



# Ocean Acidification

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**Target Grade:** 9<sup>th</sup>-12<sup>th</sup> Grade

**Time Required:** 60 minutes

## Standards

*Next Generation Science Standards:*

- HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

## Lesson Objectives

Students will be able to:

- Analyze the effects of ocean acidification on coral reefs by collecting data from a model and drawing conclusions.
- Assess environmental problems caused by humans and predict future consequences and describe how these problems can be solved.

## Central Focus

In this lesson, students will investigate the effect of ocean acidification on coral reefs through a hands-on lab, collect and analyze the data, and draw conclusions. Students will graph their data and use their graphs as evidence to justify their claims. Students will observe and compare the dissolving rates of chalk in differing concentrations of acidic water to model the increasing ocean acidification. Students can then analyze the data and compare the lab model data to the real-life scenario occurring in coral reefs.

Key terms: investigation, labs, analysis, collection, graphing, claim, reasoning, oceans, observation

## Background Information

Ocean acidification refers to the pH of the ocean decreasing. This process occurs when too much carbon dioxide (CO<sub>2</sub>) is released into the atmosphere. Carbon dioxide dissolves in the ocean causing the pH to lower and the water to be acidic. Carbon dioxide is released from fossil fuel emissions and deforestation. Fossil fuel emissions are released by cars, airplanes, power plants and factories that burn oil, coal and gas. Deforestation also causes fossil fuel emissions. Burning forest causes the release of carbon dioxide



into the atmosphere. When high levels of CO<sub>2</sub> are released into the atmosphere, it cannot be absorbed through natural processes, like photosynthesis, faster than it is created. An increased amount of CO<sub>2</sub> in the atmosphere causes an increase in the amount of CO<sub>2</sub> to be absorbed into the water, decreasing the pH and acidifying the ocean.

The decrease in pH and increase in acidity of the ocean affects coral reefs. Coral reefs are the most diverse of marine ecosystems. One quarter of the ocean species depend on the coral reefs for food and shelter. Coral reefs are made of a thin layer of calcium carbonate, when the ocean becomes more acidic, the calcium carbonate dissolves causing its destruction.

### Materials

- 4 cups (per pair)
- Acetic Acid (vinegar)
- Water
- Chalk (4 equal size pieces per pair)
- Timer (one per group)
- Student worksheet

### *Prior to the lesson:*

The teacher will need to make 4 cups with varying concentrations of acetic acid per pair. The teacher should label each cup 1 0%, cup 2 25%, cup 3 50%, and cup 4 100%. Cup one should be only clean water and cup 4 should be only acetic acid. To mix cup 2, use three parts water and one part acetic acid. To mix cup 3, use one part water and one part acetic acid. Each cup should have enough liquid to completely submerge the chalk.

### Instruction

#### *Warm up (10 minutes)*

- Students should read the passage “Ecology – Ocean Acidification” and answer the corresponding questions on the handout.
  - What is ocean acidification and why is it happening?
  - Identify two human activities that contribute to ocean acidification.
  - Why are coral reefs important?
- The teacher should select students to share their responses to the questions.
- The class should review the vocabulary terms ocean acidification, pH, and coral reefs (included in the PowerPoint), as well as the actionable steps for the day.



*Pre-lab:*

- The teacher should introduce the lab to the students and guide the students through lab setup.
- The teacher should discuss that this lab is a model of ocean acidification and should discuss what each component represents.
  - Cups of water and acetic acid = increasing ocean acidification
  - Chalk = coral reefs
- The students should be divided into pairs to discuss independent and dependent variables, the control group, and their hypothesis.
- One student in the pair should be responsible for gathering materials.

*Activity:*

1. Each pair should have the four cups with varying concentrations of acetic acid, prepared by the teacher prior to class.
2. Students should carefully place one piece of chalk into one of the cups. One student should begin timing as soon as the chalk is dropped into the cup.
3. Students should observe the chalk and record the time it takes for the chalk to dissolve in seconds on the student handout.
4. Students should repeat steps 1-3 for each cup.
5. Following the recording of data, students should graph their data using the provided grid.

*Closure:*

- Students should work in pairs to organize and analyze their data, using the provided analysis in the student handout.
- Students should discuss and answer the analysis questions using their knowledge of ocean acidification, pH, and coral reefs, as well as their collected data.

**Differentiation**

*General*

- Heterogeneous, small groups students below grade level with students on/above grade level.
- Images to illustrate key vocabulary are provided on the PowerPoint.
- Create a graphic organizer on the student handout to layout their thoughts to show their scientific reasoning when explaining their claim, evidence, and justification.

*Students below grade level*

- Provided with definitions for vocabulary words and picture to which they can refer when responding to the analysis questions.



*Students on and above grade level*

- Students will be challenged to formulate a question and a corresponding hypothesis pertaining to ocean acidification and to design an experiment to test that hypothesis.

***Supports for ALL learners***

*Engaging in high thinking*

1. What are some consequences if human activities that influence ocean acidification remain unchecked?
2. What are some drawbacks to minimizing the human activities that leads to ocean acidification?
3. What else do you want to investigate about ocean acidification?

*Scaffolding questions*

1. What does biodiversity mean?
2. What are the independent and dependent variables?
3. What pattern do you notice with each variable?
4. What are some human activities that lead to ocean acidification?
5. How does biodiversity affect the stability of the ocean?

*Student choice*

1. Students can choose their role
2. Students choose how to organize their responses.
3. Students can choose their research question, hypothesis and experimental design.

***Anticipated challenges/misconceptions***

- Some students might struggle with applying the concept to the data that they collected. However, they will be reminded to refer to key vocabulary, the reading from the prime time. They will also be asked scaffolding questions to help them to make the connections.

*Groups and Targeted Students*

- Grouping: Heterogeneous - based on performance in class
  - Medium-low collaborative pairings with students who need frequent check-ins are seated in the front of the room.
  - High-medium collaborative pairings who do not require assistance of teachers.



### *Targeted students*

- Low skilled and gen-ed students respectively both need the chance to orally demonstrate their understanding or to have someone to help them to organize their thinking. This supports their writing.
- Teacher should provide support by frequently checking in to ensure student understanding of the vocabulary is accurate and connections are meaningful.

### **Assessment**

#### *Formative Assessment*

- As the teacher circulates throughout the classroom, the teacher should observe student responses to the warm up questions, group discussions, activity, and closure questions. The teacher should review and correct misconceptions.

#### *Summative Assessment*

- Students will complete the student worksheet, answering the questions and completing the lab. Emphasis should be placed on the conclusion of the worksheet: the claim, evidence, and justification. For students to fully master this lesson, they should demonstrate scientific reasoning in their response to the question “What would happen to the biodiversity of coral reefs as the concentration of acid in the ocean increases?”

**Warm up****Ecology – Ocean Acidification**

The pH of our oceans is decreasing; this means that our oceans are becoming more acidic. Ocean acidification is happening because too much carbon dioxide (CO<sub>2</sub>) is being released into the atmosphere. This carbon dioxide dissolves in the ocean making it acidic. Carbon dioxide is being released from fossil fuel emissions and deforestation. Fossil fuel emissions are released by cars, airplanes, power plants and factories that burn fossil (oil, coal and gas).

Deforestation also causes fossil fuel emissions. Burning forest causes the release of carbon dioxide into the atmosphere. Forests are also important because plants use CO<sub>2</sub> in order to carry out photosynthesis. If we do not have enough forests, plants would not be able to use the excess CO<sub>2</sub> in the atmosphere.

The excess CO<sub>2</sub> causes ocean acidification, and this affects coral reefs. Coral reefs are the most diverse of marine ecosystems. One quarter of the ocean species depend on the coral reefs for food and shelter. Coral reefs are one of the most biologically diverse ecosystem on earth. Coral reef is made of a thin layer of calcium carbonate, when the ocean becomes more acidic, the calcium carbonate dissolves causing its destruction.

What is ocean acidification and why is it happening?

Identify two human activities that contribute to ocean acidification.

Why are coral reefs important?

**Important Definitions:**

**Ocean Acidification:** When carbon dioxide dissolves in the ocean, and makes the ocean more acidic.

**pH:** A Chemical scale that measures how acidic or how alkaline a substance is.

**Coral Reefs:** A coral is a sea animal attached to the ocean floor with a skeleton made of calcium carbonate. Coral reefs are many coral colonies growing together.

**Daily Learning Target:** I can analyze the effects of ocean acidification on coral reefs.

**Main idea:** To investigate the effect of ocean acidification on coral reefs through a simulation, collect and analyze the data and draw conclusions

**Actionable steps:**

- I need to understand what ocean acidification and coral reefs are.
- I need to carry out the simulation and collect data.
- I need to ...

Name \_\_\_\_\_

Period \_\_\_\_\_

Date \_\_\_\_\_

**Daily Learning Target:** I can analyze the effects of ocean acidification on coral reefs by collecting data from a model and drawing conclusions.

**Activity - Examining the effects of ocean acidification**

In this experiment we will examine how acidic conditions affect coral reefs. We will use chalk made of calcium carbonate in place of the corals (which are also made of calcium carbonate), and acetic acid to mimic the acidic conditions in the oceans.

**Instructions**

1. Work in pairs.
2. One person from the pair should collect the materials.
3. Do not start the experiment until you are instructed to.
4. Listen for directions:
  - You will receive 4 cups containing: Water (0% acetic acid), 25% acetic acid, 50% acetic acid and 100% acetic acid.
  - You will also receive 4 equal pieces of chalk and a timer

**Variables**

Independent variable \_\_\_\_\_ Dependent variable \_\_\_\_\_

**Hypothesis**

**In order to construct your hypothesis, answer the following questions:**

**Research question:** What would happen to the biodiversity of coral reefs as the concentration of acid in the ocean increases?

If ..... Then ..... because.....

Independent Variable
Dependent Variable
Possible answers to research questions

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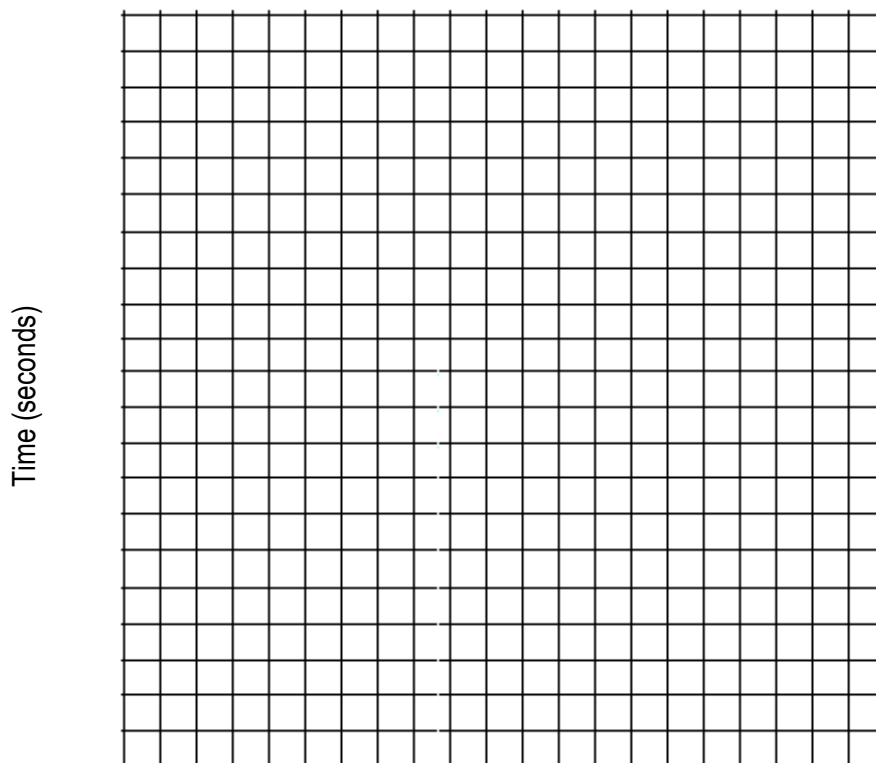
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**Results**

**Time taken for the chalk to dissolve at various acid concentration**

Concentration of Acid (%)	Time taken for the chalk to dissolve (seconds)
0 (water)	
25	
50	
100	

**Graph your data in the following grid:**



Acid concentration



## Analysis

1. What is the relationship between the amount of time it takes the chalk to dissolve and the concentration of acid?

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2. What does this tell you about the effect of ocean acidification on the survival of coral reefs? **Hint:** Ocean acidification means the water becomes more acidic. Use the following **vocabulary** words in order to answer this question: Ocean acidification, pH and biodiversity.

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3. Based on your experiment with the calcium carbonate chalk and the acetic acid, what do you think will happen to our coral reefs and their biodiversity as the acidity of the ocean increases due to CO<sub>2</sub> emissions?

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4. What could humans do in order to prevent ocean acidification? **Hint:** Carbon dioxide is release into the atmosphere due to fossil fuel emissions.

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5. How does ocean acidification affect the stability of the coral reef? Support your answer.

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**Conclusion:**

**Research question: What would happen to the biodiversity of coral reefs as the concentration of acid in the ocean increases?**

**What are you being asked?**

**Evidence:** Which of the following will help you to source your evidence?

- Use data to explain relationships between variables
- Explain what the data/graph shows
- Identify relevant supporting details from given information of notes.

**Concepts:** What are the important content information that relates to the question?

- Explain important related vocabulary
- Explain the concepts that are most important to understand the evidence.

**Claim**

- Your answer to the question with a reason.

**Justification:**

- Summarize the evidence.
- Describe the connections between the evidence and the concept.
- Explain how the evidence and concepts support the claim.

# Ocean Acidification

## Warm Up

1. What is ocean acidification and why is it happening?

**Ocean acidification is when oceans are becoming more acidic because of too much carbon dioxide dissolved in the ocean.**

2. Identify two human activities that contribute to ocean acidification.

**Deforestation and fuel emissions from cars, etc.**

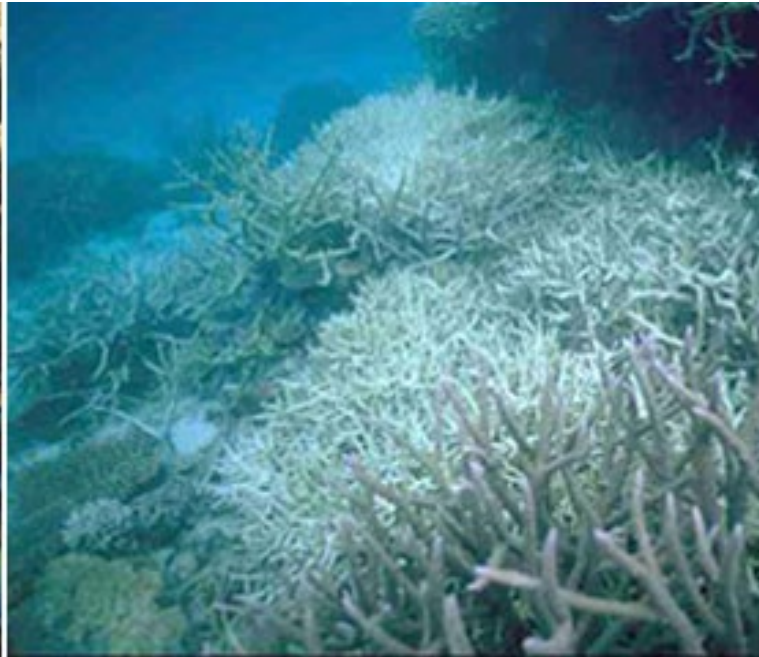
3. Why are coral reefs important?

**¼ of ocean species depend on the coral reefs for food and shelter.**

# Important Definitions

## Ocean Acidification:

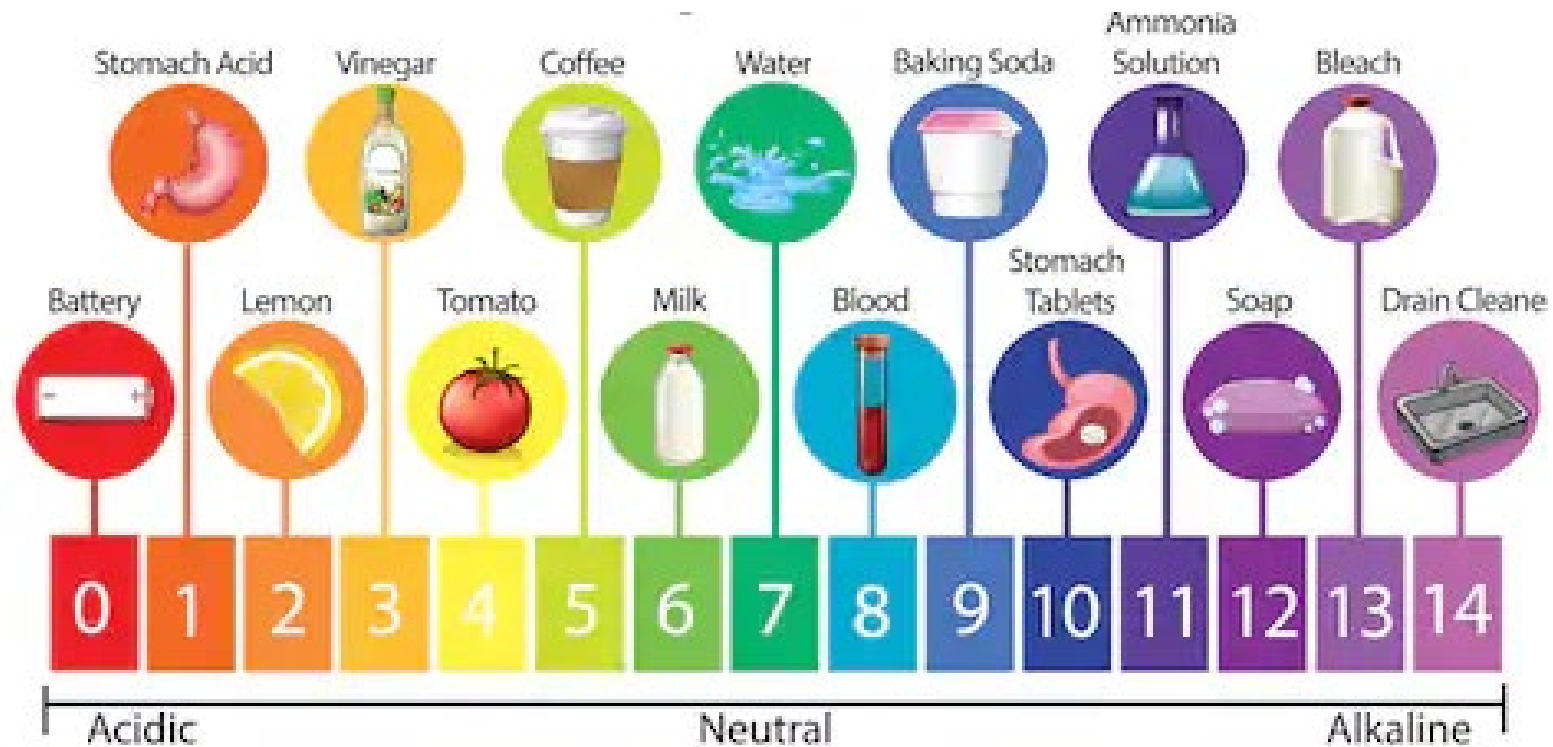
When carbon dioxide dissolves in the ocean, and makes the ocean more acidic.



# Important Definitions

## pH:

A Chemical scale that measures how acidic or how alkaline a substance is.



# Important Definitions

## Coral Reefs:

A coral is a sea animal attached to the ocean floor with a skeleton made of calcium carbonate. Coral reefs are many coral colonies growing together.



LT: I can analyze the effects of ocean acidification on coral reefs by collecting data from a model and drawing conclusions.

### **Main idea:**

To investigate the effects of ocean acidification on coral reefs through a simulation, collect and analyze the data and draw conclusions.

### **Actionable Steps:**

- I need to understand what ocean acidification and coral reefs are.
- I need to carry out the simulation and collect data.
- I need to analyze the data and draw conclusions.



LT: I can analyze the effects of ocean acidification on coral reefs by collecting data from a model and drawing conclusions.

## **Activity: Examining the effects of ocean acidification**

- In this experiment we will examine how acidic conditions affect coral reefs.
- We will use chalk made of calcium carbonate in place of the corals, and acetic acid to mimic the acidic conditions in the ocean.

LT: I can analyze the effects of ocean acidification on coral reefs by collecting data from a model and drawing conclusions.

## Research question:

**What would happen to the biodiversity of coral reefs as the concentration of acid in the ocean increases?**

Independent Variable Concentration of acid

Dependent Variable Biodiversity

Hypothesis – If... then... because...

LT: I can analyze the effects of ocean acidification on coral reefs by collecting data from a model and drawing conclusions.

## **Instructions:**

1. Work in pairs
2. One person from the pair should collect the materials.
3. Do not start the experiment until you are instructed to.
4. Listen to directions!

LT: I can analyze the effects of ocean acidification on coral reefs by collecting data from a model and drawing conclusions.

## **Small group roles:**

1. Facilitator – keep group on track also mindful of time to complete experiment
2. Time keepers – time the experiment
3. Materials manager – collect and return the supplies
4. Content expert – rallies group to answer questions first then ask teachers.

LT: I can analyze the effects of ocean acidification on coral reefs by collecting data from a model and drawing conclusions.



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## **Think about:**

**What is the control group?**

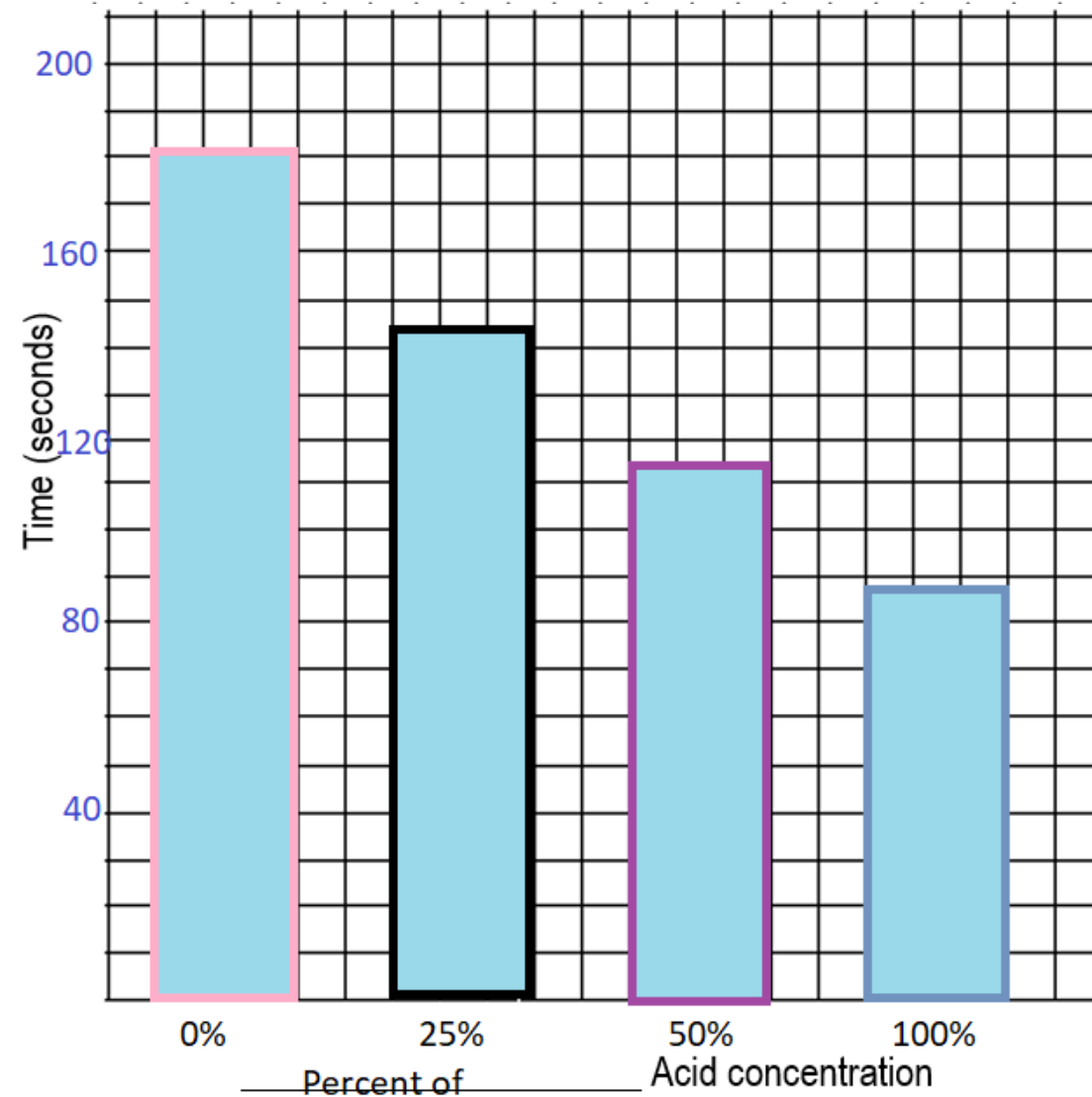
**What is the purpose of the 0% acetic acid cup?**

LT: I can analyze the effects of ocean acidification on coral reefs by collecting data from a model and drawing conclusions.

**Time taken for the chalk to dissolve at various acid concentration**

Concentration of Acid (%)	Time taken for the chalk to dissolve (seconds)
0 (water)	<b>180</b>
25	<b>145</b>
50	<b>115</b>
100	<b>85</b>

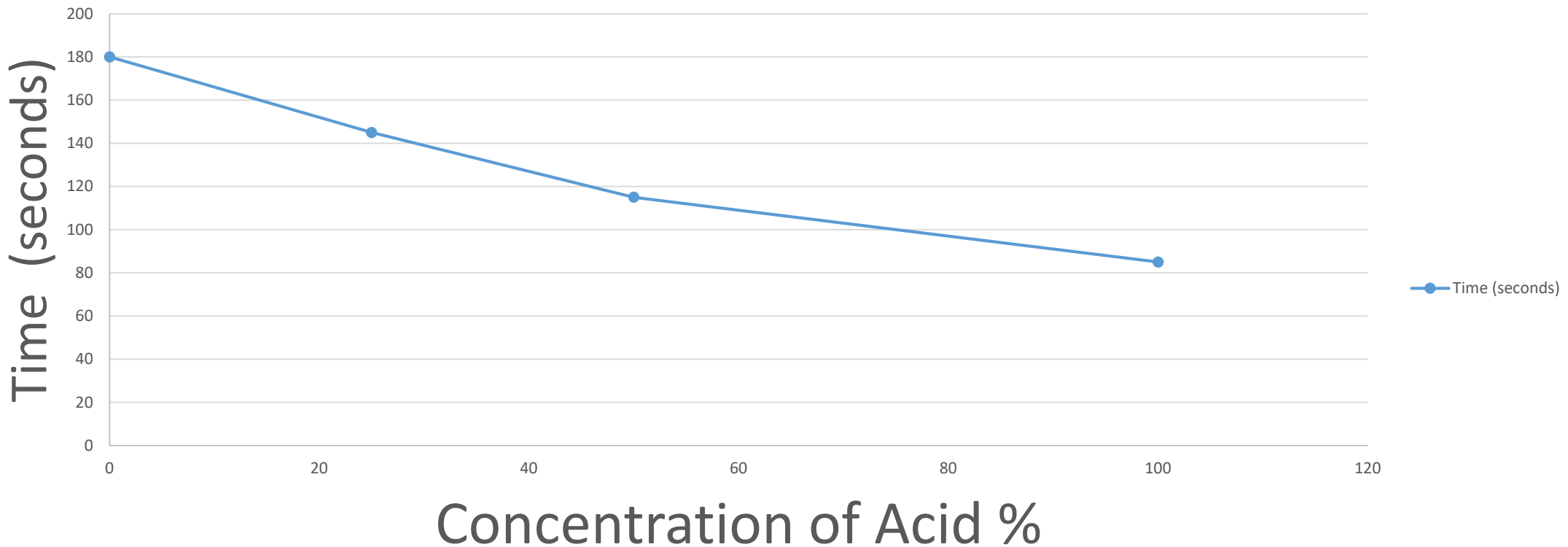
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LT: I can analyze the effects of ocean acidification on coral reefs by collecting data from a model and drawing conclusions.

**Time Taken for Chalk to Dissolve in Various Acid Concentration**



 LT: I can analyze the effects of ocean acidification on coral reefs by collecting data from a model and drawing conclusions.

## **Analysis:**

### **Turn-and-Talk**

- 1. What is the relationship between the amount of time it takes the chalk to dissolve and the concentration of acid?**

**As the concentration of acid increase, the amount of time it takes for the chalk to dissolve decreases.**

LT: I can analyze the effects of ocean acidification on coral reefs by collecting data from a model and drawing conclusions.

**2. What does this relationship tell you about the effect of ocean acidification on the survival of the coral reefs?**

**3. Based on your experiment with the calcium carbonate chalk and the acetic acid, what do you think will happen to our coral reefs and their biodiversity as the acidity of the ocean increases due to CO<sub>2</sub> emissions?**

**4. What could humans do to prevent ocean acidification? Hint: Think about activities that are associated with the release of carbon dioxide in to the atmosphere.**

LT: I can analyze the effects of ocean acidification on coral reefs by collecting data from a model and drawing conclusions.

## **Conclusion:**

**Answer the research question: What would happen to the biodiversity of coral reefs as the concentration of acid in the ocean increases?**

**Organize your writing using the claim, evidence, concepts and justification format.**