicks and mini marshmallows. Once students are satisfied with their design of their buildings, they put them through a one-minute simulated earthquake challenge using a shake table.

## Oceanography

Oceanography is the study of the physical properties and phenomena of the ocean.

### Lesson 4 – Waves: Echolocation in Action!

Ages 6-11

Students learn about echolocation: what it is and how engineers use it to "see" things deep underwater. They also learn how animals use echolocation to catch their meals and travel the ocean waters without running into things.

**Lesson 5 – Tsunami: Escaping the Giant Wave**
Ages 12-14
Students will use a table-top-sized tsunami generator to observe the formation and devastation of a tsunami. They see how a tsunami moves across the ocean and what happens when it reaches a coastline. They make villages of model houses to test how different material types are impacted by the huge waves.

**Lesson 6 – Escape Room: Plastics in the Ocean!**
Ages 15-19
Students use puzzles, clues, teamwork, and critical thinking to solve this Escape Room Challenge. Students will analyze 10 different puzzles around the issue of plastics in the ocean to see who can solve the puzzles first before the time runs out.

## Meteorology

Meteorology is study of Earth's atmosphere such as weather and climate.

**Lesson 7 – Clouds**
Ages 6-11
"Water Cycle- Made Fun & Easy for Kids" video
Students will become a weather watcher. They will observe and communicate the weather and forecast its conditions. They will then create a model of a cloud and recreate a part of the water cycle.

**Lesson 8 – Hurricanes**
Ages 12-14
"Why are Hurricanes so Dangerous" video
Students explore the effects of natural hazards, such as hurricanes. In the activity, students design multiple solutions to keep a house from blowing away in a windstorm, then compare the merits of their solutions.

**Lesson 9 – Earth's Air Pressure: Building a Barometer**
Ages 15-19
"Weather & Climate" video
Students will investigate how a barometer works to measure the Earth's air pressure by building a model. They will analyze the changes in barometer measurements over time and compare those to actual weather conditions to better understand air pressure and predict real-world weather changes.

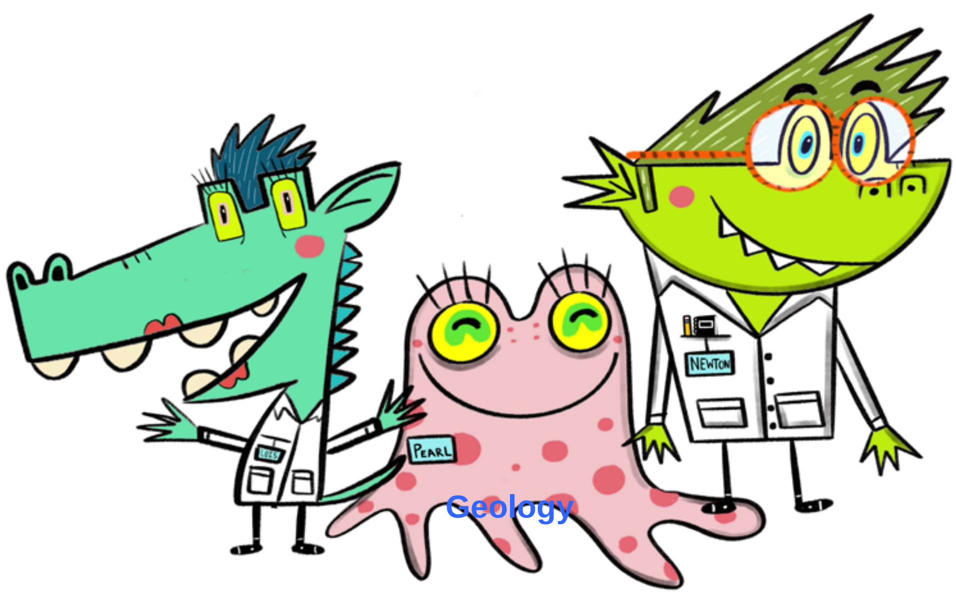
## Earth Science Kit

## NGSS Science Standards Addressed

| Lesson | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| NGSS National Science Standards: K-5 | | | | | | | | | |
| K. Forces & Interactions: Pushes and Pulls | X | | X | | X | | | | X |
| K. Interdependent Relationships in Ecosystems: Animals, Plants, and the Environment | | | | X | | X | | | X |
| K. Weather & Climate | | | | | | | X | X | X |
| K. Engineering Design | X | X | X | | X | X | X | X | X |
| 1. Waves: Light & Sound | | | X | X | X | | | | |
| 1. Structure, Function, and Information | | | | | | | | | X |
| 1. Space Systems: Patterns & Cycles | | | | | | | | | |
| 2. Structure & Properties of Matter | X | | X | | X | | X | X | |
| 2. Interdependent Relationships in Ecosystems | | | | | | | | | |
| 2. Earth's Systems: Processes that Shape the Earth | | | | | | | X | X | X |
| K-2. Engineering Design | X | X | X | | X | X | X | X | X |
| 3. Forces and Interactions | | X | X | | X | | X | X | X |
| 3. Interdependent Relationships in Ecosystems: Environmental Impacts | | | | | | | | | |
| 3. Inheritance & Variation of Traits: Lifecycles & Traits | | | | | | | | | |
| 3. Weather & Climate | | | X | | X | | X | X | X |
| 4. Energy | | X | X | X | X | | | | |
| NGSS National Science Standards: K-5 | | | | | | | | | |
| 4. Waves | | | X | X | X | | | | |
| 4. Structure, Function, & Information Processing | | | | X | | | | | |
| 4. Earth's Systems: Processes that Shape the Earth | X | X | X | | X | X | X | X | X |
| Lesson | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 5. Structure and Properties | | X | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 5. Matter and Energy in Organisms and Ecosystems | | | | | | | | | |
| 5. Earth’s Systems | | **X** | | | | **X** | **X** | **X** | **X** |
| 5. Space Systems: Stars and the Solar System | | | | | | | | | |
| 3-5. Engineering Design | **X** | **X** | **X** | | **X** | **X** | **X** | **X** | **X** |
| NGSS National Science Standards: Middle School- Physical Science | | | | | | | | | |
| MS. Structure & Properties of Matter | | | | | | | | | |
| MS. Chemical Reactions | | | | | | | | | |
| MS. Forces & Interactions | **X** | | **X** | | **X** | | **X** | **X** | **X** |
| MS. Energy | | | **X** | | **X** | | **X** | **X** | **X** |
| MS. Waves & Electromagnetic Radiation | | | **X** | | **X** | | | | |
| NGSS National Science Standards: Middle School- Life Science | | | | | | | | | |
| MS. Structure, Function, & Information Processing | | | | **X** | | | | | |
| MS. Matter & Energy in Organisms & Ecosystems | | | | | | | | | |
| MS. Interdependent Relationships in Ecosystems | | | | | | | | | |
| MS. Growth, Development, Organism | | | | | | | | | |
| NGSS National Science Standards: Middle School- Life Science | | | | | | | | | |
| MS. Natural Selection & Adaptations | | | | | | | | | |
| NGSS National Science Standards: Middle School- Earth & Space Science | | | | | | | | | |
| MS. Space Systems | | | | | | | | | |
| MS. History of Earth | **X** | | | | | | | | |
| MS. Earth’s Systems | | **X** | | | | | **X** | **X** | **X** |
| MS. Weather & Climate | | | | | | | **X** | **X** | **X** |
| MS. Human Impacts | | | | | | **X** | | **X** | |
| NGSS National Science Standards: Middle School- Engineering, Technology, and Applications of Science | | | | | | | | | |
| MS. Engineering Design | **X** | **X** | **X** | | **X** | **X** | **X** | **X** | **X** |
| Lesson | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| NGSS National Science Standards: High School- Physical Science | | | | | | | | | |
| HS. Structure & Properties of Matter | | | | | | **X** | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| HS. Chemical Reactions | | | | | | | | | |
| HS. Forces & Interactions | | | | | | | X | X | X |
| HS. Energy | | | | | | | | | X |
| HS. Waves & Electromagnetic Radiation | | | X | | X | | | | |
| NGSS National Science Standards: High School- Life Science | | | | | | | | | |
| HS. Structure & Function | | | | | | | | | |
| HS. Matter & Energy in Organisms & Ecosystems | | | | | | | | | |
| HS. Interdependent Relationships in Ecosystems | | | | | | | | | |
| HS. Inheritance & Variation of Traits | | | | | | | | | |
| HS. Natural Selection & Evolution | | | | | | | | | |
| NGSS National Science Standards: High School- Earth & Space Science | | | | | | | | | |
| HS. Space Systems | | | | | | | | | |
| HS. History of Earth | X | | | | | | | | |
| NGSS National Science Standards: High School- Earth & Space Science | | | | | | | | | |
| HS. Earth's Systems | X | X | | | X | | X | X | X |
| HS. Weather & Climate | | | | | | | X | X | X |
| HS. Human Sustainability | | | X | | X | X | | X | |
| NGSS National Science Standards: High School- Engineering, Technology, and Applications of Science | | | | | | | | | |
| HS. Engineering Design | | | X | | X | X | X | X | X |



**Lesson 1- Rocks & Minerals**
Ages 6-11

(Adapted from Mystery Science)

**Overview**
In this activity, students help Lois and Newton explore how solid rock breaks apart into smaller pieces through a process called weathering. They will start by watching a video from Mystery Doug called, "Weathering and Erosion." Students will then model the process of weathering that occurs when rocks tumble and crash into each other using sugar cubes in a container.

Engineers care about rocks, soils and minerals. One reason they are important is that they are the foundation for our buildings and roads. Engineers also get many of the materials they use for construction from rocks, soils, and minerals. Engineers must understand the properties of these rocks, soils, and minerals so that they can use the ideal material for a job that is efficient and cost effective.

**Learning Objectives**

1. Students will conduct an investigation by modeling how rocks erode over time.
2. Students will construct an explanation for why rocks erode.
3. Students will consider the cause and effect of ice and root wedging on rock as it is broken down into smaller pieces.
4. Students will understand the difference between weathering and erosion.

**Suggested Timeframe**
45 minutes

**Materials Required (Students work in pairs) each pair needs:**

- 1 Sugar Cubes (for each student)
- 1 Colored Marker
- 1 Small Plastic Container
- 1 Dry Eraser
- 1 Dry Erase Protective Sleeve for each student
- 1 Thin Expo Marker for each student
- 1 "Sugar Shake" Worksheet
  *Students can place their worksheet inside the protective sleeve and use the dry erase marker to do their work.*

**Assessment**

- Pre-Activity Assessment
- Activity Embedded Assessment
- Post-Activity Assessment

**Introduction/Initiation**
*Show students the following video from Crash Course Kids #10.2 on YouTube called, "Weathering and Erosion" 4 min. 5 seconds*
*https://www.youtube.com/watch?v=R-Iak3Wvh9c*

*Mount Everest and the surrounding Himalaya Mountains are so tall that astronauts can see their snow-capped peaks all the way from space. Part of what makes mountains so impressive is that there's solid rock all the way through.*

*Mountains are like walls of vertical rock going straight up into the sky but will these mountains always be there? Do mountains last forever? You might think well, yeah, why not?*

*In this activity, you're going to use sugar cubes in an experiment to see what happens as rocks tumble down a mountain. Sugar cubes are hard like rocks and they have sharp corners and edges just like the rocks you'd find at the top of a mountain so we'll see what happens to them after a little bit of shaking and then after a whole lot of shaking.*

**Procedure**

Before the Activity

1. Gather all supplies.
2. Get 1 Sugar Shake Worksheet, 1 Protective Sleeve, 1 Thin Expo Marker, and 1 Eraser for each student pair.

With the Students

1. Divide students into groups of two.
2. Pass out materials to each student. They can work alone or with a partner. (Materials needed: 2 markers, 2 sugar cubes, container with lid, sugar shake sheets)
3. Take a sugar cube and complete questions #1 and #2 on the sheet. The students can draw the whole cube or just one side.
4. Each student chooses a sugar cube and colors the edges.
5. Count how many edges a sugar cube has. Write the answer in question #3.
6. Decide who will be the **Shaker** and who'll be the **Counter** for the first trial.
7. **Shaker: Put the colored cubes in the container.**
8. Do the 1st trail now. **Shaker: Shake the container <u>40</u> times, counting out loud.**
9. **Shaker: Open the container & put the cubes on the plate. Both of you: Write down how the cubes have changed.**
10. **Counter: On the colored cube that was shook, count how many edges have any color left. Both of you: Write down the result.**
11. **Shaker: Put the cubes you just shook back in the container. Make sure the lid's on tight.**
12. Switch jobs and finish the data sheets (including questions 5-10). When you are done, discuss the questions on the back with your partner.

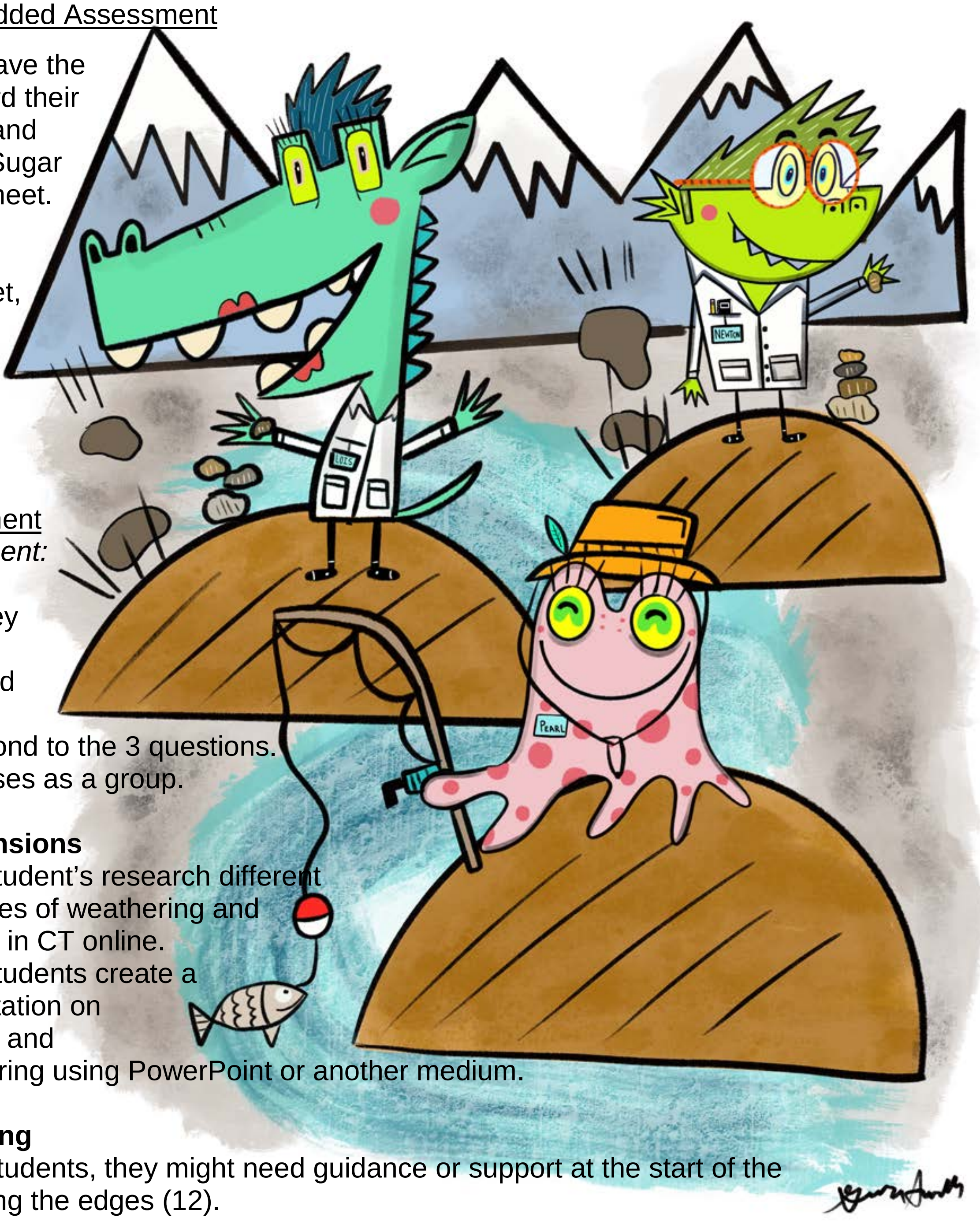
**Assessment**

<u>Pre-Activity Assessment</u>

*Discussion Questions:* Solicit, integrate and summarize student responses.

- Do you think a mountain will last forever?
- If you think a mountain changes over time, what are some reasons that cause that change?

<u>Activity Embedded Assessment</u>




*Worksheet:* Have the students record their observations and data on their Sugar Shake Worksheet. After students have finished their worksheet, have them answer the reflective questions with their partner.

<u>Post-Assessment</u>

*Post Assessment:* Using the knowledge they learned about weathering and erosion, have students respond to the 3 questions. Share responses as a group.

**Activity Extensions**

- Have student's research different examples of weathering and erosion in CT online.
- Have students create a
- presentation on
- erosion and
  weathering using PowerPoint or another medium.

**Activity Scaling**

For younger students, they might need guidance or support at the start of the activity counting the edges (12).

Name ______________________________ Date ___________________________

# Lesson 1: Rocks & Minerals

## "Sugar Shake"

**1** Draw what your sugar cube looks like here:

**2** What will it look like after 200 shakes? Draw your best guess here:

**3** How many edges does a sugar cube have? Count the edges of your cube that you colored. _________

**4**

| Trial # | Shake this many times: | Describe the shape of the sugar cubes you shook. How did they change? | How many color edges still have some color? |
|---|---|---|---|
| #1<br>switch jobs | 40 | | |
| #2<br>switch jobs | 40 | | |
| #3<br>switch jobs | 40 | | |
| #4<br>switch jobs | 40 | | |
| #5<br>switch jobs | 40 | | |

**5** You've done 5 trials of 40 shakes each. That's 200 shakes! What do the sugar cubes look like now? Draw one in the box:

**6** Does your drawing match your guess in questions 2?

Name ______________________________ Date ___________________________

# Lesson 1: Rocks & Minerals

## "Post Assessment"

1. Do mountains last forever? Why or why not?

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2. How does solid rock break into smaller pieces?

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3. How are rocks at the top of the mountain different than the ones you would find at the bottom?

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Name ______________________________ Date ___________________________

# Lesson 1: Rocks & Minerals

## "Post Assessment"

ANSWER KEY

1. Do mountains last forever? Why or why not?

A less sophisticated response is: No, they break into smaller pieces.

A more sophisticated response is: No, mountains start as solid rock but the rock breaks into smaller pieces and the pieces roll down the mountain.

2. How does solid rock break into smaller pieces?

A less sophisticated response is: Plants and ice break rock into smaller pieces.

A more sophisticated response is: Seeds and water can enter cracks in the rock. As the roots grown and the water freezes, the crack gets wider and the rock will break. Also, as rocks tumble down the mountain, the sharp edges can break off.

3. How are rocks at the top of the mountain different than the ones you would find at the bottom?

A less sophisticated response is: Rocks at the top of a mountain are sharper than the ones at the bottom.

A more sophisticated response is: Rocks at the bottom of the mountain are smoother because as they tumble the sharp corners break off.

# Geology

## Lesson 2- Volcano

Ages 12-14

(Adapted from Mystery Science)

### Overview

In this activity, students will help Lois and Newton investigate lava. They will start by watching a video from Mystery Doug called, "Can you make lava."

Students will then investigate how differences in lava types can explain the differences in the shape and eruption patterns among volcanoes. In the activity, students will experiment with "lava" of different thicknesses to solve the mystery.

Many types of engineers must understand the properties of liquids. Understanding viscosity and the factors that change how liquids move can aid in the design of structures that use liquids to do work, as well as structures and devices that control or contain liquids. Geochemical engineers use science to solve environmental and civil engineering problems, some working on ways to halt or divert lava flows to protect human-built structures. For instance, R.D. Schuiling suggests that limestone walls could be built to rapidly cool lava (making it more viscous) and thus slow the flow enough to salvage human settlements.

### Learning Objectives

1. Students will conduct an investigation to construct an explanation for why some volcanoes explode and why some do not.
2. Students will model thick and thin lava to conduct their investigations.
3. Students reason about the cause and effect of the type of lava (cause) and the nature of the eruption (effect).

### Suggested Timeframe

45 minutes

### Materials Required (Students work in pairs) Each pair needs:

- 1 Plasatic Plate
- 1 Plastic Spoon
- 2 3oz cups (Dixie cups) for each pair of students
- 1 Sample of thin lava and a sample of thick lava in 3oz cups (Dixie cups)
- 1 Paper mat
- 2 Straws (1 for each student)
- 1 Thin Dry Erase Marker for each student
- 1 Dry Eraser for each student
- 1 Dry Erase Protective Sleeve
- 1 Lava Experiment Worksheets (2 pages)
  *Students can place their worksheet inside the protective sleeve and use the dry erase marker to do their work.*

### Assessment

- Pre Activity Assessment
- Activity Embedded Assessment
- Post Activity Assessment

**Introduction/Initiation**
Show students the following video from Mystery Doug on YouTube called, "Can you make lava?" 5 min. 1 second
https://www.youtube.com/watch?v=8894ur5KvhQ

*"Volcanoes can be hazardous geological features. They contain large amounts of extremely hot molten rock mixed with dissolved gases that are very close to the surface of the Earth (show or sketch on the board a picture showing magma beneath a volcano).*

*Does anyone know what the molten rock mixture is called? (Answer: Magma.) What can happen to magma when it moves close to the surface and the gases start to bubble out? (Answer: It can erupt.) Once magma reaches the surface, it is called lava. Lava can leave volcanoes in violent bursts. We call this an explosive eruption (show a picture of an erupting volcano, or depict it by drawing on the board). It can also leave the volcano through river-like streams. This is called an effusive eruption (show a picture or draw on the board). When lava flows effusively, various factors can make it move faster or slower, and also affect how much area the lava covers."*

**Procedure**
Before the Activity
1. Gather all supplies.
3. Get 2 cups filled with 'lava', 1 plastic plate, 2 straws, 1 spoon, 1 placemat, 1 set of Lava Experiment Worksheets (2 pages), 1 Protective Sleeve, 1 Thin Expo Marker, and 1 Eraser for each student pair.

With the Students
1. Tilt each cup to see which "lava" is thin and which is thick. Put them on the placemat to remember which is which.
2. Time to experiment! Do your lava worksheets. When the class is done, clean up materials. Wipe the plastic plate to re-use again.

**Assessment**
Pre-Activity Assessment
*Discussion Questions:* Solicit, integrate and summarize student responses.
- Why do some rocks look different than others?
- What do volcanic rocks look like?

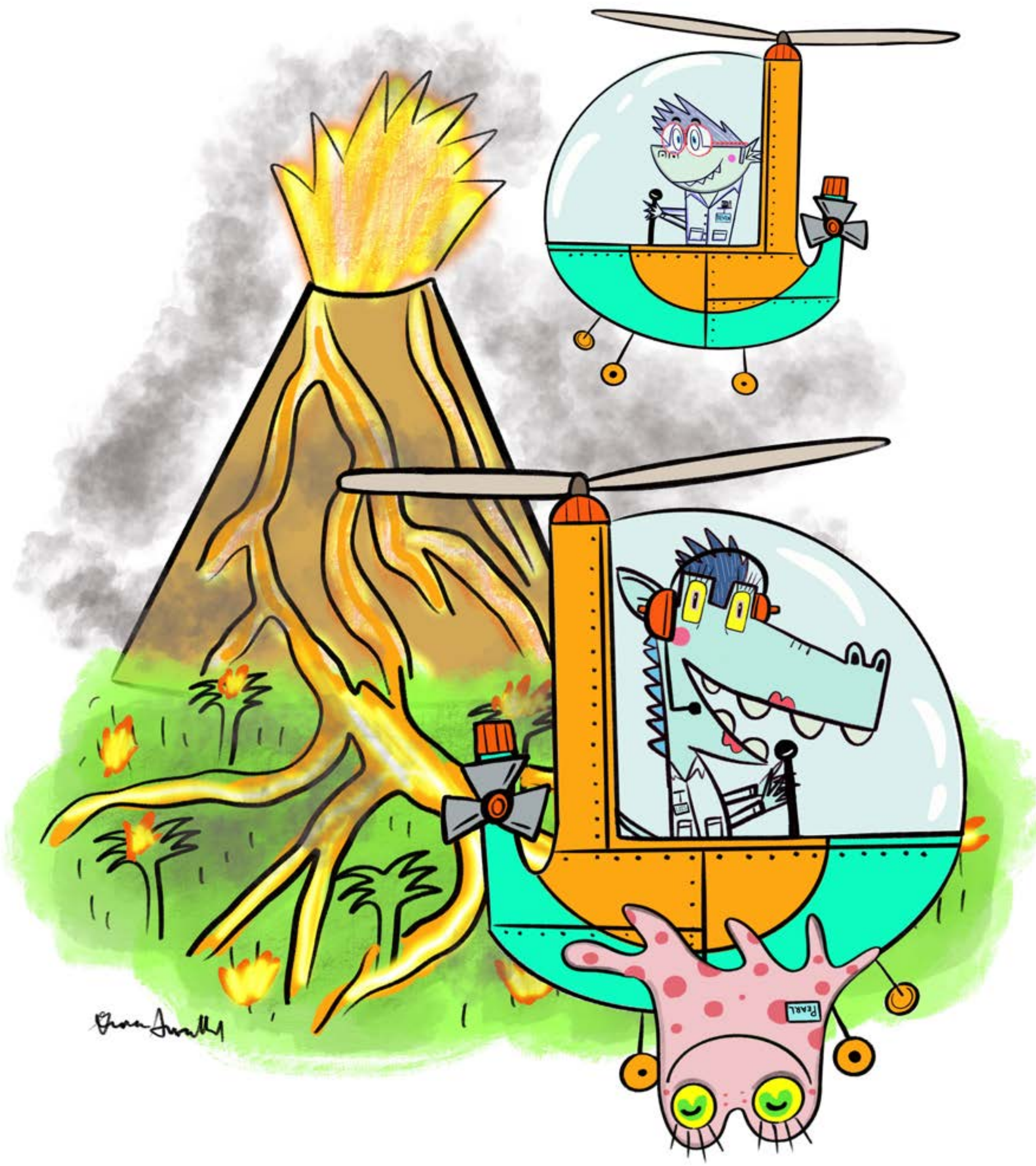
Activity Embedded Assessment
*Worksheet:* Have the students record their observations and complete the lava worksheets.

Post-Activity Assessment
*Post Assessment:* Using the knowledge they learned about volcanoes and lava, have students respond to the 3 questions. Share responses as a group or class.

**Activity Extensions**
- Have students review Additional Multimedia Support:

Lava flow video clips at Volcano Video Productions' website at http://www.volcanovideo.com/p8vidclp.htm

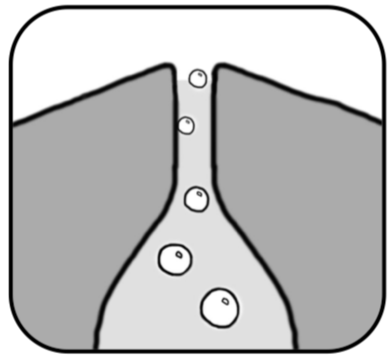
- Have students see photos of lava in various states and a list of towns destroyed by lava at Wikipedia's page on lava: https://en.wikipedia.org/wiki/Lava
- Have students see a list of the world's 21 most active volcanoes and their years of continuous eruption at the Volcano Live Website: http://www.volcanolive.com/active2.html



Name ____________________________ Date _________________________

# Lesson 2: Volcanoes

## Lava Experiment #1



Bubbles form in lava as it rises
up from deep underground.
With a straw, you can add bubbles to
your lava, too.

**1** Stir each sample with your straw.
Then blow bubbles gently into each cup,
really slow.

Note: bubbles in the thick lava may not look like
Bubbles you're used to.  Watch for craters when they burst through the surface.

**2** Which lave is it **easiest** to blow bubbles in?  **thin lava / thick lava**

**3** See if you can blow **just 1 bubble** in each cup.

Can you do it in the thin lava? Explain:

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Can you do it in the thick lava? Explain:

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**4** How are the bubbles different in the different lavas?

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Name ______________________________ Date ___________________________

# Lesson 2: Volcanoes

## <u>Lava Experiment #2</u>

**5** With your partner, put 1 spoonful of the **THIN** lava on the plate. Try to make it into a mountain-shape.

Draw a picture in the box showing how tall it turned out:

**6** With your partner, put 1 spoonful of the **THICK** lava on the plate. Try to make it into a mountain-shape.

Draw a picture in the box showing how tall it turned out

**7** What kind of lava do you think **shield volcanoes** have? Why?

__________________________________________

__________________________________________

__________________________________________

shield volcano

**8** What kind of lava do you think **cone volcanoes** have? Why?

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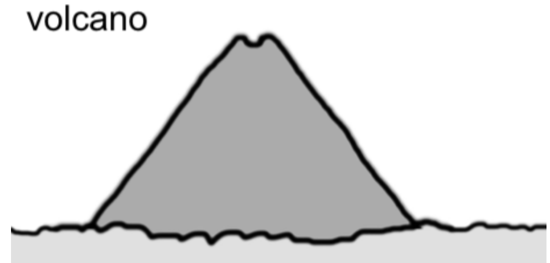
__________________________________________

cone volcano



Name ______________________________ Date ___________________________

# Lesson 2: Volcanoes

## "Post Assessment"

1. Why are some volcanoes different shapes?

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2. If you were traveling and found a volcano, how could you figure out what kind of rock the volcano makes?

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3. Which volcanoes are more likely to explode – the ones with thick lava or thin lava? Why?

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Name ____________________________ Date _________________________

# Lesson 2: Volcanoes

## “Post Assessment”

ANSWER KEY

1. Why are some volcanoes different shapes?

A less sophisticated response is: They have different kinds of lava.

A more sophisticated response is: Cone-shaped volcanoes have thick lava that oozes out forming a hill. Shield-shaped volcanoes have lava that is thin and runny, so the lava spreads out farther.

2. If you were traveling and found a volcano, how could you figure out what kind of rock the volcano makes?

A less sophisticated response is: You could look at the color of the rocks and see if they float or sink.

A more sophisticated response is: You could look at the shape of the volcano and the color of the rocks. If the volcano is shaped like a shield and the rocks are dark, the volcano probably produces basalt lava. If the volcano is shaped like a cone and the rocks are lighter, the volcano probably produces felsite lava.

3. Which volcanoes are more likely to explode, the ones with thick lava or thin lava? Why? What evidence do you have?

A less sophisticated response is: The volcanoes with the thick lava explode.

A more sophisticated response is: Volcanoes with thick lava trap the gas bubbles. Eventually the gas makes the volcano explode. In the activity, I saw the thick lava trap the gas bubbles longer and then they popped.

# Geology

## Lesson 3- Earthquakes
Ages 15-19

(Adapted from University of Colorado)

**Overview**
In this activity, students will help Lois and Newton investigate earthquakes. They will learn about how Engineers design and build shake tables to test the ability of buildings to withstand the various types of seismic waves generated by earthquakes.

Just like engineers, students will design and build their own model buildings made of toothpicks and mini marshmallows. Once students are satisfied with the design of their buildings, they put them through a one-minute simulated earthquake challenge using a shake table.

In certain areas of the world, earthquakes are a serious concern. Civil and structural engineers who focus on designing buildings, bridges, roads and other infrastructure for earthquake-prone areas must understand seismic waves and how to construct structures that are able to withstand the forces from the powerful ground motions of the Earth. For testing purposes, engineers use shake tables to simulate (or re-enact) the seismic waves produced by earthquakes and verify the stability and survivability of their structures.

**Learning Objectives**
1. Students will explain the four different types of seismic waves produced by earthquakes.
2. Students will describe the purpose of shake tables and how engineers use them.

**Suggested Timeframe**
45-60 minutes

**Materials Required (Students work in pairs) Each pair needs:**
- 1 Shake Table per class
- 20 Toothpicks
- 10 Marshmallows
- 1 Thin Dry Erase Marker for each student
- 1 Dry Eraser for each student
- 1 Dry Erase Protective Sleeve
- 1 Shake It! Experiment Worksheets (2 pages)
  *Students can place their worksheet inside the protective sleeve and use the dry erase marker to do their work.*

**Assessment**
- Pre Activity Assessment
- Activity Embedded Assessment
- Post Activity Assessment

**Introduction/Initiation**

“How many different kinds of waves can you think of? (Listen to student suggestions and add others. For *example, electromagnetic [light, radio], sound, ocean [water], seismic, pressure, compression, standing and sine waves.)*

*What types of waves do we associate with earthquakes?*

*That's right, seismic waves. Seismic waves are waves that move through the Earth, and are typically created by earthquakes. For all seismic waves, the amplitude or intensity of the wave is dependent on three things:*

1. *The depth at which the earthquake took place (the closer to the surface, the greater the amplitude of the wave)*
2. *The intensity of the earthquake (earthquakes with higher Richter scale ratings produce more intense seismic waves)*
3. *The composition of the Earth's crust*

*The people who work in "earthquake engineering" focus on protecting us and the natural and human-built environments from earthquakes. They want to limit our risk of death and damage from earthquakes.*

*How can we possibly make sure that our school or stadium or a skyscraper or a freeway overpass will not collapse in a big earthquake?*

*Well, engineers us shake tables to test the ability of buildings and other structures to withstand the seismic waves produced by earthquakes. To do this, they carefully design and construct buildings that can accurately re-enact the effects of ground motion of the Earth during earthquakes.*

*Sometimes they test full-size buildings and sometimes they test small-scale model buildings or components. Some shake tables are large enough to put a real-size building on; others are smaller, even tabletop size. By doing this, engineers can test materials, designs, and construction methods to develop building codes and best practices that provide people living in earthquake-prone areas with safe and survivable surroundings.*

*Engineers must understand everything about the various seismic waves produced during earthquakes and how they cause the Earth to move. Who can tell me the four types of seismic waves that engineers need to simulate? They are:*

1. *P-waves (or primary waves, a type of body wave)*
2. *S-waves (or secondary waves, a type of body wave)*
3. *Love waves (a type of surface wave)*
4. *Rayleigh waves (a type of surface wave)*

*What do you know about these different types of seismic waves? How are they different from each other?*

*P-waves and S-waves are body waves, which travel through the body of the Earth. P-waves are the fastest of all the seismic waves and can travel through any medium, although they move through solids faster than through liquids and gases. P-waves vibrate the parallel to Earth or in the direction of their* *propagation. They are similar to a compression wave moving through a slinky. S-waves are the second fastest type of seismic waves, and they can only move through solids. S-waves are transverse or shear waves and move the Earth perpendicular to the direction of propagation. Both P-waves and S-waves are types of body waves and travel through the interior of the Earth.*

*Love waves and Rayleigh waves are surface waves, which travel along the surface of the ground. In general, surface waves are slower than body waves—and more destructive. Love waves cause a horizontal shifting of the Earth perpendicular to the wave propagation. Rayleigh waves are a type of sinusoidal wave and move like ocean waves. They are produced by the interaction of P-waves and S-waves. Rayleigh waves are the slowest of all the seismic waves with a speed approximately equal to 3 km/second.*
*Smart design and testing make buildings resistant to the seismic wave movement of earthquakes.*

*A properly engineered structure does not necessarily have to be extremely strong or expensive, but it must be correctly and intelligently designed to withstand the seismic effects while sustaining an acceptable level of damage. What are your ideas? Let's create our own model of a building and use a shake table to test them."*

**Procedure**
Before the Activity

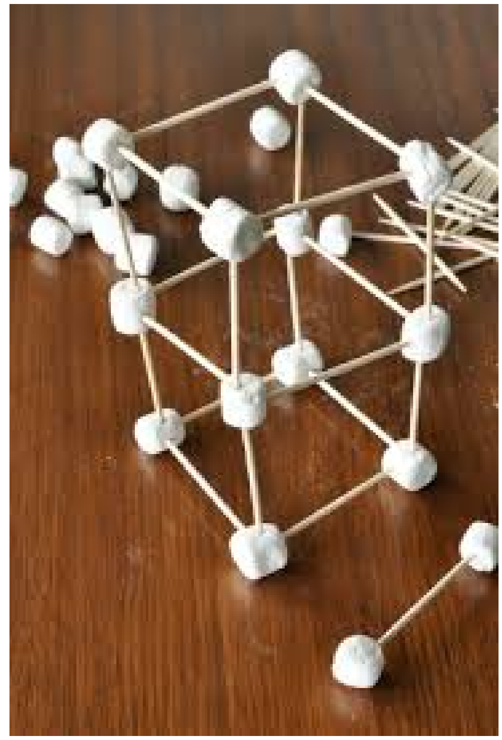
1. Gather all supplies. – 1 Shake table for the class
2. Get mini marshmallows, toothpicks, 1 set of Shake It! Experiment Worksheets (2 pages), 1 Protective Sleeve, 1 Thin Expo Marker, and 1 Eraser for each student pair.

**With the Students**

1. Show students the available materials. Point out that this project follows the steps of the engineering design process: understand the need (requirements, objective), brainstorm different design solutions, select the most promising design, plan (strategy, drawings, measurements, materials), create and test, and improve to make the best solution possible.
2. Identify a few design requirements:
   The **model buildings** must be made only from toothpicks and marshmallows, and be at least one-foot (.3 m) tall. (Consider imposing a materials limitation to make the project more challenging.) Its base will be taped to the shake table surface for testing.
3. Hand out the Shake It! Worksheets to students. Give them time to independently **design** and draw their buildings, as instructed on page 1 of the worksheet. (Note to teacher: If students need more clarification of the movement generated by the four seismic wave types, refer to the PowerPoint presentation in the associated lesson.
4. Divide the class into groups of two or three students each.
5. Ask students in each group to **brainstorm** ideas, starting by sharing their individual ideas. Have each team choose one building design to construct

for its shake table. In the spirit of true brainstorming, encourage teams to combine and compromise their ideas to come up with creative solutions.

6. Provide students with materials and give them time to construct their buildings—a minimum of 30 minutes for construction is suggested. They are only allowed to use that use only mini marshmallows and toothpicks as the materials. Require that the buildings be at least one-foot tall.



7. Have them use the shake table to test and modify (improve) the designs. Point out that the testing-improving-testing process is an important part of the bigger engineering design process. That's how weaknesses are discovered and problems solved—before you have an actual earthquake! Emphasize that in the upcoming earthquake challenge they will have only one chance to put their final building designs through a "real earthquake" test to see if they survive, so they must be certain that their buildings are survivable. What works? What doesn't? What could be improved? Test, test, test!
8. **Earthquake Challenge**: Once teams have one-foot tall structures and are satisfied with their stability and robustness, put the structures through a **one-minute** simulated earthquake challenge in which every team uses the same shaker table—either the teacher's shake table (that uses a variable speed drill to shake the table), or the best of the teams' shake tables, as agreed-upon by the class.
10. Have one student use a stopwatch (one can be found online on Google) to time how long each building survives the earthquake simulation. Remind groups to be ready to record the length of time their buildings lasted, the end building heights, as well as observations about how the building structures behaved under the shaking conditions. Have students watch all team tests to gather observations that they will use to finish the worksheet questions.

- **Failure:** If the building collapses or any part of the building besides its base touches the shake table, consider it failed, and note the time and stop the shake table. The building is not earthquake-safe for people. Once the shake table is off, measure the height of the building.
- **Success:** If the building survives for a full minute and is still one-foot tall, consider it a success—the group has engineered a solution to the challenge and is "hired" to design real buildings for their community. Record measurements and observations.

## Assessment

Pre-Activity Assessment

*Design Section of the Worksheet* : As either pre-activity, assign students to complete their own designs for their model building structures, including drawings, measurements, material specifications and explanations of how the designs function.

Activity Embedded Assessment

*Observations and Questioning*: During the activity, move around the classroom to observe students and ask them questions about what they are doing to determine how well they understand the activity. Ask individual students to explain what the group is working on, their strategies, what type of seismic waves their shake table creates, etc.

Post-Activity Assessment

*Post Assessment:* Have students complete the concluding worksheet questions, incorporating what they learned from observing their own and other groups' model building behavior under seismic stress. Have them draw conclusions about the relationship between the appearance of the structure and its building strategies, and its performance. If time permits, lead a class discussion using the concluding questions so students can hear each others' opinions and ideas.

## Activity Extensions

- Now that students have completed their own trial and error experiment, have them research the real-world design and construction strategies being used to make earthquake-resistant structures. Have students investigate and report back to class on earthquake engineering strategies for both new and existing structures of all types. Start by researching seismic base isolation, seismic vibration control and earthquake-resistant construction.

## Activity Scaling

For lower grades or younger students, skip the team construction of shake tables altogether. Give students the challenge of building a structure that is at least 1 foot tall with only mini marshmallows and toothpicks, and only have them test on a common shake table provided by the teacher. Allow students to create more than one structure so they have the opportunity to radically alter their designs and recognize building strategies that work best. Also, provide different materials, such as gumdrops, pipe cleaners or dry spaghetti, so they can test to see if some materials work better than others.

For upper grades or older students, offer more advanced materials for the team shake table construction, such as foam core board, wood, saws, drills and drill bits, and drills to power them. If desired, make the objective of the activity to create shake tables that most accurately represent a given seismic wave type or one that proves to be the most destructive. To test which shake table is the most destructive, have students each follow a set of instructions to build the same building. Then time how long it takes for each shake table to destroy the building, with the goal to have the lowest time.


NEWTON
EARTHQUAKE

Name ______________________________ Date ___________________________

# Lesson 3: Earthquakes

## Shake It! Activity Worksheet

**Design**

In the space below, draw a design for your model building. Label all the materials you used in your design and include measurements.

**Model Building/Structure Design Space**

(Materials: marshmallows and toothpicks only!)

Name ____________________________ Date _________________________

# Lesson 3: Shake It! Activity Worksheet

**Design Cost**

1. A box of toothpicks cost $6.00, and has #1,000 toothpicks in it. The unit cost per toothpick is $_______/per toothpick. My design uses _________ toothpicks, which will cost $___________ total for construction of my model building.

2. A bag of mini-marshmallows cost $2.09 oz., and has 16 oz. in the bag with about 208 mini-marshmallows. My design uses _______ marshmallows, which will cost $____________ total for construction of my model building.

**Shake Table Testing**

1. Which type(s) of seismic wave(s) does your shake table simulate?
   P –waves S-waves Love-waves Rayleigh-waves

   Explain the movement of the shake table.

2. Describe what happens to your building when you test it on your shake table.

**Earthquake Challenge**

1. How long did your building last through the "earthquake"?

2. Describe what happened to your building while it was going through the earthquake.

3. Based on what you noticed from your group and other groups, which design and strategies worked the best? Draw a sketch below and describe the design.

4. Why do you think this particular type of design worked the best?

# Oceanography

## Lesson 4- Waves: Echolocation in Action!

Ages 12-14

(Adapted from University of Colorado)

### Overview

In this activity, students will help Lois, Newton, and Pearl investigate waves. Students learn about echolocation: what it is and how engineers use it to "see" things in the dark, or deep underwater. They also learn how animals use echolocation to catch their meals and travel the ocean waters and skies without running into things.

Obviously, we need to know where things are in order to function. And, many times we need to be able to "see" something even when it is dark outside or something is far away and obstructed, by the ocean or clouds, for example. Engineers have learned from nature how to use sound and radio waves to locate objects. This technology is called **SONAR** (**SO**und wave **N**avigation **A**nd **R**anging) and **RADAR** (**RAD**io wave navigation **A**nd **R**anging).

### Learning Objectives

1. Students will be able to explain echolocation and give an example of echolocation application.
2. Explain that engineers developed SONAR based on natural echolocation.

### Suggested Timeframe

45 minutes

### Materials Required (Students work in pairs) Each pair needs:

- 1 Blindfold
- Crayons
- 1 Thin Dry Erase Marker for each student
- 1 Dry Eraser for each student
- 1 Dry Erase Protective Sleeve
- 1 Echolocation in Action! Worksheets (2 pages)
  *Students can place their worksheet inside the protective sleeve and use the dry erase marker to do their work.*

### Assessment

- Pre Activity Assessment
- Activity Embedded Assessment
- Post Activity Assessment

### Introduction/Initiation

*“After waiting out the storm, Angie and Harmon head back out to sea with a Fisherman named Frank to look for what they think is the wreck of a Spanish treasure on the ocean floor. As they get farther from shore it gets increasingly difficult to see the ocean bottom, and they still haven't seen the treasure. How are they going to find the it now?*

*Let's pretend that we are engineers, and we need to design a way for Angie and Harmon to see the ship and its treasure as it lies on the bottom of the ocean. Hmmm, what could we possibly do?*

*Take a couple minutes to talk to the person next to you and see what engineering solution you can think up! (Ask students to share their ideas after about two minutes).*

*Those are some fabulous suggestions. Many of your ideas involved different ways of seeing underwater. Animals that live in the water also have the problem of seeing underwater. In fact, many of them have eyes to see reflected light, but this only works to a certain depth until it gets too dark. Some animals have another way to see — they use sound waves instead of light waves. This is called echolocation.*

*Echolocation is a big word, so I'm going to write it on the board. Any ideas about what it means? Well, we know what "location" means — it is where something or someone is located, right? What does "echo" mean? Have you ever heard an echo? It sounds like the sound, or noise, is bouncing back to you, doesn't it? Well, that really is exactly what's happening! The sound waves are bouncing off of something and coming back to you, so you can hear them again. So, "echo" has to do with sound waves bouncing back, and "location" has to do with where something is.*

*Any ideas then about what "echolocation" means? What does it mean when we combine those two words? Why don't we take another minute and talk to the person next to us to see if we can figure it out. (Ask students to share their ideas after about one minute). Fabulous!*

**Echolocation means using sound waves bouncing back to tell how far away something is.**

Many different animals — including whales and dolphins — use echolocation to determine where they are under water. It also helps them capture their dinner! Dolphins make little clicking noises. The noises the animals make bounce off of objects and come back to their ears. The reflected noise, or the echo, will sound different depending on where the object is. These animals can tell how far away the objects are by listening to the echoes coming back.

Engineers have figured out a way to do the same thing that animals do; however, they need some special equipment to do it. Engineers use *sonar*, which stands for Sound wave Navigation And Ranging. This technology uses sound waves to navigate ocean waters and skies. *Radar*, RAdio wave navigation And Ranging, uses the same principals, but with radio waves instead of sound waves. Sonar and radar work almost exactly the same way that echolocation for animals. This is a great example of how engineers mimic what occurs in nature and use it to help people who have needs similar to the animals'.

You know about echolocation now, but first we need to talk a little bit more about sound waves. Sound waves have all these characteristics. When something or someone makes a sound, the sound creates pressure changes in the air (or water, if the sound is traveling through water). Those pressure changes travel to our ear, and our ear interprets them as sound.

Now we're going to do a fun activity where you will get to see how good your echolocation skills are!"

**Procedure**

Before the Activity

1. Gather all supplies
2. Get 1 Blindfold, Variety of crayons, 1 set of Echolocation in Action! Experiment Worksheets (2 pages), 1 Protective Sleeve, 1 Thin Expo Marker, and 1 Eraser for each student pair.

**With the Students**

1. Show students the activity worksheets and go over the activity.
2. Break the students into groups of two.
3. For each team, have one student sit in a chair and the other stand nearby with the Echolocation Worksheet.
4. Have students gently blindfold their partner so that they are unable to see. Remind them not to peek!
5. Have the non-blindfolded student snap or clap their fingers while the other student guesses the location from where the snap came.
6. Students should record their partner's response on the Echolocation Worksheet after each snap/clap.
7. Have students follow the Echolocation Worksheet for all nine snaps or claps, and record all responses on the sheet. Students should put a check mark if their partner guessed correctly and an X if they guessed incorrectly.
8. Ask students to write down the number of times they guessed correctly for each location (side, behind or in front).
9. Have students switch places and repeat the procedures. Once both students have guessed, have them give each other their worksheets, so they can use them to create their own bar graphs.
10. Help students color in their Echolocation Bar Graph Worksheet with the number of times that they guessed correctly for each location.
11. Talk as a class about the results! Discuss why some locations may be harder to guess than others. (Be aware that noise from other teams will likely be a contributing factor to erroneous guesses.)

**Assessment**

<u>Pre-Activity Assessment</u>

*Who Remembers?:* Ask students to raise their hands and share one thing they know about how animals in the ocean travel and/or communicate.

<u>Activity Embedded Assessment</u>

*Teacher Observation*: Walk around while students are completing the activity and assist them as needed. Talk with students about how challenging or simple it is to locate the sounds. Remind students that some animals are great at echolocation, and engineers mimic (in Sonar) this natural animal response.

<u>Post-Activity Assessment</u>

*Results Analysis*: Have several students share their bar graphs (if you have time, you can make one giant bar graph for the entire class). Talk about the results, and discuss why some locations were perhaps harder to guess than others.

Encourage students to think about why noise from other teams may have made it harder to guess the location of the snaps or claps.

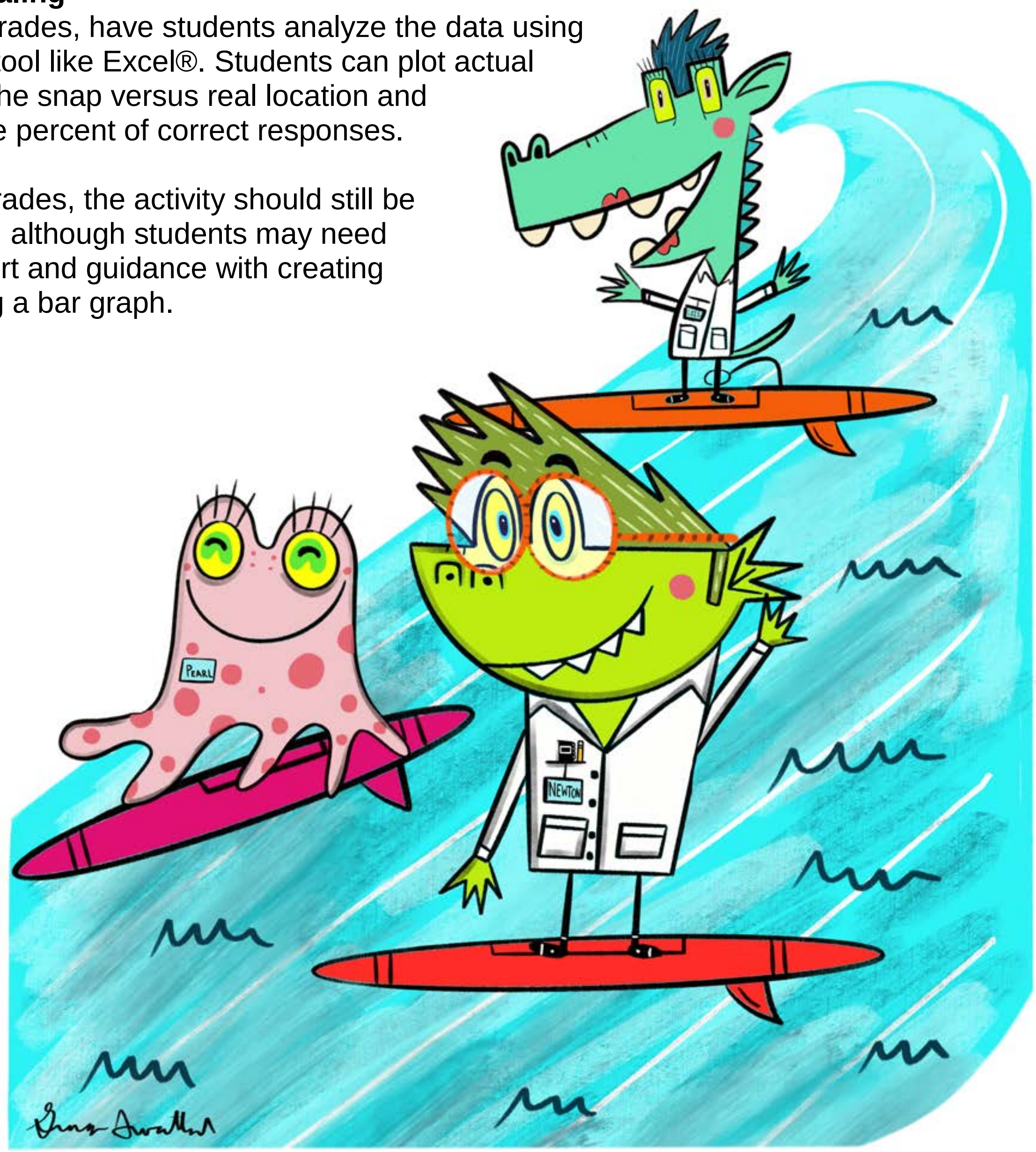
**Activity Extensions**

- Now that students have learned about echolocation. Have them research other animals that use echolocation that do not live in the ocean. Have them find the similarities and differences between them.

**Activity Scaling**

For upper grades, have students analyze the data using a graphing tool like Excel®. Students can plot actual location of the snap versus real location and then find the percent of correct responses.

For lower grades, the activity should still be appropriate, although students may need more support and guidance with creating and labeling a bar graph.



Name _____________________________ Date __________________________

# Lesson 4: Waves

## Echolocation In Action! Worksheet

Step 1: Help blindfold your partner and then have them sit in a chair.
Step 2: Write their name above the data table.
Step 3: Snap your fingers or clap your hands as directed on the table below and record if your partner was right or wrong.
Step 4: Once done, switch roles with your partner so that you can guess the location and they record your responses.

Recorder (team partner's name): ______________________________

| Location | Actual Guess | Right? | Wrong? |
|---|---|---|---|
| **Front** | | | |
| **Behind** | | | |
| **Side** | | | |
| **Side** | | | |
| **Behind** | | | |
| **Front** | | | |
| **Front** | | | |
| **Behind** | | | |
| **Side** | | | |

Number of times the "front" guess was right: __________

Number of times the "side" guess was right: __________

Number of times the "behind" guess was right: __________

Name ______________________________ Date ___________________________

# Lesson 4: Waves

## <u>Echolocation In Action! Worksheet</u>

Number of times the “front” guess was right: __________
Number of times the “side” guess was right: __________
Number of times the “behind” guess was right: __________

Color in the bar graph below with the number of times each guess was right. If the answer is 0, leave that group blank.

| | | | |
|---|---|---|---|
| | | | |
| 3 | | | |
| 2 | | | |
| 1 | | | |
| | Front | Side | Behind |

1. Which location had the most correct guesses? (If it was a tie, you can write both locations). ________________________________________

2. Which location had the least correct guesses? ___________________

3. What are your ideas about why some locations were easier or harder to guess?

_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________

# Lesson 5- Tsunami: Escaping the Giant Wave

Ages 12-14

(Adapted from University of Colorado)

## Overview

In this activity, students will help Lois, Newton, and Pearl investigate tsunamis. Students will learn about tsunamis, discovering what causes them and what makes them so dangerous. They will learn that engineers design detection and warning equipment, as well as structures that that can survive the strong wave forces.

In a hands-on activity, students will use a table-top-sized tsunami generator to observe the formation and devastation of a tsunami. They see how a tsunami moves across the ocean and what happens when it reaches a coastline. They will make villages of model houses to test how different material types are impacted by the huge waves. They further discuss how engineers design buildings to survive tsunamis.

Engineers use their creativity to save lives and decrease the destruction caused by tsunamis. While tsunamis cannot be prevented, engineers can design monitoring equipment to help scientists gather data to detect them early so people can be warned and evacuated to safety. Cameras continually watch volcanoes, seismometers measure tremors, GPS receivers measure mountain swelling, pressure sensors monitor air waves caused by explosions, and radar and satellites communicate the height, size and location of ash plumes. Some engineers design structures that can survive tsunamis. Other engineers design warning systems such as harbor disaster sirens, automated news media bulletins and emergency communication centers.

No one can stop tsunamis from forming since we cannot prevent earthquakes, volcanoes and landslides, but we can devise ways to minimize the impact of these killer waves on human communities. Engineers design and install seismographs, tide gauges, ocean floor pressure sensors and loud sirens. Engineers also design buildings using materials and shapes that are more likely to survive a tsunami. Between high-tech detection systems and smart structures, the impact of a tsunami strike can be lessened dramatically. But, in many areas, dense populations, unreliable local communication, and poor or nonexistent roads remain the biggest obstacles to quick evacuation to safety.

## Learning Objectives

1. Students will describe a tsunami as a large wave that is caused by the movement of the sea floor.
2. Students will explain how engineers are working to create buildings that can survive tsunamis.
3. Communicate that buildings constructed with materials that are heavier are more likely to survive a tsunami, but may be too expensive or not available.
4. Describe how engineers cannot prevent tsunamis, but they can design and build buildings so that they are more resistant to tsunamis.

**Suggested Timeframe**
45 -60 minutes

**Materials Required (Divide the class into three groups):**
<u>Materials for the table-top-sized tsunami generator:</u>
- 1 large, shallow, plastic waterproof tub (8-in x 14-in x 30-in or 20-cm x 36-cm x 76-cm, clear plastic is better but not necessary)
- 20 to 30-pound (9 to 14 kg) bag of sand
- 1 piece of sheet metal, ~20-in x 10-in x 0.1-in thick (as long as it is rigid, it is thick enough) or 51-cm x 25-cm x .25-cm thick
- Duct tape

<u>For the entire class:</u>
- Masking tape
- Scissors
- Model House Template
- 1 Thin Dry Erase Marker for each student
- 1 Dry Eraser for each student
- 1 Dry Erase Protective Sleeve

<u>Students in group A need:</u>
- 2 sheets of tissue paper (the gift wrap type)

<u>Students in group B need:</u>
- 3 sheets of cardstock or manila envelope material

<u>Students in group C need:</u>
- 3 sheets of notebook paper
- 40 toothpicks

**Assessment**
- Pre Activity Assessment
- Activity Embedded Assessment
- Post Activity Assessment

**Introduction/Initiation**
*"What is a tsunami? Well, it is a really large wave — much larger than the waves you see when you splash in a pool or surf at the beach. The difference between a regular wave and a tsunami is that a regular wave is just a surface disturbance of the water, and a tsunami is a disturbance that reaches all the way to the ocean floor!*

*What do you think causes a tsunami? Well, tsunamis can be caused by anything that moves the ocean or sea floor, like earthquakes, volcanoes and landslides. Think about an underwater earthquake that is caused by the moving of tectonic plates. Do you think that this could move the sea floor and create a tsunami? Yes, it could! Do you think engineers can prevent tsunamis? Engineers cannot prevent natural events like earthquakes or volcanoes, or the tsunamis that can result from them. So, what can engineers do about tsunamis? One thing engineers can do is build structures that can survive a tsunami.*

*In December 2004 a huge tsunami hit the beach in Indonesia. Do you know from what material most of the destroyed houses were made? Most were made of wood, and some were actually made of paper. What do you think are the advantages and disadvantages of wooden or paper houses? How might houses made of these materials be a disadvantage when it comes to a tsunami? Well, a house made out of weak material, such as wood or paper, probably will not survive the great forces of a tsunami. So, what can engineers do so that a building or structure is able to survive a tsunami? (Possible ideas: Build it out of stronger material; build it on stilts.) What might be some disadvantages of these types of the new houses? (Possible ideas: More costly and difficult to construct, look different than usual buildings.)*

*Today, we are going to explore some of the choices that engineers have when designing buildings with tsunamis in mind and make some conclusions as to what shapes and materials make the most tsunami-resistant buildings. Today you are going to make a model building and see if it will survive a tsunami. Are you ready?*

**Procedure**

Before the Activity

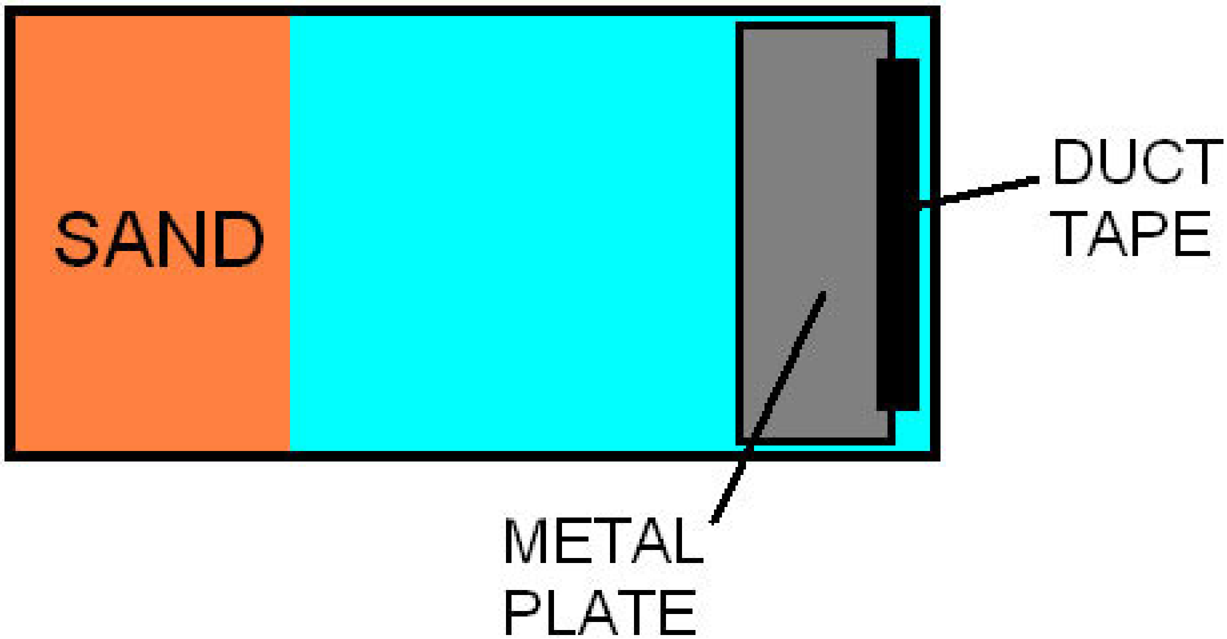
1. Gather all supplies for the Tsunami Generator
2. You will need:

- 1 large, shallow plastic waterproof tub (8-in x 14-in x 30-in or 20-cm x 36-cm x 76-cm, clear plastic is better but not necessary)
- 20 to 30-pound bag of sand
- 1 piece of sheet metal, ~20-in x 10-in x 0.1-in thick (as long as it is rigid, it is thick enough) or 51-cm x 25-cm x .25-cm thick
- Duct tape

Teachers can construct and test the tsunami generator beforehand, or involve the class, particularly when working with older students, as a further demonstration of engineering design and production.

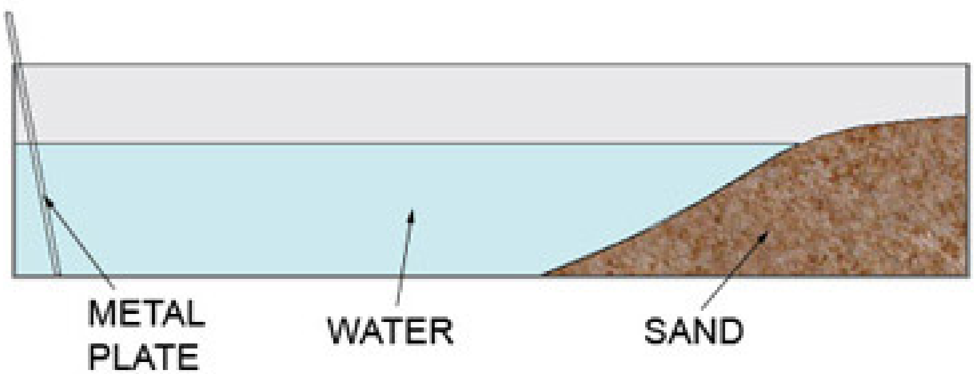
**Setup of the Tsunami Generator should look like the following:**

**Figure 2**




1. Fill one end of the tub with sand, creating a continental shelf and beach (see Figures 2 and 3).
2. At the opposite end of the tub, attach the metal sheet to the bottom of the tub using a piece of duct tape along one edge, so it works like a hinge (Figures 2 and 3).
3. Fill the tub with water so that most of the sand is covered, but leave some sand above the waterline to represent a sandy beach (Figure 3).

**Figure 3**




4. Test the tsunami generator by first leaning the metal plate against the back wall of the tub and then pushing the plate all the way down into the water. A tsunami should form that covers most or the entire beach. To adjust the wave height,adjust the speed with which you push down the plate (Figure 4, below).

**Figure 4**

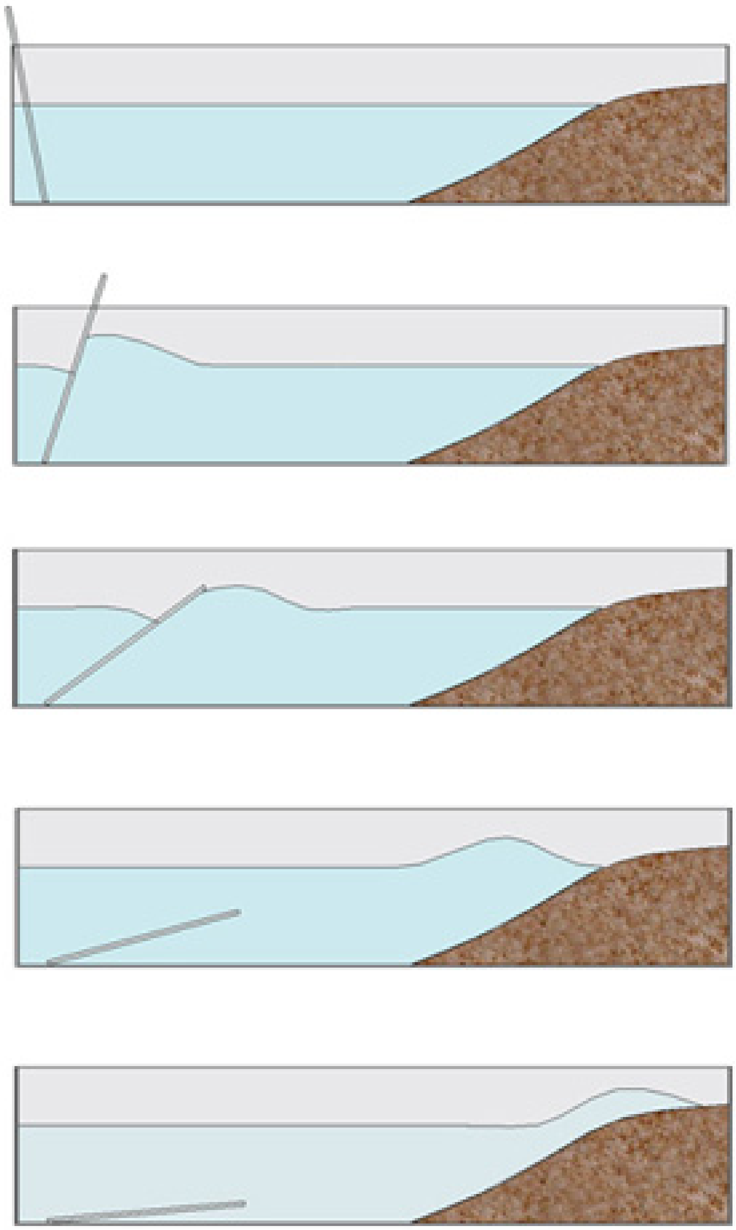


Figure 4 shows a tsunami generator in action. Pushing the metal plate down into the water creates a wave that moves across the tub of water and onto the sandy beach.

**Troubleshooting**: To create more controlled and consistent waves, have the teacher operate the tsunami generator for each trial. It helps to practice creating waves before conducting this activity in class.

**With the Students**

**Building the Houses**

1. Divide the class into three groups (A, B and C). Each group will make a different type of house, using either tissue paper, cardstock or notebook paper and toothpicks. Students in each group need not sit together while they construct their model houses.
2. Provide each student with supplies according to his/her assigned group, as well as access to scissors and masking tape.
3. Distribute the Model House Template, and demonstrate the construction of the buildings as shown in Figure 1 and on the diagram template. This is a good time to point out that the students are

working with geometric shapes.
4. Provide time for each student to construct his/her type of building (tissue, cardstock or notebook paper) using scissors and tape.
5. Have the group of students who construct the buildings using notebook paper tape toothpicks to the four corners of their buildings so that the toothpicks function as stilts, as shown in Figure 5, to the right.

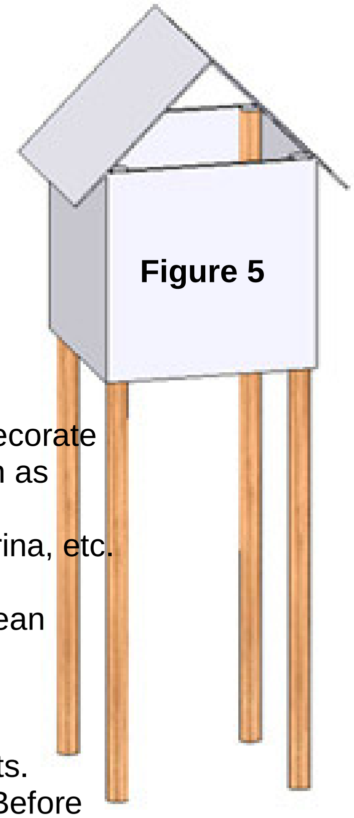


Figure 5

6. Give the students time to decorate their houses. They can label and decorate their model structures to represent a variety of community buildings, such as houses, schools, bank, grocery store, restaurant,
police station, library, city hall, power plant, playground, factory, boat marina, etc.
7. Show students the tsunami generator and explain how it works,
with the metal plate simulating sea floor movement and causing huge ocean waves.

**The Tsunami Test**

In four different trials, set up the buildings made by each group of students. Have students predict the outcome of the activity before it is performed. Before hitting each village with a wave, ask the students they think is going to happen to the village. Students should start to realize that the buildings made from the lighter and more water absorbent materials are more susceptible to tsunami damage. The heavier buildings and those built up and away from the water are most likely to survive. Have the students rank the houses from lightest to heaviest materials in their summary observations.

***I. Tissue Paper test.*** First, have the students who constructed their model buildings from *tissue paper* place them scattered across on the beach to create a paper model village (see Figure 6). Before the tsunami, have students predict what will happen to the village.
A tsunami hits! Using the metal plate, create a wave that swamps most of the land. Create several more waves and remind the students that there is usually more than one wave associated with a tsunami. Expect the waves to destroy most of the tissue paper buildings.

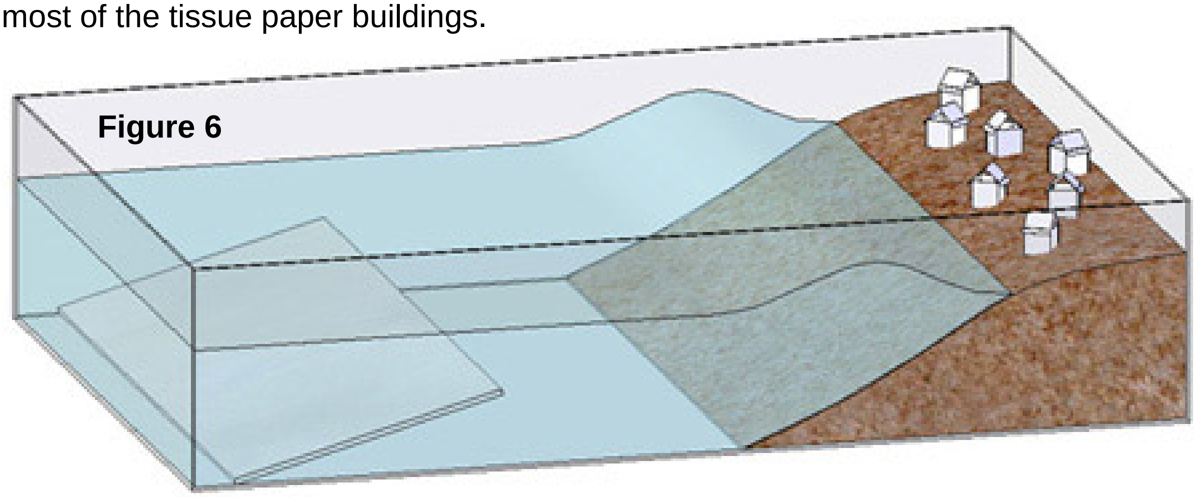


**Figure 6**

Figure 6. A tsunami wave moves towards the paper model village.
Evaluation: Ask the students what they thought of the tsunami hitting the tissue village. Is this what they expected? Why did the tissue buildings fail so easily?

What else do you observe?

***II. Cardstock Tsunami Test.*** Perform the tsunami test again, this time with the students who built the *cardstock buildings*. In this scenario, students observe that some buildings move slightly, but overall the cardstock village survives better than the tissue village. Note: After several waves the sand erodes slightly, so build up the continental shelf and beach with more sand, as needed.

**III. *Notebook Tsunami Test*** . Perform the test yet again, with the students who built the notebook paper buildings with toothpick stilts. Make sure students just set the stilted buildings on the sand and do not push the toothpicks all the way into the sand (see Figure 7).

**Figure 7**

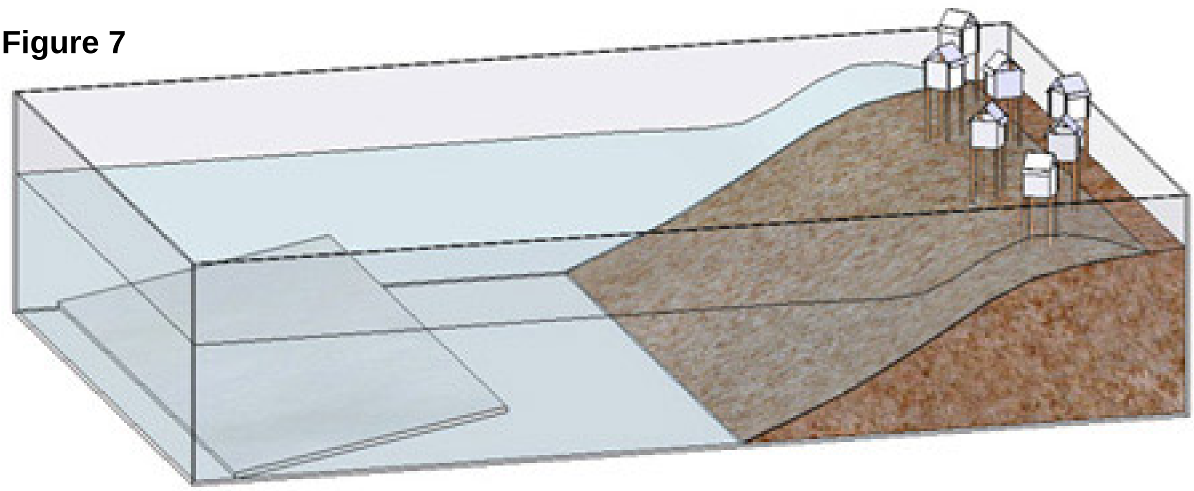


Figure 7. A tsunami wave moves through the stilts of this paper model village.

**Assessment**

<u>Pre-Activity Assessment</u>

*Voting:* Have the class vote yes or no on the following question:

- Can engineers prevent tsunamis? (Answer: No. Tsunamis are natural events caused by earthquakes, landslides and volcanoes, over which people have no control. Since we cannot control or prevent tsunamis, engineers help us predict and survive them.)

<u>Activity Embedded Assessment</u>

*Prediction:* Have students predict the outcome of the activity before the activity is performed. Before hitting each village with a wave, ask the students: What do you think is going to happen to the village? (Students should start to realize that the buildings made from the lighter and more water absorbent materials are more susceptible to tsunami damage. The heavier buildings and those built up and away from the water are most likely to survive.) Have the students rank the houses from lightest to heaviest materials in their summary observations.

<u>Post-Activity Assessment</u>

*Concluding Discussion:* Ask the students and discuss as a class:

- Describe the results of the three tsunami trials? How did they compare? What did you observe?
- Rank the types of model buildings in order from worst to best at surviving the tsunamis.
- How might engineers design a building or structure so it is able to survive a tsunami? (Possible answers: Build it out of concrete, stone or bricks [heavier, stronger materials]; build it on stilts so it is above the water flow; make sure it has a deep footing into the soil; or shape it so that water flows around it.)
- What might be some disadvantages of these types of houses? (Possible answers: Buildings like this might cost more to construct, be more difficult to build, or be considered less attractive.)
- How might you re-design your models to improve their chances of surviving big waves?

**Activity Extensions**

- *Re-Engineering:* Ask the students how they might improve the buildings in their village. Have them sketch or test their concepts for tsunami-resistant buildings. What material would they use? How would they be shaped? What features would they have? Where would they be located?
- Have students research the house designs engineers have come up with to resist tsunamis. Look at the website http://senseable.mit.edu/tsunami-prajnopaya/ to see what a group of engineers from Harvard and MIT are doing. Have them write a paragraph describing the building and what makes it unique.

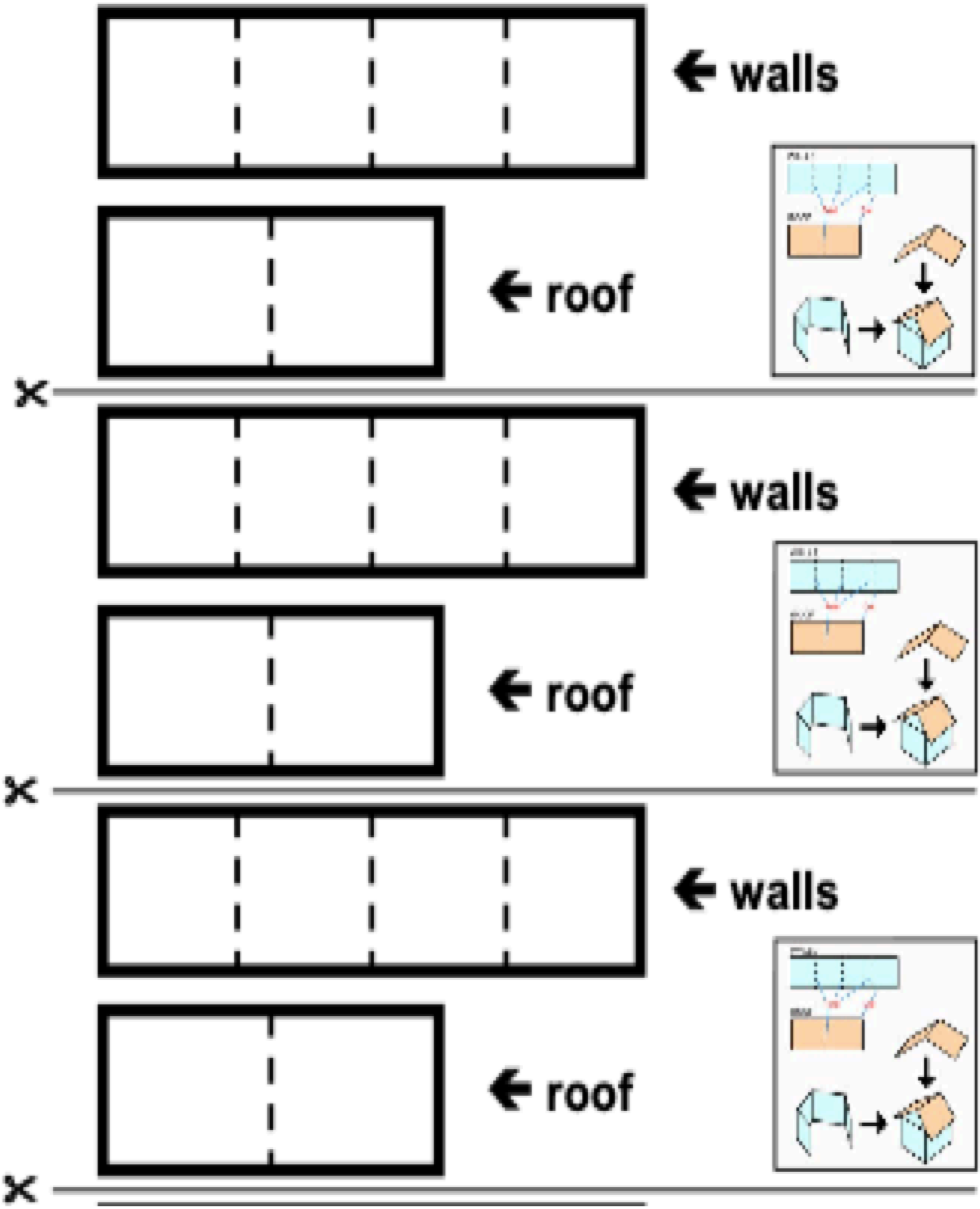
**Activity Scaling**

For lower grades, pre-cut the paper and consider pre-building the structures.

For upper grades, after exploring what happens to the different villages during a tsunami, have students design and build their own new buildings to survive a tsunami. Provide limited supplies and a size constraint of 2.5 cubic cm.

**Lesson 5: Tsunami- Escaping the Giant Wave**

## Model House Template



## Oceanography

### Lesson 6- Escape Room: Plastics in the Ocean!

Ages 15-19

**Overview**

In this activity, students will use puzzles, clues, teamwork, and critical thinking to solve this Escape Room Challenge. Students will analyze 10 different puzzles around the issue of plastics in the ocean to see who can solve the puzzles first before the time runs out.

Students are introduced to the growing worldwide environmental problems that stem from plastic waste. They learn how plastic materials don't go away, but become micro-plastic pollution that accumulates in water resources as well as human and other animal bodies.

Plastic pollution is a rising concern that demands new research methods to identify and quantify the amount of plastic in our waterways and to observe and measure the impacts of this plastic. Environmental engineers identify potential hazards in water supplies and evaluate different methods for treating water resources for drinking or releasing back into the environment. They use mechanical and chemical processes to remove toxic and biotic pollutants.

**Learning Objectives**

1. Students will explain how micro-plastic pollution can result from both ordinary plastic use and plastic disposal.
2. Think of ways that daily disposed-of plastic items could be produced or packaged to eliminate or reduce their likelihood of becoming micro-plastic pollution.

**Suggested Timeframe**

45-60 minutes

**Materials Required (Students work in groups of 2-4)**

**Each group needs:**

- 1 Timer for each group
- 1 Thin Dry Erase Marker
- 1 Dry Eraser
- 1 Dry Erase Protective Sleeve
- 1 Escape Sheet Answer Key
  *Students can place their worksheet inside the protective sleeve and use the dry erase marker to do their work.*

**Assessment**

- Pre-Assessment Activity
- Unlock the last puzzle before time runs out

**Introduction/Initiation**

*"What do you think happens to a plastic cup or bottle after it is thrown away into the trash? (Listen to student responses.) That's right, when it comes to disposing the materials we use, there is no "away."*

*When we put something into the trash, it goes to the landfill. When we burn fuel, toxic gases and particles are released into the air. Whatever we flush down our drains is carried to streams and seas. In particular, all the plastic we use and dispose of daily is added to our growing "plastisphere"—the fragmented layer of discarded hydrocarbons that humans are rapidly creating in the land and water around the Earth (Zettler, 2013).*

*Micro-plastics originate from cosmetic products, washed clothing and the breakdown of larger plastic pieces. The National Oceanic and Atmospheric Administration defines micro-plastics as hydrocarbon particles that are 5 mm or smaller in diameter—or about the size of a sesame seed (USDOC/NOAA, 2016). More and more people are becoming aware of this form of pollution. These pieces may be small, but the ripple effects of problems are huge. Ingestion of particles and byproducts by wildlife and humans are linked to disorders and diseases."*

*"In today's activity you will use puzzles, clues, teamwork, and critical thinking to solve this Escape Room Challenge. To escape the room you must analyze 10 different puzzles around the issue of plastics in the ocean to see who can solve the puzzles first before the time runs out."*

**Procedure**

Before the Activity

1. Gather all supplies. – 1 Escape Room Answer Sheet, 1 Protective Sleeve, 1 Thin Expo Marker, and 1 Eraser for each group.
2. Set the timer to desired time (45-60 minutes).

**With the Students**

1. Give each group puzzle #1
2. As students work on the puzzles, they are not allowed to write on them. They can place the puzzle in the protective sleeve and use the dry erase marker if the puzzle needs to be written on (like the word search puzzle). Once they solve the puzzle, they should write their answer on the answer key and show you before moving on to the next puzzle.
3. The goal of the student groups is to have them solve all 10 puzzles before the time runs out.

**Assessment**

<u>Pre-Activity Assessment</u>

*Make It Personal:* After presenting the Introduction/Motivation content to the class, have students individually list plastic items that they dispose of daily. Then have them share their lists in small groups and discuss ways that their particular items are disposed of after use, followed by ideas for reuse and/or elimination, perhaps by coming up with ideas for alternatives to the plastic items. Especially think of single use items that will not decompose for hundreds of years (if ever). Example items might include zip-lock bags, food wrappings, candy wrappers, straws, pull-tabs, plastic bottles, screw plastic bottle caps, wrappings from purchased products, shopping bags, jar lids, dental floss, toothbrushes, pens, packing materials, strapping tape, plastic-coated materials.

Refer to chart "How Long Before It's Gone?" to support conversation.

Post-Activity Assessment
Solve all 10 puzzles before time on the timer runs out to escape the room!

**Activity Extensions**

- Assign groups to follow the resource links in the Additional Multimedia Support section and write summaries about the information sources, including the purpose of the online publication and possible biases.

**Additional Multimedia Support**
A quick introduction to the planetary problem of plastics (2:17 minutes): Science Today: *Plastic Pollution | California Academy of Sciences* (2:17 seconds) at https://www.youtube.com/watch?time_continue=128&v=h-hn6w9t7ZM

A guest column about microbeads/plastics written by a high school student: “Beauty and the Beads” by Marcella Capuco, June 3, 2015, *Water Online*, at http://www.wateronline.com/doc/beauty-and-the-beads-0001

A high school-level scientific paper about microplastics in facial cleansers, “Contributing to Marine Pollution by Washing Your Face: Microplastics in Facial Cleansers” by Lisa S. Fenall and Mary A. Sewell, August 2009, *Marine Pollution Bulletin*, at http://www.sciencedirect.com/science/article/pii/S0025326X09001799

International campaign against microplastic ingredients in cosmetics, supported by 38 countries: *Beat the Micro Bead*, at http://www.beatthemicrobead.org/en/science

Product lists by country of products that do and do not contain microplastic ingredients, *Beat the Micro Bead*, at http://www.beatthemicrobead.org/product-lists/

Reducing plastics in the ocean information, 5 Gyres Institute: Science to Solutions (nonprofit), at http://www.5gyres.org

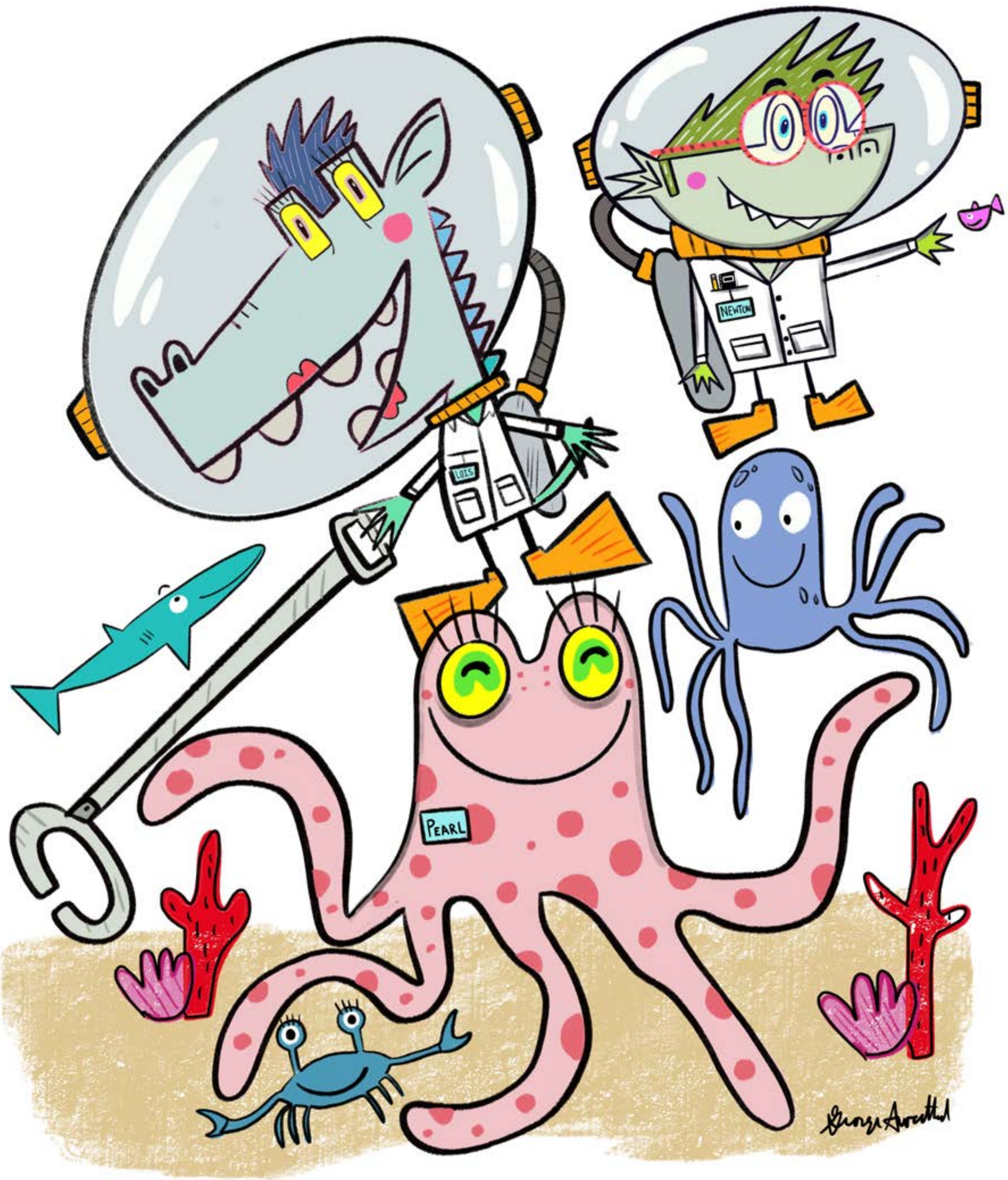
“Crest Toothpaste Embeds Plastic in Our Gums,” (a dental hygienist/mom’s home experiment to find and try to dissolve the inert polyethylene particles in toothpaste that she finds when cleaning teeth) by Trish Walraven, *Dental Buzz*, March 4, 2014, at http://www.dentalbuzz.com/2014/03/04/crest-imbeds-plastic-in-our-gums/

Early microplastic in marine ecosystem research in “Lost at Sea: Where Is All the Plastic?” by Richard C. Thompson et al., in *Science*, May 7, 2004, at http://www.sciencemag.org/content/304/5672/838

Plastic in the environment in “Plastics, the Environment and Human Health: Current Consensus and Future Trends,” by Richard C. Thompson et al., in *Philosophical Transactions of the Royal Society,* June 14, 2009, at http://rstb.royalsocietypublishing.org/content/364/1526/2153

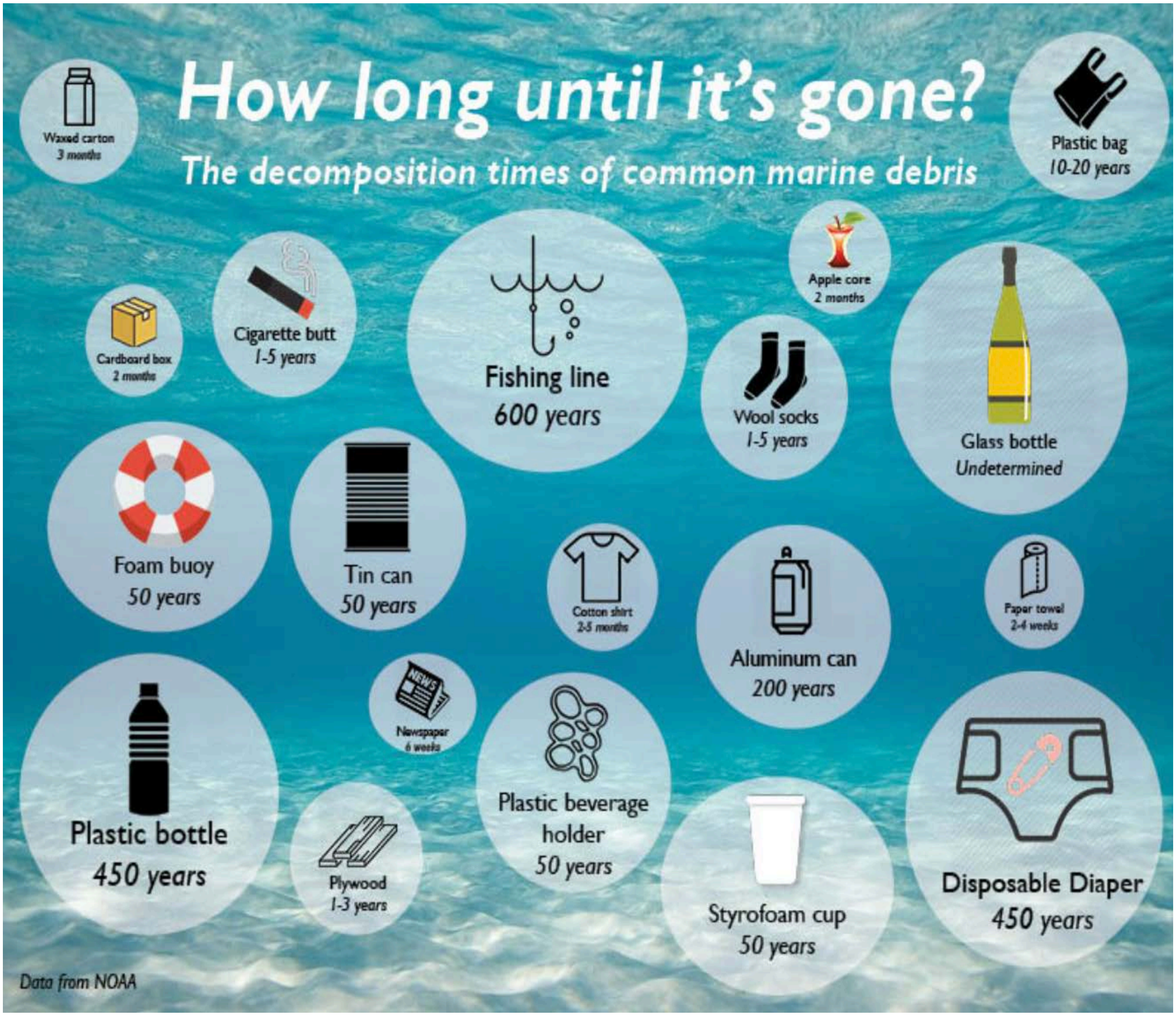
**Activity Scaling**

For lower grades or younger students, you can provide 3 “hint cards” to each group. They can turn them into you as needed when they are stuck on a puzzle.



## Lesson 6: Escape Room- Plastics in the Ocean!

## "Pre Assessment"



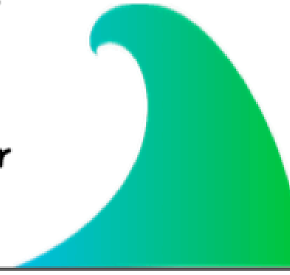

Have students individually list plastic items that they dispose of daily. Then have them share their lists in small groups and discuss ways that their particular items are disposed of after use, followed by ideas for reuse and/or elimination, perhaps by coming up with ideas for alternatives to the plastic items. Especially think of single use items that will not decompose for hundreds of years (if ever).

**PUZZLE 1 DIRECTIONS:** Unscramble the words to create two sentences. Once you think you have the sentences unscrambled, record the letters in order on your Escape Sheet to reveal one question. Show the question to your teacher for the next puzzle!

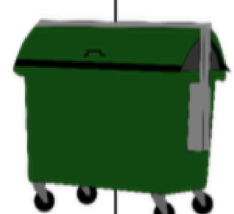
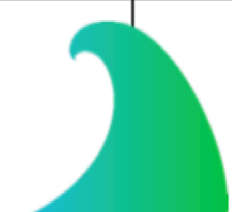
**Cut the words apart separately or in clusters of words, depending on what your students will enjoy. Clusters work best for my students.

# Eighty percent of the plastic trash in the oceans started out on land. This means 'throwing away' all of our plastic isn't enough to keep them clean.

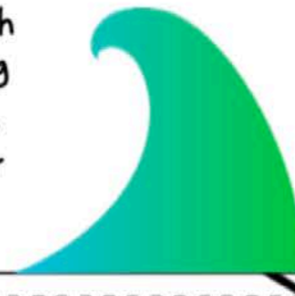
**PUZZLE 2 DIRECTIONS:** Using the pieces, construct the potential life cycle of a plastic bag. Next, record the numbers starting with the first step in it's life. Convert those numbers into a code word, record the word on your Escape Sheet and show your teacher for your next puzzle!



**Cut each strip apart so that you have 5 strips. Keep the names attached to the numbers.

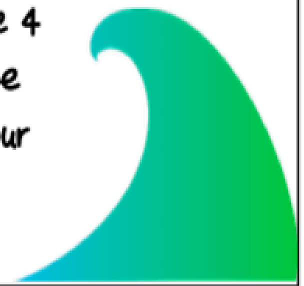
| | | |
|---|---|---|
| Oil |  | 20 |
| Grocery Store |  | 18 |
| Homes |  | 1 |
| Landfills |  | 19 |
| Oceans |  | 8 |

**PUZZLE 3 DIRECTIONS:** Find 10 words in the word search that deal with plastics in the ocean. Then, use the remaining letters to create a sentence (top to bottom, left to right). Record this sentence on your Escape Sheet and show your teacher for your next puzzle!

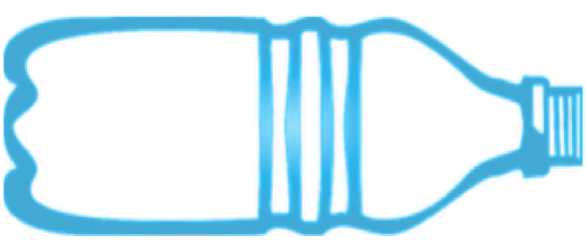


| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Y | B | E | A | R | L | Y | N | G | R |
| B | I | O | D | E | G | R | A | D | E |
| O | O | C | E | R | Y | G | N | B | S |
| R | A | T | V | O | R | A | O | I | E |
| E | C | S | O | B | A | R | P | O | A |
| C | C | G | R | G | R | B | A | P | T |
| Y | U | O | T | C | E | A | R | L | L |
| C | M | R | E | I | E | G | T | A | A |
| L | U | S | X | U | S | E | I | S | N |
| A | L | I | N | G | T | P | C | T | T |
| B | A | H | I | R | T | A | L | I | I |
| L | T | G | Y | R | E | T | E | C | C |
| E | I | YB | I | L | L | C | S | I | O |
| N | O | P | L | A | S | H | T | IC | B |
| A | N | GS | P | A | C | I | F | I | C |

**PUZZLE 4 DIRECTIONS:** Read the passage in puzzle 4 carefully. The answer to the question at the end of the passage is hidden in the text. Record the answer on your Escape Sheet and show your teacher for your next puzzle!



Most all plastics are made using oil. The process of creating pla*tics from crude oil is relatively sim*le and *heap, which explains why plast*cs dominate so many areas of our lives. The use of plastics in many countries around the world has become an issue because of how long they remain on earth. They are not truly biodegrada*le; they only break into tiny particles. In fact, every piece of plastic ever made *till exists on earth. When plast*cs are not proper*y disposed, they become an environmental hazard. Even then, plastics can end up in our oceans since 80% of all plastic ocean trash once star*ed out on the land. For these re*sons, some c*untries have outlawed the production of plastics.



What is a better alternative to making plastics using oil?

**PUZZLE 5 DIRECTIONS:** The question in puzzle 5 is encrypted. Crack the code and answer the question on your Escape Sheet. Show the answer to your teacher for the next puzzle!

23 8 1 20

3 15 12 15 18 19

15 6

16 12 1 19 20 9 3 19

23 5 18 5

6 15 21 14 4

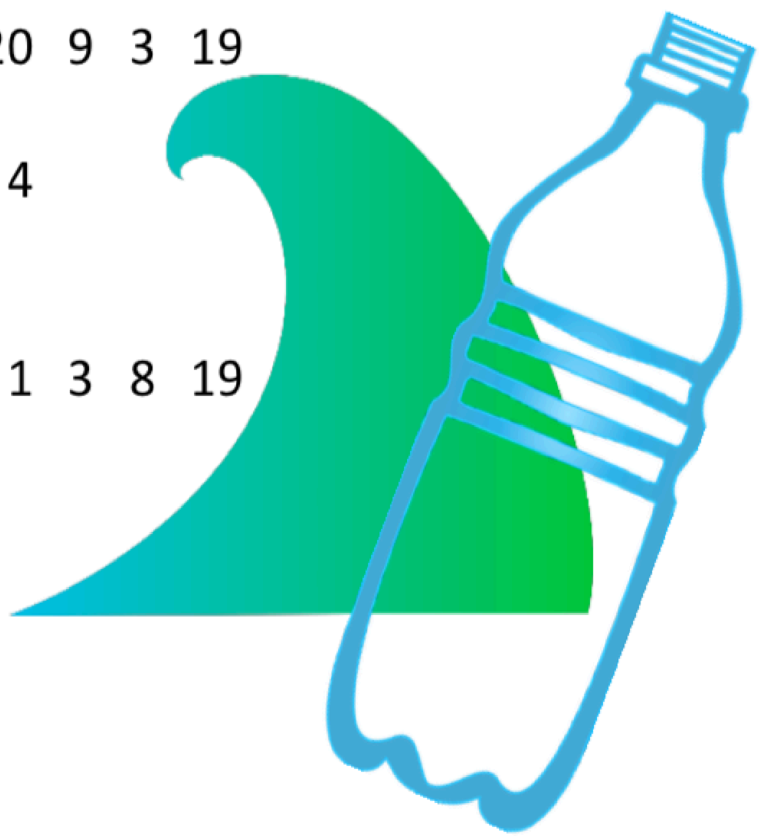
9 14

20 8 5

19 20 15 13 1 3 8 19

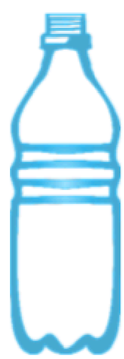
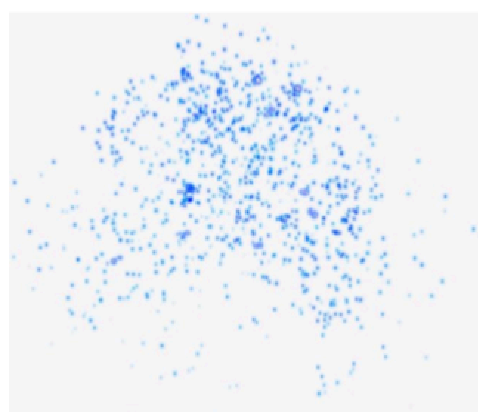
15 6

2 9 18 4 19



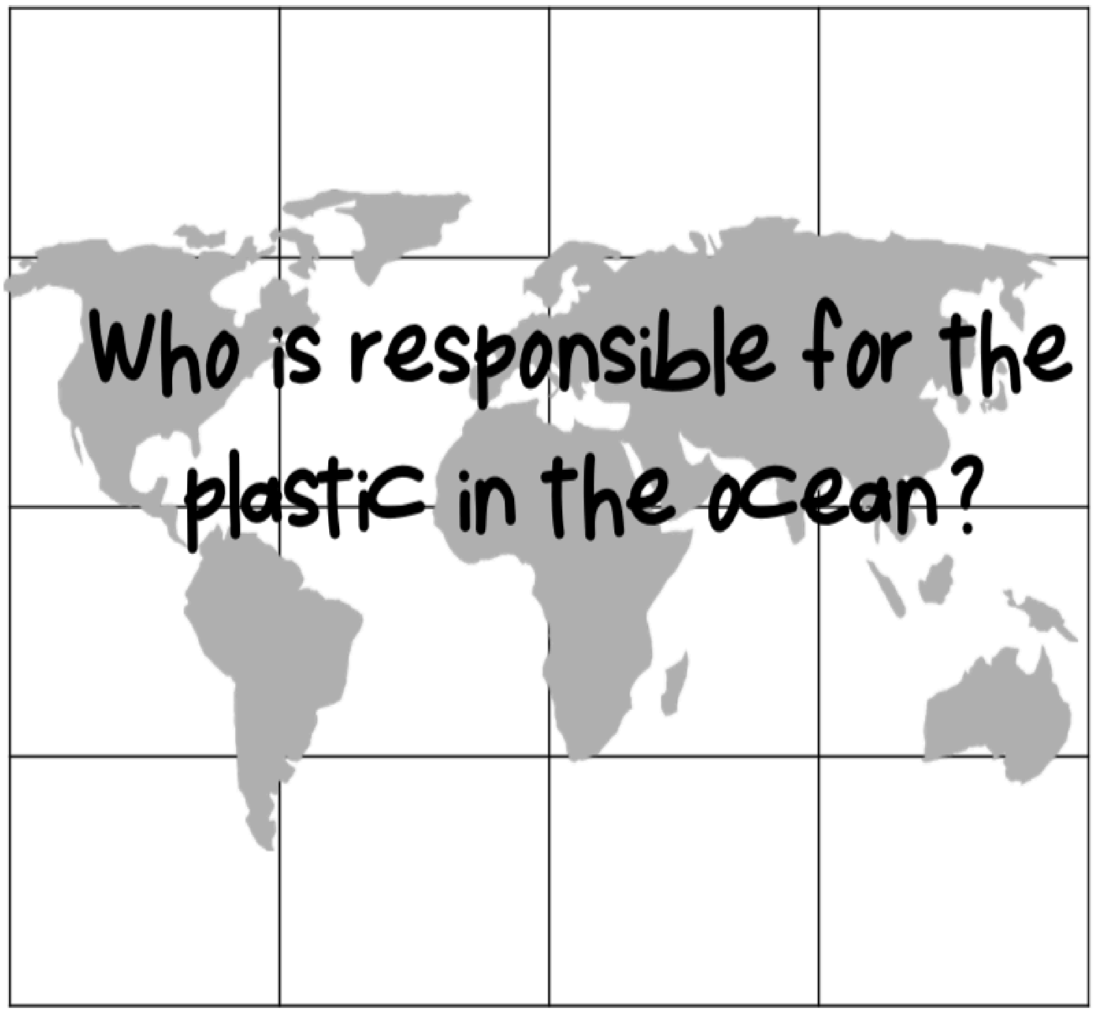
**PUZZLE 6 DIRECTIONS:** Match the gyres to their correct fact. The puzzle is encrypted. Record the code word you are able to create on your Escape Sheet. Show your teacher for your next puzzle!

**Cut apart the puzzle pieces.

| | |
|---|---|
| North Pacific Gyre | South Pacific Gyre |
|  XIV I XIV XV XVI I XVIII |  XX IX III XII V XIX |

**PUZZLE 7 DIRECTIONS:** Put your puzzle together. It will reveal a question. Record your answer on your escape sheet. Show your teacher for your next puzzle!

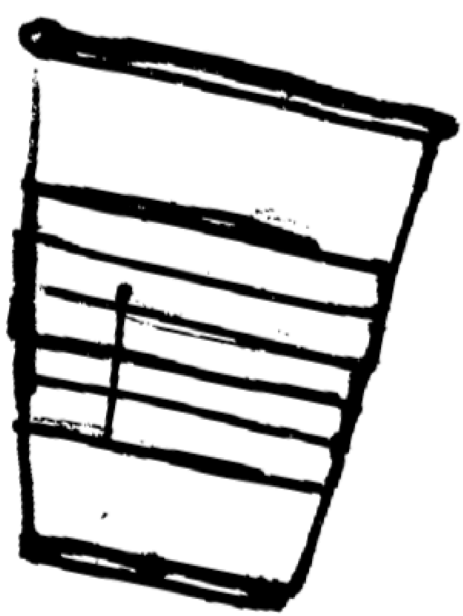
**Cut apart the puzzle pieces.



**PUZZLE 8 DIRECTIONS:** The question for puzzle 8 is encrypted. Figure out what the question is asking and answer the question on your Escape Sheet. Show your answer to your teacher for your next puzzle!

**Leave this page as is, or cut the words apart to make it more challenging for students.

# Hwo dseo sticpla dne pu ni msnhua' dsiet?



**PUZZLE 9 DIRECTIONS:** Decode the question for puzzle 9. Record the answer on your Escape Sheet. Show the answer to your teacher for your next puzzle!


Other + PS = ______ = ______
PP + PP + PP = ______ = ______
Other + Other + PP = ______ = ______
PS + PS + PS + HDPE = ______ = ______

LDPE + LDPE + LDPE + LDPE = ______ = ______
PS + PS = ______ = ______
PET = ______ = ______
Other + Other + PP = ______ = ______
Other + Other + PS = ______ = ______
PS + PVC = ______ = ______
PVC = ______ = ______
Other + Other + PP = ______ = ______

PET = ____ = ______
PS + PS + PS = ______ = ______
PP = ______ = ______

Other + PS = ______ = ______
PET = ______ = ______
LDPE = ______ = ______
PP = ______ = ______

PS = ______ = ______
PS + PS + PS = ______ + ______
PP + PP + PP = ______ = ______
Other + PS = ______ = ______

**PUZZLE 10 DIRECTIONS:** Arrange the strips of paper to form a question. Write your answer on your Escape Sheet and show your teacher.

**Cut apart the strips.

Who is

taking the

initiative to clean

up all the

plastics in the

ocean?

# ESCAPE SHEET

Student Name(s): ______________________________

As you solve each puzzle, record your codes, numbers, or answers on this page. After completing each puzzle, you must bring this sheet (as well as the materials from the puzzle) to your teacher before receiving your next puzzle. Good luck! Will you escape in time?

1. Puzzle 1: ___ ___   ___ ___ ___   ___ ___ ___ ___ ___   ___ ___ ___ ___?
2. Puzzle 2: ___ ___ ___ ___ ___
3. Puzzle 3:

______________________________________________________________

______________________________________________________________

4. Puzzle 4: ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
5. Puzzle 5: ______________________________
6. Puzzle 6: ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
7. Puzzle 7: ___ ___ ___   ___ ___ ___ ___ ___
8. Puzzle 8: It moves through the ___ ___ ___ ___   ___ ___ ___ ___ ___
9. Puzzle 9: ___ ___ ___
10. Puzzle 10: ___ ___   ___ ___ ___

## CONGRATULATIONS! YOU'VE ESCAPED THE GAME!

Time remaining: _______

# ESCAPE SHEET

Student Name(s): ______________________________

As you solve each puzzle, record your answers on this page. After completing each puzzle, you must bring this sheet (as well as the materials from the puzzle) to your teacher before receiving your next puzzle. Good luck! Will you escape in time?

1. Puzzle 1: I s t h e o c e a n s a f e ?
2. Puzzle 2: T r a s h
3. Puzzle 3:
   Yearly, grocery stores bag groceries using thirty billion plastic bags
4. Puzzle 4: B i o p l a s t i c s
5. Puzzle 5: Reds, purples, and yellows
6. Puzzle 6: N a n o p a r t i c l e s
7. Puzzle 7: T h e w o r l d
8. Puzzle 8:Puzzle 8: It moves through the F o o d c h a i n
9. Puzzle 9: O i l
10. Puzzle 10: N o o n e *a cool alternative might be "we are"

## CONGRATULATIONS! YOU'VE ESCAPED THE GAME!

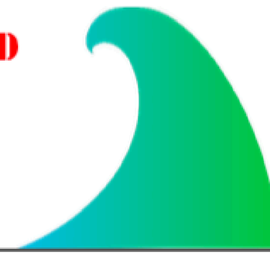
Time remaining: ________

**ANSWER: STUDENTS WILL NEED TO CORRECTLY ASSEMBLE THE 2 SENTENCES IN ORDER. WHEN THEY RECORD THE UNDERLINED LETTERS IN ORDER, IT WILL READ "IS THE OCEAN SAFE?"**

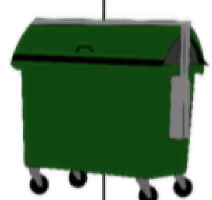
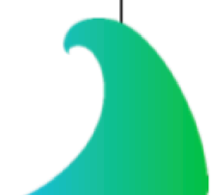
**Cut the words apart separately or in clusters of words, depending on what your students will enjoy. Clusters work best for my students.

# Eighty percent of the plastic trash in the oceans started out on land. This means 'throwing away' all of our plastic isn't enough to keep them clean.

**ANSWER: STUDENTS SHOULD ARRANGE THE PICTURES AS SHOWN BELOW. ONCE THEY HAVE THE CORRECT ORDER, THEY WILL NEED TO CONVERT THE NUMBERS TO LETTERS FROM THE ALPHABET, WHICH READS "TRASH".**



**Cut each strip apart so that you have 5 strips. Keep the names attached to the numbers.

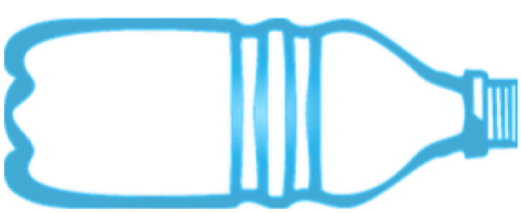
| | | |
|---|---|---|
| Oil |   | 20 |
| Grocery Store |  | 18 |
| Homes |  | 1 |
| Landfills |  | 19 |
| Oceans |  | 8 |

**ANSWER: STUDENTS SHOULD FIND 10 WORDS, COLOR CODED BELOW. ALL UNUSED LETTERS FROM TOP TO BOTTOM, LEFT TO RIGHT WILL READ: "YEARLY, GROCERY STORES BAG GROCERIES USING THIRTY BILLION PLASTIC BAGS".**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Y | B | E | A | R | L | Y | N | G | R |
| B | I | O | D | E | G | R | A | D | E |
| O | O | C | E | R | Y | G | N | B | S |
| R | A | T | V | O | R | A | O | I | E |
| E | C | S | O | B | A | R | P | O | A |
| C | C | G | R | G | R | B | A | P | T |
| Y | U | O | T | C | E | A | R | L | L |
| C | M | R | E | I | E | G | T | A | A |
| L | U | S | X | U | S | E | I | S | N |
| A | L | I | N | G | T | P | C | T | T |
| B | A | H | I | R | T | A | L | I | I |
| L | T | G | Y | R | E | T | E | C | C |
| E | I | YB | I | L | L | C | S | I | O |
| N | O | P | L | A | S | H | T | IC | B |
| A | N | GS | P | A | C | I | F | I | C |

**ANSWER:** AS STUDENTS READ, THEY NEED TO REPLACE THE (*) WITH THE CORRECT LETTER. THE LETTERS WILL UNSCRAMBLE TO CREATE THE WORD "BIOPLASTICS".

Most all plastics are made using oil. The process of creating pla*tics from crude oil is relatively sim*le and *heap, which explains why plast*cs dominate so many areas of our lives. The use of plastics in many countries around the world has become an issue because of how long they remain on earth. They are not truly biodegrada*le; they only break into tiny particles. In fact, every piece of plastic ever made *till exists on earth. When plast*cs are not proper*y disposed, they become an environmental hazard. Even then, plastics can end up in our oceans since 80% of all plastic ocean trash once star*ed out on the land. For these re*sons, some c*untries have outlawed the production of plastics.

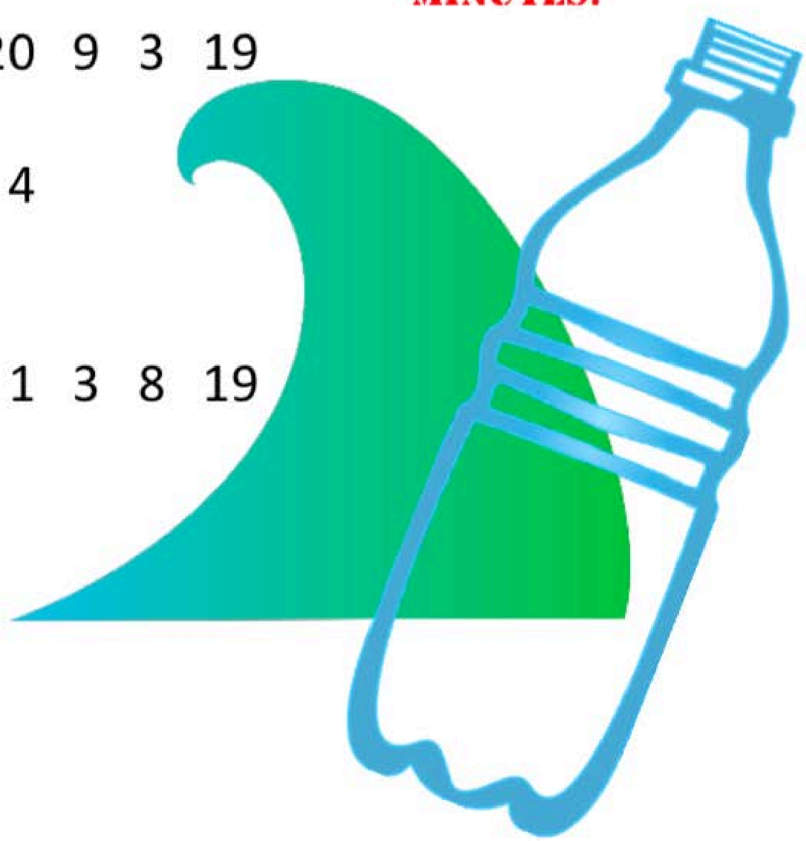


What is a better alternative to making plastics using oil?

**<u>ANSWER:</u> CONVERT EACH NUMBER TO A LETTER FROM THE ALPHABET. QUESTION WILL READ "WHAT COLORS OF PLASTICS WERE FOUND IN THE STOMACHS OF BIRDS?" (THIS QUESTION COMES FROM MY OCEANS UNIT)**

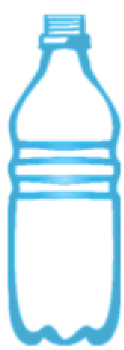
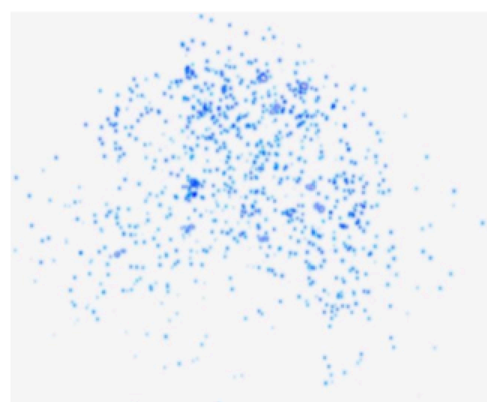
**IF STUDENTS NEED HELP RESEARCHING THE ANSWER, DIRECT THEM TO THE YOUTUBE VIDEO "PLASTICS THE REAL SEA MONSTER". THE ANSWER IS REVEALED AT AROUND 17 MINUTES.**

23 8 1 20
3 15 12 15 18 19
15 6
16 12 1 19 20 9 3 19
23 5 18 5
6 15 21 14 4
9 14
20 8 5
19 20 15 13 1 3 8 19
15 6
2 9 18 4 19



**<u>ANSWER</u>: THE STUDENTS WILL HAVE TO MATCH UP THE PLASTIC PARTICLES IN THE NORTH VS. THE SOUTH PACIFIC GYRES. THEY WILL HAVE TO CONVERT THE ROMAN NUMERALS TO LETTERS, WHICH WILL READ "NANOPARTICLES".**

**Cut apart the puzzle pieces.

| | |
|---|---|
| North Pacific Gyre | South Pacific Gyre |
| <br>XIV I XIV XV XVI I XVIII | <br>XX IX III XII V XIX |

**ANSWER: STUDENTS NEED TO PUT TOGETHER THE PUZZLE PIECES TO READ THE QUESTION. THE ANSWER IS "THE WORLD".**

**Cut apart the puzzle pieces.

**ANSWER:** STUDENTS WILL UNSCRAMBLE EACH WORD TO REVEAL THE QUESTION. I RECOMMEND CUTTING APART THE WORDS AS WELL. THE QUESTION READS "HOW DOES PLASTIC END UP IN HUMANS' DIETS?

**Leave this page as is, or cut the words apart to make it more challenging for students.

# Hwo dseo sticpla dne pu ni msnhua' dsiet?

**ANSWER**: STUDENTS USE THE PLASTIC RECYCLING CHART TO GIVE A NUMBER TO EACH CODE. THEY WILL ADD THE CODES UP TO GET ANOTHER NUMBER AND CONVERT THE TOTAL TO A LETTER FROM THE ALPHABET. THE QUESTION READS "MOST PLASTICS ARE MADE FROM ___"


Other + PS = ______ = ______
PP + PP + PP = ______ = ______
Other + Other + PP = ______ = ______
PS + PS + PS + HDPE = ______ = ______

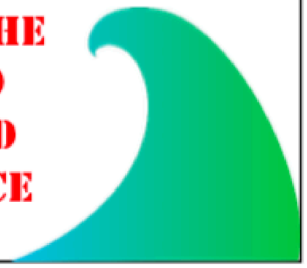
LDPE + LDPE + LDPE + LDPE = ______ = ______
PS + PS = ______ = ______
PET = ______ = ______
Other + Other + PP = ______ = ______
Other + Other + PS = ______ = ______
PS + PVC = ______ = ______
PVC = ______ = ______
Other + Other + PP = ______ = ______

PET = ____ = ______
PS + PS + PS = ______ = ______
PP = ______ = ______

Other + PS = ______ = ______
PET = ______ = ______
LDPE = ______ = ______
PP = ______ = ______

PS = ______ = ______
PS + PS + PS = ______ + ______
PP + PP + PP = ______ = ______
Other + PS = ______ = ______

**<u>ANSWER:</u> ARRANGE THE STRIPS TO REVEAL THE QUESTION. STUDENTS SHOULD ANSWER "NO ONE" BUT SOME OF MY STUDENTS ANSWERED "WE ARE" SINCE WE ARE WORKING TO REDUCE OUR PLASTIC USE IN CLASS.**



**Cut apart the strips.

Who is

taking the

initiative to Clean

up all the

plastiCs in the

ocean?

# Meteorology

## Lesson 7- Clouds

Ages 6-7

(Adapted from Mystery Science)

**Overview**

In this activity, students will help Lois, Newton, and Pearl investigate clouds and become a weather watcher. Students will observe and communicate the weather and forecast its conditions. They will then create a model of a cloud and recreate a part of the water cycle.

Who cares about the weather? A lot of people do, including engineers! Engineers have designed modern weather forecasting equipment, including weather balloons, satellites, Doppler radar, and computer simulation programs to help meteorologists make accurate weather forecasts. Engineers have also designed the automatic weather station (AWS), which collects weather data automatically in remote areas such as the mountains or Antarctica. Engineers design and build the high-tech equipment that is used for weather forecasting. They test the equipment to make sure that it is safe to use and can withstand severe atmospheric conditions. Other engineers contribute to weather forecasting equipment by designing the electronics, circuitry and software so the equipment can sense, measure and relay weather data accurately.

**Learning Objectives**

1. Students will be able to observe and make predictions about the weather using their senses and the clouds.
2. Make a weather forecast based on sensory observations, cloud characteristics and collected weather data.
3. Develop a model that simulates rain clouds so students can observe part of the water cycle called precipitation.

**Suggested Timeframe**

30-40 minutes

**Materials Required (Students work in pairs) Each pair needs:**

- 2 Plastic Cups
- 1 Can of Shaving Cream
- 1 Water Dropper/Pipette
- 1 Blue Food Coloring
- 1 Thin Dry Erase Marker for each student
- 1 Dry Eraser for each student
- 1 Dry Erase Protective Sleeve
- 1 Weather Watcher Worksheet
  *Students can place their worksheet inside the protective sleeve and use the dry erase marker to do their work.*

**Assessment**

- Activity Embedded Assessment
- Post Activity Assessment

**Introduction/Initiation**

*"What's the most amazing cloud you've ever seen? Clouds come in all sorts of different shapes and different sizes! What are clouds really anyways? Where do they come from? Are clouds the same thing as smoke that comes from a fire? Or are clouds slightly more solid like cotton candy? Clouds float up there in the sky and they look so puffy! What do you think? If you could reach up and touch a cloud what do you think it would feel like? Why do you think it would feel that way?*

*Have you ever touched a cloud? Maybe you've seen one that was very low like at the top of a mountain? You could hike up to the top of the mountain and reach up and grab it. Or if a cloud comes even lower and touches the ground. Can you think of its name? It's fog! Fog is just a cloud that's come down to the ground. That's really your best chance to get to touch a cloud.*

*I notice that when fog comes through my neighborhood it leaves behind little droplets of water on everything like my windows, the car windshield, everywhere. Before today's activity, you're going to watch a short video to show you how clouds are made.*

*Show students the following video from Generation Genius on YouTube called, "Water Cycle- Made Fun & Easy for Kids" 1 min. 38 seconds https://www.youtube.com/watch?v=Mcw2KgS7dHo&list=PLU6jFH1l4N08S47nCUiZKF7GwJfkIbADZ&index=9*

*People have been forecasting the weather for thousands of years. Even you forecast the weather when you look out the window or step outside in the morning before deciding what to wear. In this case, you are using your senses to forecast the weather. You might be looking at the shape and color of the clouds in the sky, feeling how warm or cool the air is, or watching the trees to see if they are swaying in the breeze.*

*Modern weather forecasting is more complicated than using our senses to predict the weather—it really depends on the work of engineers and scientists. What are some of the engineering devices that are used today to forecast the weather?*

*In this activity, you're going to become a weather watcher and record the weather for today and collect some information about the temperature and forecast. Then, you will model a cloud in a cup and see what happens when the cloud can't hold any more water droplets!*

**Procedure**

Before the Activity

1. Gather all supplies
2. Get 2 Plastic Cups, 1 bottle of blue food coloring, 1 Water Dropper/Pipette , 1 Can of Shaving Cream, 1 Weather Watcher Experiment Worksheets ,1 Protective Sleeve, 1 Thin Expo Marker, and 1 Eraser for each student pair.

**With the Students: Part 1- Weather Watcher Activity**

1. Show students the activity worksheets and go over the activity.
2. Give each pair of students a Weather Watcher Worksheet.

   *Note: This is a good time to take students outside. As a class, create a list of weather observations. Pay special attention to the color and shape of the clouds.* Take this list back inside to help students draw pictures of the current weather state on their worksheets. Referring to their drawings, ask them to predict what they think the weather will do next.

   *Background Information*
   The most basic way to observe and make predictions about the weather is by using our senses. *Sight* is the easiest sense to use to forecast the weather. You can see when it is raining or snowing. You can see the different types of clouds in the sky. *Touch* is also an easy sense to use. When the sun is shining, you can feel it on your face. You can feel it become colder when a cloud blocks the sun. You can also use touch to sense how strong the wind is and from which directions it is blowing. *Hearing* helps us detect weather phenomena. When you hear thunder, you know a storm is nearby. You can hear wind blowing harder or softer through trees or as it whips around your ears. *Smell* can also help us predict the weather! Have you ever smelled the air before a rainstorm? It has a distinct smell. Snowstorms have a certain smell, too.
3. If it isn't possible to take students outside, they can gather weather data and information using the Internet: https://kidsweatherreport.com
4. After students have collected information on the weather in their area they can then begin to make the model of a rain cloud.

**With the Students: Part 2- Rain Cloud Model Activity**

1. First, mix a few drops of blue food coloring in a plastic cup and set it aside. This will become your "rain".
2. Fill the 2nd plastic cup with about ¾ of the way full with cool water.
3. Use the shaving cream can and put a dollop of shaving cream on top of the cup with the ¾ cool water. It should make a fluffy "cloud" on top of the water.
   ***Refer to the picture on the right.**
4. The student will then use the pipette to suck up some of the "rain water" and then gently squirt it on top of the shaving cream cloud.
5. As the students squirt more and more water onto the shaving cream, the cloud will become heavier and heavier.

6. Within a few minutes, the first drops of colored rain will make its way through the cloud and drop into the water underneath.
   ***Refer to the picture on the right.**

**Assessment**

<u>Activity Embedded Assessment</u>

*Weather Watcher Worksheet*: Have students make weather forecasts using their sensory observations, online data collection and knowledge of the clouds.

For these basic weather forecasts, have them predict if the weather is going to change or stay the same.

- Do they predict that it is going to become colder or warmer?
- Is it going to rain or snow?
- Is it going to become windy?

Share and compare the students' basic weather forecasts as a class. Reiterate how sensory weather observation and prediction is easy to do, but it is not always dependable.


<u>Post-Activity Assessment</u>

*End of Activity Assessment*:
Have students take the post activity assessment and then share out responses as a class before cleaning up.

**Activity Extensions**

- Have students follow the weather forecasts from the newspaper or Internet. Have them compare how similar their forecasts are to the published professional weather forecasts.

**Activity Scaling**

Lead younger students through Parts 1 and 2 of this activity to explain what the weather is doing based on their senses and knowledge of the clouds.

For older students, have them collect weather data over a longer period of time to generate a more detailed weather forecast report.

Name ____________________________ Date _________________________

# Lesson 7: Weather Watcher Worksheet

## Weather Observation Using Senses

The most basic way to describe the weather is by using our senses. Use each of your senses to describe the weather.

**Sight**

______________________________________________________________

**Touch**

______________________________________________________________

**Hearing**

______________________________________________________________

**Smell**

______________________________________________________________

Draw a picture of the weather below based on the information from your senses below.

## Weather Forecast

Look up the weather forecast using the Internet and fill in the information below.

| Current Temperature | Current Weather | Wind Speed |
|---|---|---|
| Humidity<br>(Amount or % of water in the air) | UV Index<br>(The strength of the sun from 0-11+) | High/Low Temperature of the Day |

Name ______________________________ Date __________________________

# Lesson 7: Clouds

## "Post Assessment"

1. Draw a picture that shows how clouds form in the sky. **Label** the steps in your picture.

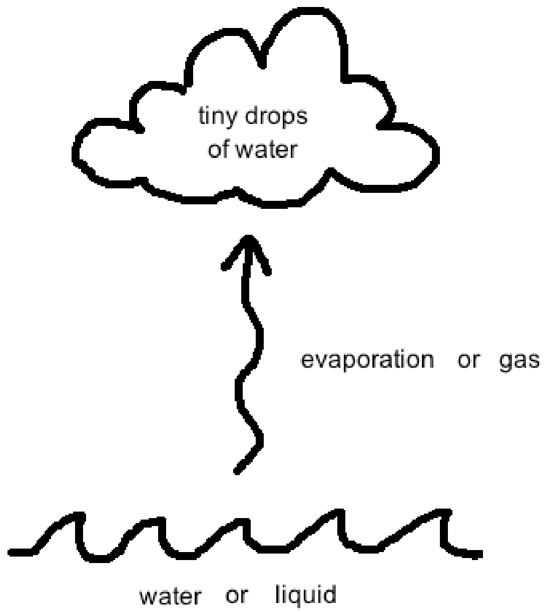
2. Explain your drawing above. Where is the water before it is a cloud? What forms does the water take as it becomes a cloud?

Name ______________________________ Date __________________________

# Lesson 7: Clouds

## "Post Assessment" – ANSWER KEY

1. **Draw** a picture that shows how clouds form in the sky. **Label** the steps in your picture.




2. Explain your drawing above. Where is the water before it forms a cloud? What forms does the water take as it becomes a cloud?

| LESS sophisticated response: | MORE sophisticated response: |
|---|---|
| Clouds change from liquid water on the ground to gas that rises up in the air. Then, the gas turns back into small liquid water drops, forming a cloud. | Clouds start as liquid water on the ground. As time passes, the water evaporates into a gas and rises up in the air. When it gets high enough, the gas turns back into small liquid water drops, forming a cloud. |

Meteorology

**Lesson 8- Hurricanes**
Ages 12-14

(Adapted from Mystery Science)

## Overview

In this activity, students help Lois, Newton, and Pearl explore the effects of natural hazards, such as hurricanes. In the activity, students design multiple solutions to keep a house from blowing away in a windstorm, then compare the merits of their solutions.

They will start by watching a video from Mystery Doug called, "Why are Hurricanes so Dangerous." Students will then model the process of a hurricane and see if their designed house can withstand the force.

Engineers strive to design structures that can endure tornadoes and protect people from violent wind forces. Following storms, they collect evidence to analyze tornado behavior and find better ways to economically build safer structures in high-risk areas. To test the strength and durability of materials and construction methods, engineers re-create tornado conditions. Creative engineering techniques to tornado-proof structures include improved roof shingles and roof design, well-secured house walls, an anchored foundation, and enhanced building materials.

## Learning Objectives

1. Students will define problems that strong winds cause.
2. Students will develop and use a model of a home in order to design a solution that keeps the roof attached to the home and stops the home from blowing away in the wind.
3. Students identify the cause and effect relationship between strong winds and the problems they cause.

## Suggested Timeframe

45 minutes

## Materials Required

**Each student needs:**

- 1 "Design a Windproof House" Worksheet
- 1 "Paper House Model" Worksheet
- 1 "Wind-maker" Worksheet
- 1 Paperclip (For the Wind-maker Worksheet)
- 1 Pair of Scissors
- 2 Circle Stickers or Small Pieces of Tape
- 1 Dry Eraser
- 1 Dry Erase Protective Sleeve for each student
- 1 Thin Expo Marker for each student
  *Students can place their worksheet inside the protective sleeve and use the dry erase marker to do their work.*

**Each pair of students need:**

- 1 Blank Sheet of Paper
- 6 Toothpicks
- 4 Paperclips
- 2 stickers

**Assessment**

- Pre-Activity Assessment
- Activity Embedded Assessment
- Post-Activity Assessment

**Introduction/Initiation**

*Show students the following video from Mystery Doug on YouTube called, "Why are Hurricanes so Dangerous" 5 min. 22 seconds*
*https://www.youtube.com/watch?v=PJSTgZ6HxtQ*

*Hurricanes are an important topic of study for civil engineers because they are the people who design, build and maintain our roads, railways and structures. Some engineers collect evidence following storms, which they use to help classify hurricanes, dispel hurricane myths, and research to design better hurricane-resistant structures for high-risk areas.*

*One danger of hurricanes is their ability to propel objects like missiles through the air. For example, wind engineers at Texas Tech University especially designed a cannon to test the strength of various construction materials. The cannon fires boards and other objects at more than 100 mph into different building materials to simulate (mimic) the effects of a hurricane, such as wood splinters flying into a brick—or other material—building. The high winds and water blowing over roofs also cause changes in air pressure just above the roofs. The pressure difference between inside and outside a building can cause the building to crumble or the roof to bulge up and be blown away in the wind.*

*Because buildings are not always built to resist a the forces that come with hurricanes it is important to understand hurricane safety procedures. The first thing to do if you learn that a hurricane is coming near you is to find shelter, immediately! Safe places include storm cellars, basements and interior rooms with no windows.*

*Now that you know everything—well not quite everything!—it is time to make a better house for a family that lives a high-risk hurricane area, the area of the U.S. where most hurricanes occur. Hurricanes can produce winds that are more than 250 mph. According to NOAA, about 7 hurricanes are reported across the U.S. in an average of every 4 years; resulting in many deaths and more than 1,500 injuries. With these statistics in mind, it is easy to see why it is important for engineers to build structures—homes, schools, offices, stores, stadiums, etc.—that can withstand the tremendous forces of hurricanes. Can you come up with a few ideas to design a house that will be super hurricane-proof?*

**Procedure**

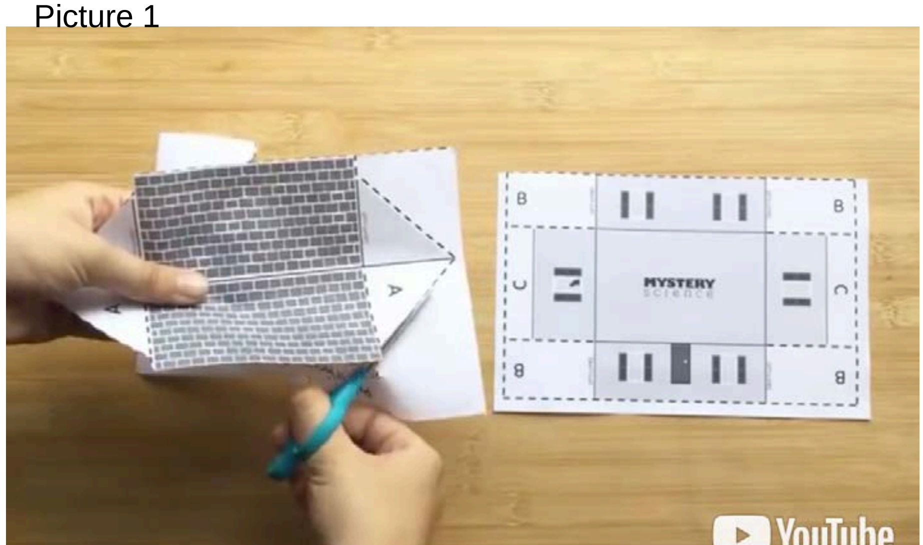
Before the Activity

1. Gather all supplies.
3. Get 1 Design a Windproof House Worksheet, 1 Paper House Model Worksheet, 1 Wind-maker Worksheet, 1 Paperclip (For the Wind-maker Worksheet, 1 Pair of Scissors, 2 Circle Stickers, 1 Dry Eraser, 1 Dry Erase Protective Sleeve, 1 Thin Expo Marker, 1 Blank Piece of Paper, 6 Toothpicks, 4 Paperclips, 2 Stickers

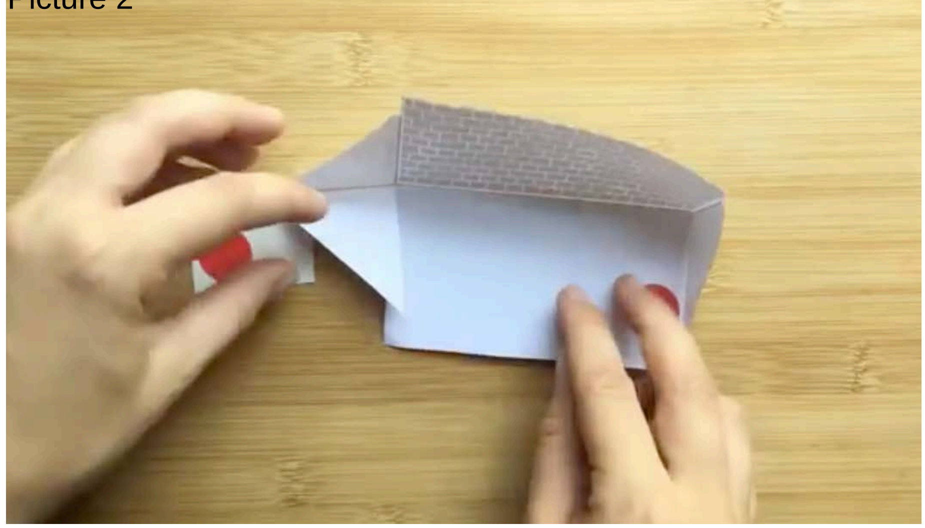
With the Students: Directions to Build the House

1. Divide students into groups of two.
2. “Today, you are going to do what a construction engineer does. You’re going to build a model of a house made out of paper then you’ll use your model to figure out a way to attach your roof to your house and keep it from blowing off. You’ll also need to design a way to keep your whole house from blowing away in the wind.”
3. “Okay, first I will help you build a paper model of a house. You’ll get to test out two different designs. I’ll show you how to get started step by step.
4. Get your house worksheet, cut on the center dash line first to separate the two halves of the house. Then cut all the other dashed lines. Be careful, don’t cut on any of the solid lines.
   ***Refer to picture 1**
5. You’ll start by making the roof for your house. Carefully fold each of the solid lines. Crease each fold with your fingernail. The pattern of the roof should be on the outside when you’re finished.
6. Turn the paper over and put each “A” flap flat against the inside of the roof. Hold it in place with a sticker.
   ***Refer to picture 2**
7. Now you’re going to make the base of your house. You’re going to fold this just like you did with the roof. Fold each of the sold lines and crease each fold.

Picture 1

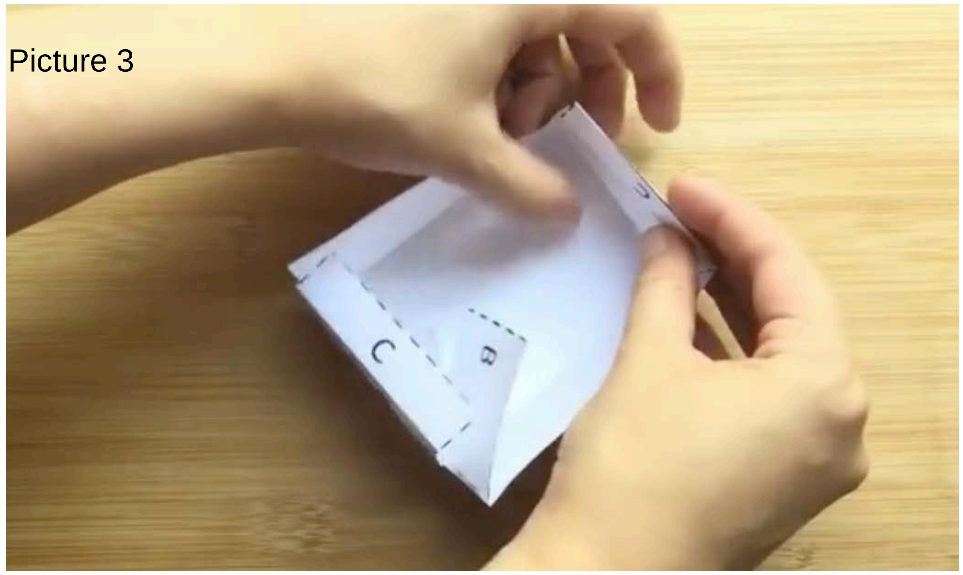



Picture 2



8. Start with one end of the house. Overlap the two “B” flaps. Fold the “C” flaps over them. Do the same thing on the other side.
   ***Refer to picture 3**

Picture 3



9. Find your Wind-maker Worksheet. Fold the sheet in half on the thick solid line. Fold the 1 on top of the 1, then flip the paper over and fold the 2 on top of the 2. Keep on folding so that your paper looks like a paper fan.
10. Put a paper clip across the end of the folded paper. Spread out your fan. Test your fan by quickly moving it around.

With the Students: Directions for the Activity

1. Find a partner.
2. Set the roof on top of the base of the house.
3. You and your partner will choose which house you’re going to test first. Don’t worry, you’ll test both houses eventually.
4. Take turns waving your wind-maker at the house. Can you blow it away?
5. You and a partner each need a set of worksheets (Design a Wind-Proof House). Each group (you and your partner) will need: 1 blank sheet of paper, 4 paper clips, 6 toothpicks, and 2 stickers.
6. Get your Design a Wind-Proof House Worksheet and with your partner, answer question #1.
7. Using these new materials you have, can you and your partner come up with a way to keep your house from blowing away. Build your first design and test it using your Wind Maker.
8. Do question #2. Draw what you and your partner designed and describe what happened with your design.
9. How did you and your partner do? Are there things that you want to try differently? Build and test your second design now. Do question #3 on your worksheet after you designed and tested your second idea using the other house.
10. Now that you and your partner have both tested two different houses it’s time to decide which of your two designs worked better and why? Answer question #4. Which one was easiest to build? Which one used the fewest materials? Which one do you think would last the longest?

*“In the activity, you did what a construction engineer does! You created a model then you used that model to design solutions to a problem. In real life the next steps would be to actually try those solutions on a real house.*

**Assessment**

Pre-Activity Assessment

*Brainstorming:* As a class, have students engage in open discussion. Remind them that in brainstorming, no idea or suggestion is "silly." All ideas should be respectfully heard. Encourage wild ideas and discourage criticism of ideas. Have them raise their hands to respond. Write answers on the board. Ask the students:

- How might a hurricane damage a house?

Activity Embedded Assessment

*Hurricane Design Solutions:* Students should analyze which design solutions worked the best and how they improved their designs after each test.

Post-Assessment (Two Options)

*Presentations:* Have student teams present their building design posters to the class.

*Sales Pitch!:* Students pretend to be salespeople who are selling their designs to construction companies. Have student teams create advertisements as well as 10-minute sales pitches of their findings to present to the next class. Require groups to include descriptions of the services they can provide and their past design accomplishments.

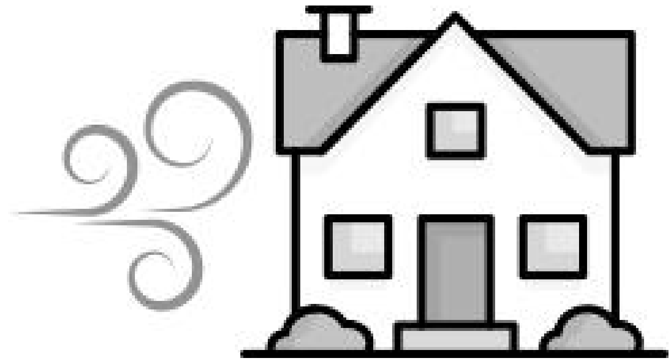
**Activity Extensions**

- Invite a structural or civil engineer to discuss building designs that help prevent loss during windstorms and hurricanes.
- Have students make 3D models of their hurricane-proof homes.
- Suggest that students
- create posters for the community after they research safety measures. For example: building standards that require all houses to have storm cellars or basements.

Name ____________________ Partner's Name ________________________

# Lesson 8: Design a Wind-Proof House

### 1. WHAT'S THE PROBLEM?

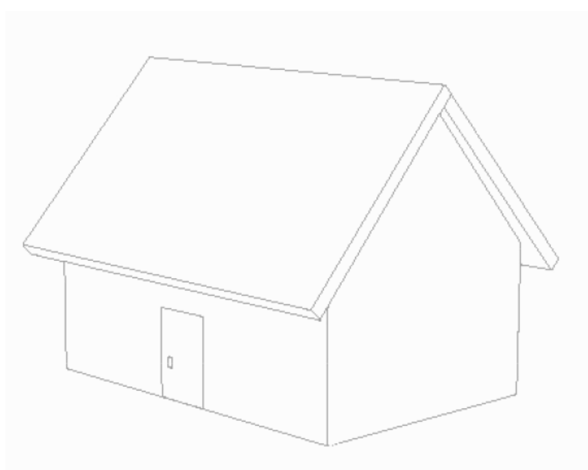


The problem with our house is:

(describe what you noticed when testing your house with the wind-maker)
Why does it matter? Why is it important to fix it?

### 2. CREATE AND TEST YOUR FIRST DESIGN.

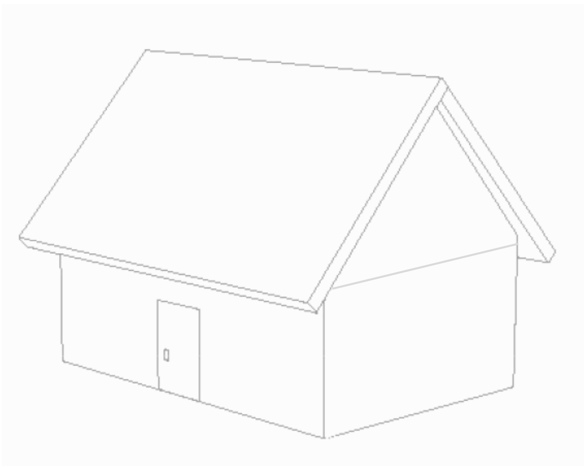
**Design #1:** Draw your design



What happened when you tested design #1?

**3. CREATE AND TEST YOUR SECOND DESIGN.**

**Design #2:** Draw your design



What happened when you tested design #2?

**4. WHICH DESIGN WORKED BETTER AND WHY?**

Which one was easiest to build? Which one used the fewest materials? Which one do you think would last the longest?

Design #1 / Design #2 (choose one) worked best because

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

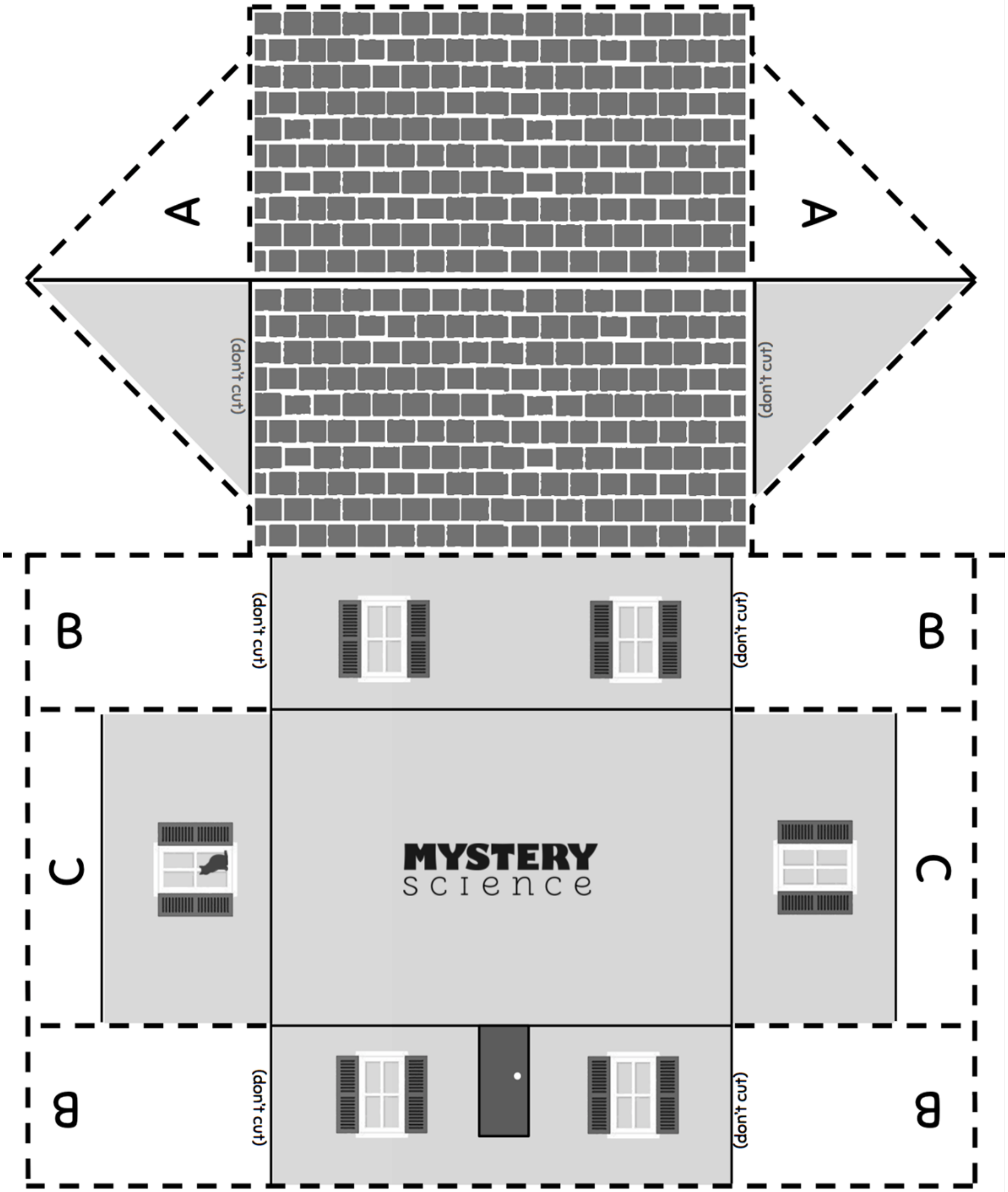
______________________________________________

______________________________________________

______________________________________________

______________________________________________

# Paper House Model



| | |
|---|---|
| Wind Maker paperclip | 8 |
| 7 | 8 |
| 7 | 6 |
| 5 | 6 |
| 5 | 4 |
| 3 | 4 |
| 3 | 2 |
| 1 | 2 |
| 1 | |

## Meteorology

**Lesson 9- Earth's Air Pressure: Building a Barometer**
Ages 15-19

(Adapted from University of Colorado)

**Overview**
Students investigate the weather from a systems approach, learning how individual parts of a system work together to create a final product. They learn how a barometer works to measure the Earth's air pressure by building a model using simple materials. Students analyze the changes in barometer measurements over time and compare those to actual weather conditions. They learn how to use a barometer to understand air pressure and predict real-world weather changes.

They will start by watching a video from Generation Genius called, "Weather & Climate." Students will then build a model of a barometer and use it to predict weather changes.

Engineers often look at a problem from a systems approach—analyzing the individual parts or processes of a system that are designed to work together to perform a specific function. Then engineers can see how each part or process affects the system as a whole. Weather forecasting is studied from this type of systems approach, by analyzing each component that makes up the weather. Engineers develop instruments, such as barometers, to help measure and predict weather on Earth and in space. Engineers are always trying to improve these instruments to make them more accurate, more efficient or to utilize new technologies.

**Learning Objectives**
1. Describe a systems approach that engineers might use to address problems, such as weather forecasting.
2. Explain how engineered instrumentation, such as a barometer, can help predict changes in weather systems.
3. Relate how air pressure affects changes in weather systems.

**Suggested Timeframe**
45 minutes

**Materials Required (each group)**
- 1 Clear Bottle with a long, narrow neck with no lid
- 1 Large Plastic Cup
- Ruler
- 1 Permanent Marker
- 1 Barometer Analysis Worksheet
- 1 Dry Eraser
- 1 Dry Erase Protective Sleeve for each student
- 1 Thin Expo Marker for each student
  *Students can place their worksheet inside the protective sleeve and use the dry erase marker to do their work.*

**Assessment**

- Pre-Activity Assessment
- Activity Embedded Assessment
- Post-Activity Assessment

**Introduction/Initiation**

*Show students the following video from Generation Genius on YouTube called, "Weather & Climate" 2 min. 3 seconds*
*https://www.youtube.com/watch?v=bZwdn3-9xP4*

*"Wouldn't it be great to be able to predict when a storm was going to arrive in your area? Of course, you could always look at the weather page in the newspaper or Internet or watch the TV news; but what if you could just observe the clouds and make a prediction based on your own knowledge of the different types of clouds? Would you be able to make a prediction from this information? How accurate would your prediction be? What other types of things might you need to know to more accurately predict the weather? You may want to also look at the change in temperature, air pressure, wind speed and direction and even humidity.*

*Weather has many things that affect it. Knowing each of its individual components may help us make more accurate predictions of the weather overall. If we can make measurements and calculations about air pressure, wind speed, temperature and humidity, then we can look at how all of those pieces of information interact to learn about what is really going on with the weather. This way, we can learn about the weather as a system of separate parts that work together. Engineers often look at a problem through a systems approach. They break down a problem into its individual parts, study each part, and then bring what they analyze from each part back together to learn how they interact with each other. Engineers help us do this with weather as well. Engineers design instrumentation that takes measurements of temperature, air pressure, wind and humidity. They design software programs to pull the information from these instruments together and give us a complete description of the weather. When you watch a weather forecast on TV, you are seeing the results of weather instrumentation that engineers have designed here on Earth and in space to help us predict the weather.*

*We have learned that much of our weather is caused by changes in air pressure. We know that hot air rises and cold air sinks. The rising hot air exerts less pressure on the Earth's surface, so air pressure decreases. Then cooler, dense air, that often carries moisture with it, comes in and replaces the hot air that has risen away. When the air fills with moisture, it releases that moisture in the form of rain, and we have a rainy day. Can we measure air pressure? How do we tell if the air around us is rising or falling?*

*Well, today we are going to design a weather forecasting instrument to help us predict one change in the system of weather around us. The instrument we are going to make is called a barometer, a device that measures air pressure. Our simple barometers consist of an empty bottle turned upside down in a cup. The wider sides of the bottle rest on the rim of the cup, so that the mouth of the bottle is not touching either the bottom or sides of the cup. Water that we put in the cup will rise to a certain level up the neck of the bottle. The reason that the water rises is that air is pushing down on the water in the cup and forcing it up into the* *bottle. We call this air pressure. If the air pressure goes up, then it pushes harder on the water in the cup and forces more water up into the bottle. We will be able to measure the change in air pressure by measuring how much the water level in the neck of the bottle goes up or down. If the air pressure goes down, then the air is not pushing as hard on the water in the cup and less water will be in the bottle. The water level in the bottle will go down. Falling air pressure usually indicates that a storm of some sort is approaching. Conversely, rising air pressure is usually an indication that the weather is clearing up.*

*We will act like engineers as we analyze one individual component of our weather system. What might be our next step if we were trying to help predict the changes in weather around us? Using a systems approach, we might look at other factors affecting the weather system, such as temperature, humidity and wind speed."*

**Procedure**

Background

If a barometer shows that air pressure is decreasing, it indicates a chance for rain very soon. The more rapid the decrease in air pressure, the stormier it will be. The reason decreasing air pressure signals the arrival of a storm is that the decrease in air pressure indicates warm air is rising; the rising air carries moisture with it that forms clouds, and when the clouds fill with moisture, it rains. If the air pressure is increasing, the weather is going to clear up or stay fair.


**Picture 1. A homemade barometer**

Before the Activity

1. Gather materials.
2. 1 Barometer Analysis Worksheet
3. Ensure that the bottle when resting upside-down on the glass edges fits in the glass yet does not touch the bottom of the glass (see Picture 1).

With the Students

1. Starting at the top of the neck of the bottle, have students make a mark every two centimeters, going all the way to the bottom of the bottle.
2. Turn the bottle upside down and number the marks, starting with "1" at the upside down bottom of the bottle (or, the actual top of the bottle). These numbers do not represent an actual unit of pressure; they are simply to help students measure and compare values.
3. Fill the bottle about half-way with water; hold upright.
4. Place the glass upside-down over the bottle.

5. Quickly flip the bottle and glass over so that the glass is upright and the bottle is upside-down. Some water will spill out, but the water level inside the empty bottle should be higher than the level outside of it (that is, inside the glass). If it is not, repeat steps 3-5, using a little more water.
6. Add about an inch more of water into the cup. This ensures that if the pressure increases and pushes more water up the bottle, the bottle opening will remain submerged. Note: The water level in the cup should be just a little higher than the lip of the bottle. To take a barometer reading, take note of where the water level is inside the bottle.
7. Place the barometer in a safe place where the temperature stays fairly constant, and where they can be easily observed. They can be stored inside.
8. Record the current water level by using the numbered marks. Record the current weather conditions on your worksheet.
9. Take more barometer readings and weather observations once each day for at least a week if possible. Record the information on your worksheet.
10. Compare any barometer changes to weather changes and looks for trends. Were there any changes in weather during the week? Did the barometer change when the weather changed? Did the barometer change without a change in weather? How well did the barometer work? Was the design of your barometer effective? What would you change if you could design the barometer again?

**Assessment**

Pre-Activity Assessment

*Review for Prior Knowledge*: Ask the students:

- What causes weather? (Answer: Weather is the result of the movement of air masses that have different pressures.)
- What causes the movement of air masses? (Answer: Different pressures and temperatures of the air cause masses to move; for example, warm air rises.)
- What are some properties of air that can be measured and that can tell us about weather? (Answer: Temperature, pressure and humidity are all properties of air that can help us predict weather.)

Activity Embedded Assessment

*Prediction*: Ask each group to predict what will happen during the week to the barometric pressure as the weather changes (for example, if it rains outside, what will happen to the water level?).

*Observations*: Have students record their observations of their barometers on the attached worksheet or in an engineering log (journal). After the week has passed, have student share their observations with the class in the form of a class discussion.

Post-Assessment (Two Options)

*Optimize It!:* As the class makes barometers, they will be working as engineers. Engineers continuously make improvements on existing devices, such as barometers, that increase the reliability of the instrument. With the class, make a list on the board of ideas that could improve the barometers' functions. What are some ideas for things they could add to their barometers to get a complete picture of how the weather system is changing in their area? Are there aesthetic considerations (the way the barometer looks) that went into the original design of their barometer? Would they change the aesthetics if they could design it again? Would aesthetics take away from the barometer's functionality (how well it works)? When considering all the ways to improve their design, the class will be doing exactly what engineers do as they strive to make increasingly better and useful products.

**Activity Extensions**

- Model the effects of air pressure with an aluminum can. The can keeps its shape because the air pressure inside the can equals the air pressure outside the cup. Try putting the empty can upside down in ice cold water, and notice how the can implodes due to the difference in the air pressure inside and outside the can (That is, as the air in the can gets colder, the air pressure in the can decreases. The higher air pressure from the outside air crushes the can).

Name ___________________________ Date ________________________

# Lesson 9: Barometer Analysis Worksheet

## Barometer Observations

Fill in the chart below with your observations and measurements from your barometer.

| Date | Barometer Measurement | Change in Barometer Pressure | Weather Outside | Other Observations |
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Questions to discuss/think about:

1. Were there any changes in the weather during the week?
2. Did the barometer measurement change when the weather change? How much?
3. What would you change if you could design it again?