



Lesson 8: How can we show that an increase in CO₂ causes an increase in temperature?

MS Climate Unit

Previous Lesson....Where we've been: We know human activities that burn fossil fuels release greenhouse gases, like CO₂, and that greenhouse gases warm Earth's temperature.

 This Lesson....What we are doing now: This lesson explores how more CO ₂ in the atmosphere causes global warming.			
Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), <i>New Questions and Next Steps</i>
L8: How can we show that an increase in CO₂ causes an increase in temperature? (2 periods)  <div style="border: 1px solid gray; padding: 5px; width: fit-content;"> <i>Building toward</i> ↓ NGSS PEs: MS-ESS-3-5 </div>	The Mythbusters Test the Global Warming Theory Neil DeGrasse Tyson's Explanation of Climate Change What does carbon dioxide have to do with global warming? Climate Change Basics video Optional GHG lab: adapt resource for air & CO ₂ only	Plan and carry out an investigation ... in which students identify variables, tools needed, and data needed to model whether an increase in CO ₂ in the air can cause an increase in air temperature.	<p>Last time, we saw a relationship between CO₂ and temperature. We decided to investigate how more CO₂ in the atmosphere can cause an increase in temperature.</p> <p>We decide we need to design an investigation to model how more CO₂ causes an increase in temperature.</p> <p>We brainstorm some ideas for where we can find CO₂ easily, and we remember that when soda fizzes, it releases CO₂. We talk about ways we can create an easy but effective method to release CO₂, capture it, and then be able to model how CO₂ can cause an increase in air temperature.</p> <p>We plan and carry out an investigation with two soda bottles, where we test out the idea that CO₂ can cause a rise in temperature. In one bottle, we mix water with Alka Seltzer, producing CO₂. In the other, we just have regular air and water. We measure, the temperature in both bottles in 2-5-minute increments.</p> <p>We see:</p> <ul style="list-style-type: none"> When light is shined (like the sun) on both bottles, the temperature inside both bottles increases. However, the temperature of bottle with the CO₂ increases more. <p>We model the system we're observing based on what is happening in the atmosphere. The top and sides of the bottle are also partly like our atmosphere. Our atmosphere lets in light, and it also keeps in particles (but not all of them).</p> <p>We think the pattern we see in the bottle is similar to what happens in the atmosphere. When more carbon dioxide is released into the atmosphere, it is then able to trap more heat.</p> <p>Modelling our results to the atmosphere, we conclude that increasing carbon dioxide in the atmosphere can warm the temperature of the air around it and thus cause global temperatures to rise, not just locally.</p> <p>We engage in Building Understandings discussion, to put together what we think we've figured out so far about the relationships among the human population, carbon dioxide, and temperature.</p> <p>We've figured out that:</p> <ul style="list-style-type: none"> In the Industrial Revolution, people started engaging in many activities that use fossil fuels. Using fossil fuels takes carbon out of the ground and burning it puts CO₂ into the atmosphere. When there's more CO₂ in the atmosphere, it makes the atmosphere warmer by trapping heat.

			<ul style="list-style-type: none">• Since humans are adding more CO₂ to the atmosphere, that helps explain why temperatures are increasing around the world.• The increase in the burning of fossil fuels and other activities by human beings in the last 200+ years are contributing to temperature increases by releasing more CO₂ into the atmosphere. <p>We are seeing big changes around the world related to climate change and we are wondering: What can we do?</p>
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Getting Ready: Materials Preparation

Materials For Each Group

- 2 liter soda bottles (2)
- Alka-Seltzer tablets (4)
- Rubber bands (2)
- Plastic wrap squares (2) or some modeling clay
- Lamp (1)
- Thermometers (2)

Preparation of Materials (15 min.)

- Create a set of materials for each group of 3-4 students in advance.
- Post “Notices and Wonderings” chart from previous lesson.
- Print Student Activity Sheet
- Cue for class viewing:
 - “The Mythbusters Test the Global Warming Theory”
<https://www.youtube.com/watch?v=pPRd5GT0v0I>
 - Neil DeGrasse Tyson’s Explanation of Climate Change:
<https://www.youtube.com/watch?v=6VUPIX7VEOM>

Materials For Each Student

- Student Activity Sheet (1 per student)

Safety

- Goggles should be worn since dealing with household chemicals.
- Remain vigilant of the amount of pressure building up in the bottles.





Getting Ready: Teacher Preparation

Background Knowledge

Students have learned helpful information in previous grades before reaching middle school that will give them the background knowledge they need to plan and carry out this investigation:

Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.

- Students work together to plan an investigation to answer a particular question.
- Students decide on what evidence is needed to answer their questions.
- Students use fair tests in which variables are controlled.
- Students conduct multiple trials to generate evidence.

Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.

- Students make observations and measurements.
- Students interpret observations as evidence.
- Students use evidence to construct explanations.

Alternative Student Conceptions

Students come into this lesson thinking that it is one specific thing that is causing the temperature to increase. Each lesson prior to this one has had a focus on what could be causing the increase and this lesson will put it all together, but it might be difficult at first for students to realize that it is a LOT of factors that lead to the increase in CO₂ and increased temperatures.

Linking Our Understanding to Scientific Terminology

- Greenhouse Gases
- Carbon Dioxide
- Global Warming





Lesson 8: How can we show that an increase in CO₂ causes an increase in temperature? (100 min)

1. (10 min) Do a Consensus Building Discussion ¹ to help reorient students in the story line. Use the following prompts to help students articulate what they figured out in the last lesson.

Suggested Prompts:

- What did we wonder about last class?
- What was the most important thing that we figured out in our last lesson? How did we figure it out?
- What other evidence do we need to collect?

Listen for *student responses* that refer to what we figured out last time, such as:

- *The Greenhouse Effect works by GHGs like CO₂ absorbing heat. If humans release more CO₂ into the atmosphere then it will absorb more heat and increase temperatures on Earth.*
- *We figured out that there appears to be a strong correlation between the number of cars on the road and the temperature increase because the graphs looked very similar when we plotted them.*

2. (10 min) Next, shift to a Sharing Initial Ideas Discussion ³. Use the following prompts to guide students to articulate what they think they should focus on in today's lesson.

Suggested Prompts:

- What do you think we could/should do to help us decide if the increase in CO₂ produced by cars and burning of other fossil fuels could actually be the *cause* of an increase in temperature, and not just a correlation?

Listen for *student responses* that mimic the next step in the story line, such as

- *We need to construct a fair test -- something we could maybe do in our classroom in a controlled environment, to see whether increased CO₂ can cause an increase in the temperature of the air.*



Teacher Supports & Notes



Strategies for this Consensus Building Discussion

1: This Consensus Building Discussion should help students begin to put together the different pieces of an explanation.



3. (5 min) Now that students have decided the path of the lesson, have students come up with some initial ideas for how they might construct such a fair test. Provide them with a list of potential tools to use, and ask students to work in small groups to think about how they might use them.

Suggested Prompts:

- How could we use these tools to help us design a fair test, to see whether CO₂ really could be the cause of an increase in air temperature?
- What kinds of data would we need to collect? How much data would we need to collect?
- What would the pattern of evidence need to show us, to conclude that CO₂ could cause an increase in temperature?

Listen for *student responses* such as:

- A fair test is one where we can really see if something is causing something else. Therefore, we need a control or a comparison group.
- In our experiment, we need one bottle where there's more CO₂, and we also need to have a light source that represents the light from the sun.
- We think we can use thermometers to measure the temperature where there's less and more CO₂.
- We think we can put the Alka-Seltzer in water in one of the bottles (treatment), and just water in the other (control). We might use the plastic wrap to create a seal at the top of the bottles, so that the CO₂ or air can't escape.
- We'd need to see that the temperature increased at a higher rate in the bottle with CO₂ than in the bottle without it.

4. (25 min) Ask students to work in small groups to develop their investigation plans, providing feedback to individual groups to help them with developing the fair tests they will carry out the next day.

Suggested Prompts:

- What do we need to keep the same between the two conditions?
- What do we need to vary or change, to investigate whether CO₂ is causing an increase in temperature?
- What do you think will happen when the light is placed in front of the control setup? What about in the treatment (change) set up?

Listen for *student responses* such as:

- We need to make sure there's water and air in both conditions. Both bottles need to be sealed. We need to take measurements of temperature at the same time. We need to keep the light the same distance away.
- We need to put CO₂ in one bottle, but not the other. Then, if the temperature change is different in that bottle, because it's the only thing we're changing, we can conclude that CO₂ is the cause of the change.
- In both bottles, the inside air is going to get warmer. It will get warmer in the CO₂ bottle, especially if the CO₂ is the cause of a temperature increase.



5. (25 min) Students carry out their investigation plan. Each group has two plastic bottles, two thermometers, two rubber bands, two sheets of plastic wrap, 4 Alka-Seltzer tabs, water, and a lamp. Students follow the procedure they developed and graph their data in between each collection.

NOTE: The following student-driven simulation supplements the investigation (be sure to have students to complete the free student project portal registration in order to save their data):

- What is the future of Earth's climate? <http://cleanet.org/resources/43831.html>

6. (15 min) When students have completed the activity bring them back together as a whole group, having team members sit close to one another. In this Building Understandings Discussion, use the following prompts to help students debrief what they observed in their activity.

Suggested Prompts:

- What is one thing your group noticed about the bottles before you added the Alka-Seltzer?
- What is one thing your group noticed about the bottles after you added the Alka-Seltzer?
- What happened to the temperature of each bottle over your data collection time?

Listen for *student responses* such as:

- *Our group noticed the bottles looked the same before adding the tablets, then once the tablets were added to one of the bottles it started to fizz and make bubbles. The temperature before adding the Alka-Seltzer was the same, but then over time with the plastic wrap on top, the bottle with the tablets became warmer than the bottle without the tablets.*

7. (10 min) After students have shared, revisiting the question, “What have we figured out so far?” Watch the short videos “What does Carbon Dioxide Have to Do with Global Warming?” and “Climate Change Basics”. Then, use the following prompts to guide this Consensus Building Discussion.

Suggested Prompts:

- What did we find out after we did the activity?
- Now that we have completed our activity, what is the role of CO₂ in the temperature increase?
- Do we have any more questions about CO₂ and how it relates to climate change?



Listen for *student responses* such as:

- *We found out that there is definitely a relationship between the CO₂ and temperature increase. As the CO₂ in the bottle or atmosphere increases, so does the temperature.*
- *We wonder if there other factors in addition to the increase in CO₂ that is increasing global temperatures.*
- *We are wondering what we can do to cut down on our GHG emissions to reduce our impacts on global warming.*



Alignment With Standards

Building Toward Target NGSS PE

- **MS-ESS3-5:** Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Building Toward Common Core Standard(s)

ELA/Literacy -

RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS3-5)

Mathematics -

MP2: Reason abstractly and quantitatively. (MS-ESS3-5)

6.EE.B.6: Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS3-5)

7.EE.B.4: Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-ESS3-5)

