SUCCESS ACADEMY EDUCATION INSTITUTE

Earth and Space Science:

Unit 4

Human Impact - Climate Change: Lessons

Lesson 1: How Do We Know What to Believe?

Lesson Objective: When researching a topic, scholars know that all materials (written, oral, multimedia) should be read with a critical eye to quality of evidence and possible ideological bias. Scholars can evaluate a text and determine the presence of unsubstantiated claims by describing the bias of a source. Materials Needed

- For each group: computer

What are scholars doing in this lesson?

- Scholars learn how to assess a source for credibility and reliability by first examining the adverse impact of the chemical dihydrogen monoxide (water).

[**Tip:** In part one of this activity, scholars will be presented with information that is intentionally manipulated and could frighten sensitive scholars. While they will quickly learn that the "scary" substance described is actually just water, you may choose to let certain scholars who might become very upset in the moment "in on the secret" at the start of class.]

Do Now

- Follow the **Do Now plan**.

Launch

- Ask: If someone wanted to learn more information on a topic, where could they look?
    - Explain that in the age of technology, people learn about the world through a variety of sources and platforms. The American citizen is inundated with news, from articles on Facebook to clips on Hulu. This is particularly true of a controversial topic like climate change.
- Introduce the concept of **climate change** and define it. Why is climate change considered controversial?
    - Acknowledge that while this topic is considered controversial in the media, it is not much of a controversy within the scientific community. Climate change is an accepted theory that almost all scientists support.
- Explain that the Internet is an amazing tool to discover new knowledge. However, if people are not careful, the Internet can also be a tool to recruit them to ideologies they may not otherwise believe in.
    - Ask: How can the Internet persuade you to believe in something?
    - Ask: How do you know when to trust a source of information?
- Explain to scholars that in this lesson, they will study some information online to see how data can be manipulated to support different agendas.

Activity

- Introduce scholars to dihydrogen monoxide through this **website**. Pause throughout to allow scholars to take notes about dihydrogen monoxide.
    - Allow small groups to discuss: Should this substance be banned?
- After reviewing some of the information, break down the meaning of the term dihydrogen monoxide by defining each prefix. Ask scholars: Has anyone ever heard of a substance that is made of two parts hydrogen and one part oxygen? Reveal that dihydrogen monoxide is, in fact, plain old water!
    - Go back and reread the information on the website. Was any of it a lie? (Scholars should see that the facts on the website are still trueâ€" they are just chosen carefully and written in a way that omits some information and makes them sound frightening.)
        - Ask: What does this mean about the public perception of science and how people can manipulate science for their own purpose?
            - Define **propaganda** and **bias**.
    - Brainstorm as a class around how to tell whether a resource is a credible source of information.

- Show **What They Haven't Told You About Climate Change Video** by Prager U (4 minutes, 54 seconds).
    - Bring focus back to the graph shown at 1:35.
        - Discuss whether this clip is a reliable source of information.

Discourse Debrief experiment/activity:

- Ask: Why do we believe some sources over others?
- Ask: How can there be different interpretations of the same data?
- Ask: What information do we need about a source in order to decide whether it is credible?

Make broader connections:

- Ask: Why do you think there are different opinions on climate change?
- Ask: How might different opinions affect our ability to act to reduce climate change?
- Ask: How might people use data manipulation to change the publics' view of climate change?

Make connections to the Essential Question:

- Introduce the Essential Question: What will happen to Earth if we do nothing about climate change?
    - Have scholars share their initial ideas.

Accountability

- This lesson does not have a formal Exit Ticket. Assess scholars' prior knowledge and understanding informally.

Lesson 2: What Do Greenhouse Gases Do to the Environment?

Lesson Objective: Scholars understand that the greenhouse effect is a naturally occurring process that traps sunlight through the concentration of carbon dioxide; this increases the temperature of our atmosphere and keeps Earth habitable. When the concentration of carbon dioxide increases, the temperature also increases and causes global warming. Materials Needed

- For the teacher: utility knife or scissors for cutting plastic bottles, one clip-on light source with at least a 100-watt bulb per team of students
- For each group: 2 clear plastic 2-liter bottles, plastic wrap or clear plastic bags to cover the "greenhouses," string or rubber bands to hold the plastic in place, 2 thermometers, two 2" x 2" pieces of cardboard, soil, ice cubes, water, plastic rulers, masking tape

Prep

- Materials Prep:
    - Plan your time carefully and well in advance. This lesson involves extended periods of wait time and data collection time, so an extended class period will be necessary.
- Intellectual Prep:
    - Review **Making a Greenhouse Guide** by NASA. Read through this guide thoroughly, as this lesson requires advance setup and planning.
    - Review **Greenhouse Effect Graphic** by NASA.

What are scholars doing in this lesson?

- Scholars design and implement an experiment to study the impact of the greenhouse effect on air, water, or soil temperature. They apply their findings to draw conclusions about how the greenhouse effect impacts Earth's surface.

Do Now

- Follow the **Do Now plan**.

Launch

- Explain to scholars that in order to make informed decisions about climate change, they need to understand the science behind it.
    - Ask: Based on what you know about climate and weather, what do you think causes climate to change?
- Explain that today, scholars develop their own experiment to observe the greenhouse effect and learn about this major mechanism that contributes to climate change.

[**Tip:** Do not define *greenhouse effect* during the Launch. Press scholars to use the model as a tool to understand the natural scientific process.]

- Introduce the experimental design task as outlined in the **Making a Greenhouse Guide**.
- Define **atmosphere** and **greenhouse gas** as you introduce the task.

Experiment

- Scholars design and execute experiments to study the impact of the greenhouse effect on Earth's surface. (Follow the guidance in the **Making a Greenhouse Guide**.)

Discourse Debrief experiment/activity:

- Have two to three groups share their experimental design and discuss their results.
    - Allow time for evaluation of each group's experimental design and discuss possible sources of error.
- Ask: What trends do we see across all of the experiments?
- Ask: Based on what you observed, what do you think the greenhouse effect is?
    - Define the **greenhouse effect**.
        - Ask: How does the greenhouse effect relate to climate change?
            - Explain that the greenhouse effect is not a phenomenon caused by humans. It is a process that has been occurring naturally for billions of years. The greenhouse effect is not just a bad thing; it created the conditions on Earth that allowed life to develop. The greenhouse effect is not isolated to Earth, either, and can be found on other planets (notably Venus). However, if too much heat is trapped in our atmosphere, the planet will become increasingly warmer over time, and even what seems like a "small" change in average temperature can have devastating effects on the Earth.
            - Show the **Greenhouse Effect Graphic** by NASA.

Make connections to the Essential Question:

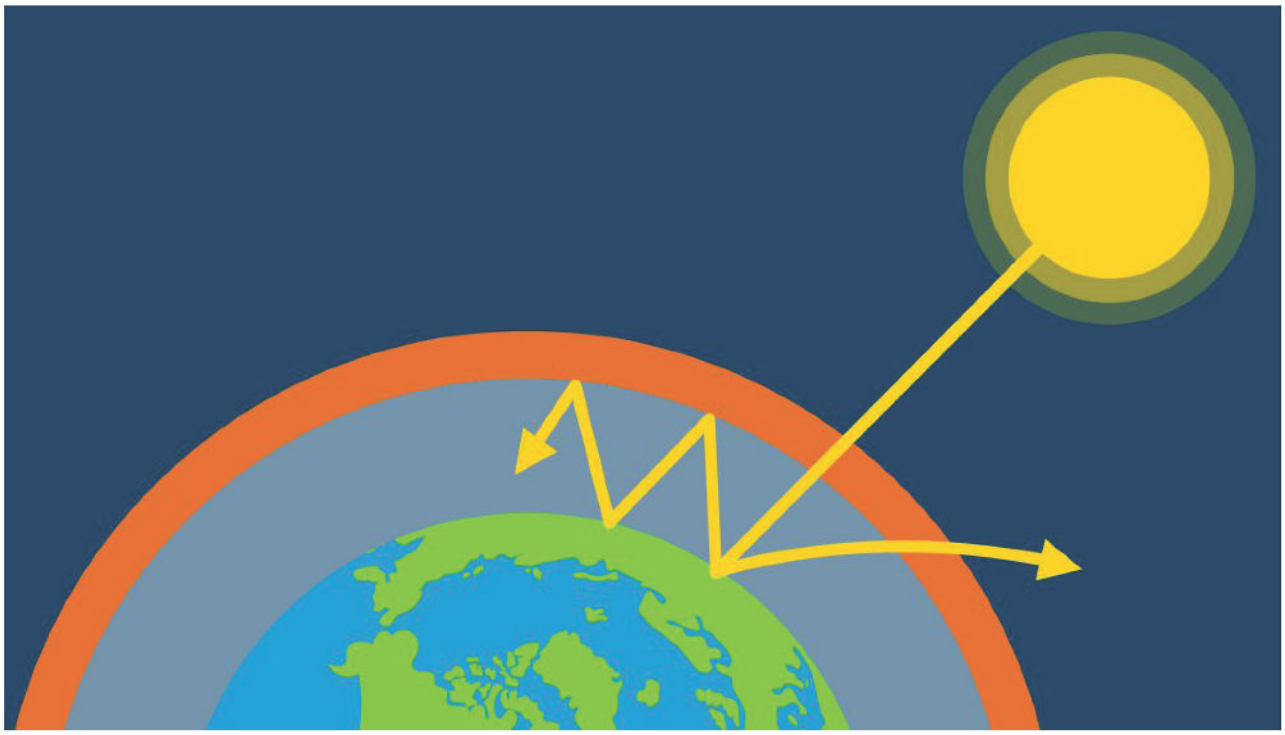
- Ask: Would we want to live on Earth if the atmosphere never got warmed by the Sun?
- Ask: Would we want to live on Earth far in the future if the amount of greenhouse gases continued to increase significantly? Why or why not?
    - Define **global warming**.

Accountability (Exit Ticket)

1. If humans increase the amount of carbon dioxide in Earth's atmosphere, what will happen to the average temperature on Earth? Read the statements below and (âœ“) the correct response. [1]

The average temperature on Earth will increase because the concentration of greenhouse gases will decrease.
The average temperature on Earth will decrease because the concentration of greenhouse gases will decrease.
The average temperature on Earth will increase because the concentration of greenhouse gases will increase.
The average temperature on Earth will decrease because the concentration of greenhouse gases will increase.

2. Explain how the greenhouse effect both benefits and harms Earth. [2]



The greenhouse effect uses the carbon dioxide in our atmosphere and traps in sunlight. It helps Earth because it makes it warm enough for organisms to survive, but if there are too many greenhouse gases, there will be too much heat trapped, and the temperature will increase too much, causing climate change.

3. If there were no greenhouse gases in the atmosphere what would the Earth be like? [1]
    1. Extremely hot
    2. Warm
    3. Cool
    4. Extremely cold

Scoring

1. Award one point for selecting the correct response.
2. Award points as follows:

    - One point for describing how the greenhouse effect benefits Earth
    - One point for explaining how the greenhouse effect harms Earth

3. Award one point for answer D.

Lesson 3: What Is Natural Climate Variation?

Lesson Objective: Scholars understand that climate varies naturally over time, and its fluctuations display no long-lasting upward or downward trend. When climate changes significantly due to global warming, these variations change dramatically and noticeably to an upward trend. The effects of climate change have significant impacts for the natural climate variation found on Earth. Materials Needed

- For the teacher: prepared Condition A and B containers
- For each group: takeout containers, beads (red, white, and blue), cup (condition B)

- For each scholar: Graph paper

Prep

- Materials Prep:
    - Set up deli trays:
        - Condition A:
            - Deli container
            - 25 red beads
            - 25 blue beads
            - 5 white beads
        - Condition B:
            - Deli container
            - 25 blue beads
            - 25 red beads
            - 5 white beads
            - Cup for removed beads
    - Create a color key to be posted in the room or provided for each group.
        - Blue = −1
        - White = 0
        - Red = +1

[**Tip:** For high-flying groups, you can have other beads to represent other values, such as light blue (−0.5) and pink (+0.5).]

- Alternate bead breakdown (optional):
    - 10 blue beads
    - 15 light blue beads
    - 10 red beads
    - 15 pink beads
    - 5 white beads
- Intellectual Prep:
    - Review **Natural Variations in Climate** by NIWA.

What are scholars doing in this lesson?

- Scholars explore the concept of natural vs. unnatural climate variation by creating mathematical models of both natural and biased global temperature change.

Do Now

- Follow the **Do Now plan**.

Launch

- Explain that our global temperature is constantly shifting from year to year. This is one of the key arguments from climate change deniers. Ask:
    - Why does our global temperature constantly shift?
        - Define **climate variation**.
        - Explain that it is correct that our global temperature changes yearly; however, the evidence for climate change isn't seen in yearly data but through examining this data over a long range of time.
        - Ask: Why would studying global temperatures over a long period of time be more helpful?

Activity

- Divide your class into two conditions for the lab.
    - Condition A:
        - Partners draw five beads out of their bin.
        - Partners use the color key to determine change in temperature over a five-year period.
        - Partners graph data point on their graph.
        - Return all beads to the bin.
        - Repeat 15–21 times (predetermine what number works best for your class while trying out the labâ€" number must be divisible by three).
    - Condition B:
        - Partners draw five beads out of their bin.
        - Using the color key they determine the change in temperature over the past five years.
        - Partners graph data point on their graph.
        - Return all beads to the bin.
        - Repeat three times.
        - After, remove four blue beads from the bin and place in a cup. These remain out of the bin for the rest of the lab.
        - Repeat until the number of years is equal to the target set by the teacher.

- As scholars are working, circulate and press scholars to question the meaning behind their results during each trial.
    - How has the temperature changed every five years? What might be happening on Earth to cause this change?
    - What is different about Condition B? What happened to the temperature after the third trial? What might this represent on Earth?

Discourse Debrief experiment/activity:

- Compare the graphs from condition A and condition B. Have scholars describe the overall shape of the graph to determine if a trend is present. Ask:
    - What trends are similar?
    - What trends are different?

Make broader connections:

- Compare graphs to real-world temperature data over the past 100 years.
    - Ask: Which one more closely resembles the real-world data?
- Ask: Do both conditions show “natural climate variation”? Why or why not?
- Ask: How does this model relate to **current** climate models and data?
    - Is it probable that current changes in temperature are just a result of natural climate variation?

Make connections to the Essential Question:

- Ask: Which condition in today’s activity best models what might happen to Earth if we do nothing about climate change?

Accountability (Exit Ticket) The graph below shows the total ozone above Antarctica as measured by different instruments between 1957 and 2019.

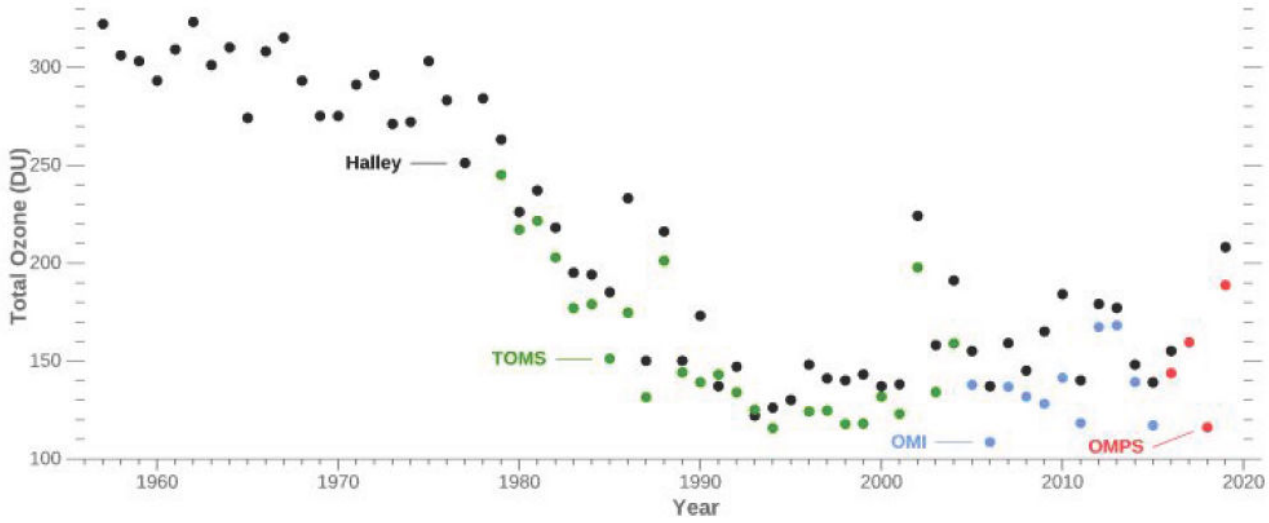


*Image and Caption Credit: **NASA**. Instruments on the ground (at Halley) and high above Antarctica (the Total Ozone Mapping Spectrometer [TOMS] and Ozone Monitoring Instrument [OMI]) measured an acute drop in total atmospheric ozone during October in the early and middle 1980s. (Halley data supplied by **J.D. Shanklin, British Antarctic Survey**.)*

After analyzing the total ozone (a gas in the atmosphere that absorbs ultraviolet radiation from the Sun), the following claim was made:

"Ozone loss in Antarctica from 1957 to 2019 was most likely caused by natural climate variation."

1. Evaluate the accuracy of the statement above. Include evidence and reasoning to support your response. [3]

The statement is not accurate because it is unlikely that ozone loss between 1957 and 2019 was caused by natural climate variation. In 1957, for example, the reading was over 300DU. From the 1980s on, no readings were above 250. The graph shows that the data just keeps falling over time, and it would be an extremely strange coincidence if the trend shown was random.

Scoring

1. Award points as follows:

    - One point for indicating the inaccuracy of the statement
    - One point for evidence cited from the graph (can name specific data points or explain the general trend in the data)
    - One point for justification/reasoning that further ties the analysis of evidence from the graph to the concept of natural climate variation

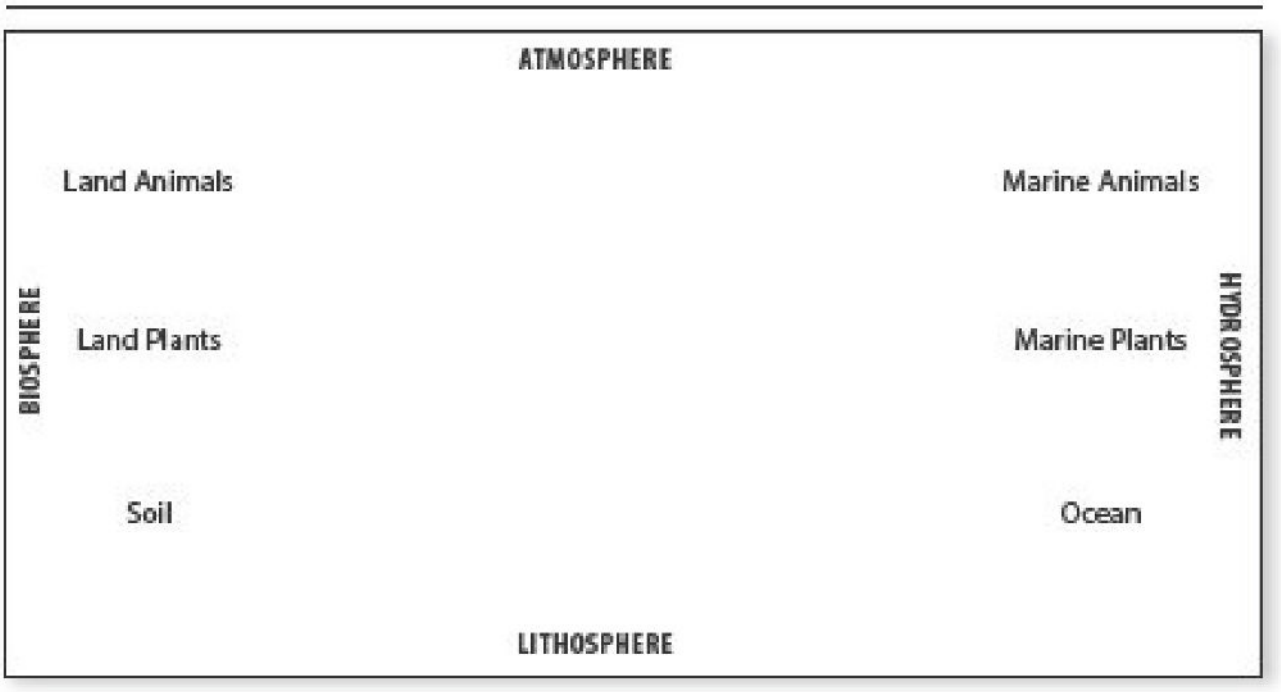
Lesson 4: Where Does Carbon Come From?

Lesson Objective: Scholars understand that carbon circulates through Earth in a cycle that involves storage and release, and that humans have impacted the carbon cycle by taking away carbon from Earth's surface through the burning of fossil fuels and adding it back to the atmosphere. Materials Needed

- For the teacher: **station cards (pages 44-52)** (laminated), 2 playing card decks (separated by suit), 8 fine-point dry erase markers, **station posters**, **Student Division Chart (page 13)**
- For each scholar: **Carbon Tracking Sheet (page 53)**

Prep

- Materials Prep:
    - Set up stations:
        - Print out station cards and laminate.
        - Print and enlarge station posters and laminate.
        - Map out station placement in your room (see below for example):



- Divide decks of cards into four parts based on suit.
- Place one part of the deck at each station (shuffled).
- Place a dry erase marker at each station.

What are scholars doing in this lesson?

- Scholars model the movement of carbon through Earth's systems by acting as a carbon atom in a whole-class walkthrough.

Do Now

- Follow the **Do Now plan**.

Launch

- The majority of the arguments you looked at during the Engage of this unit mentioned carbon. Carbon (in the form of CO_2) is a major factor when exploring climate science.
    - Ask: Where does carbon come from?
    - Ask: What is carbon used for?
        - Introduce carbon to the class and ensure they understand that carbon is a major building block of life.
- Introduce the carbon cycle and explain the concept of carbon reservoirs, the movement of carbon through these sources, and **carbon sinks** as a source of **absorption**.
    - Ask: How might the carbon cycle be related to climate change?

Activity Adapted from Exploring Cycle Change, Carbon Cycle Simulation by **The NEED Project** ©2015

- Round 1: Pre-Industrial Revolution
    - Use the **Student Division Chart (page 13)** to assign scholars to starting stations.
    - Scholars record their starting station information on their Carbon Tracking Sheet.
    - Using dry erase markers, one scholar records the number of scholars at the station on the station card.
    - Direct scholars to draw a playing card at the station to determine where each scholar will move next.
    - Scholars record where they are moving next on their Carbon Tracking Sheet.
    - Scholars return cards to their station deck and shuffle.
    - Teacher signals scholars to move to the next station.
    - One scholar again counts the number of scholars at each station and records this using a dry erase marker on the station card. Scholars again record their station on their Carbon Tracking Sheet, draw playing cards to determine their next movement, record where they will move next, and move at teacher's signal.
    - This is repeated for 10 rounds.
- Round 2: Present Day
    - Use the **Student Division Chart (page 13)** to assign scholars to starting stations.

        - Ensure the Lithosphere station card is out and that the Atmosphere card has been switched to the Present Day side.
        - Repeat the same process as Round 1 for scholars to move between stations.
        - Complete 10 rounds.

- As scholars are working, circulate and press scholars to explain how carbon moves around Earth and the implications this may have toward climate change. Ask:

    - What are the different ways carbon moves through Earth? Is this harmful or beneficial to Earth?
    - What is different about Round 1 and Round 2? Has this changed the way carbon moves through Earth? Why?

Discourse Debrief experiment/activity:

- Define **industrial revolution**. Ask: How was the carbon cycle impacted by an increase in manufacturing during the industrial revolution?
- Ask: How did the cycle differ between the pre-industrial and present day simulations?
- Ask: Which stations were most impacted by the change in the second simulation?
- Ask: How have humans impacted the carbon cycle?

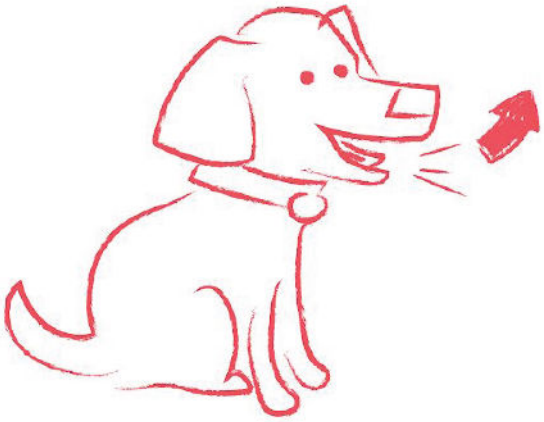
    - Define **fossil fuels** and **carbon emissions**.

Make connections to the Essential Question:

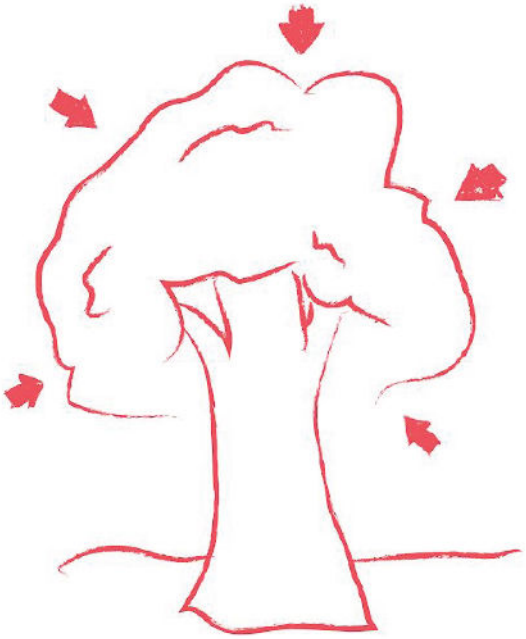
- Ask: What does this simulation tell us about continuing to rely on fossil fuels as our main source of energy?

Accountability (Exit Ticket)

1. Carbon circulates through Earth in many ways. In the box below each one, use words or drawings to represent one real-life example of this occurring. [2]



Animal respires and gives off carbon dioxide



Plants take in carbon dioxide

2. How have humans impacted the carbon cycle? [1]
    1. Humans have taken carbon away from the atmosphere and added it to the Earth's surface.
    2. Humans have taken away carbon from the Earth's surface and added it to the atmosphere.
    3. Humans have decreased the total amount of carbon in the cycle.
    4. Humans have increased the total amount of carbon in the cycle.

The graph below shows changes in carbon dioxide concentrations in Earth's atmosphere over a 140-year period. Carbon dioxide concentrations are shown in parts per million (ppm).

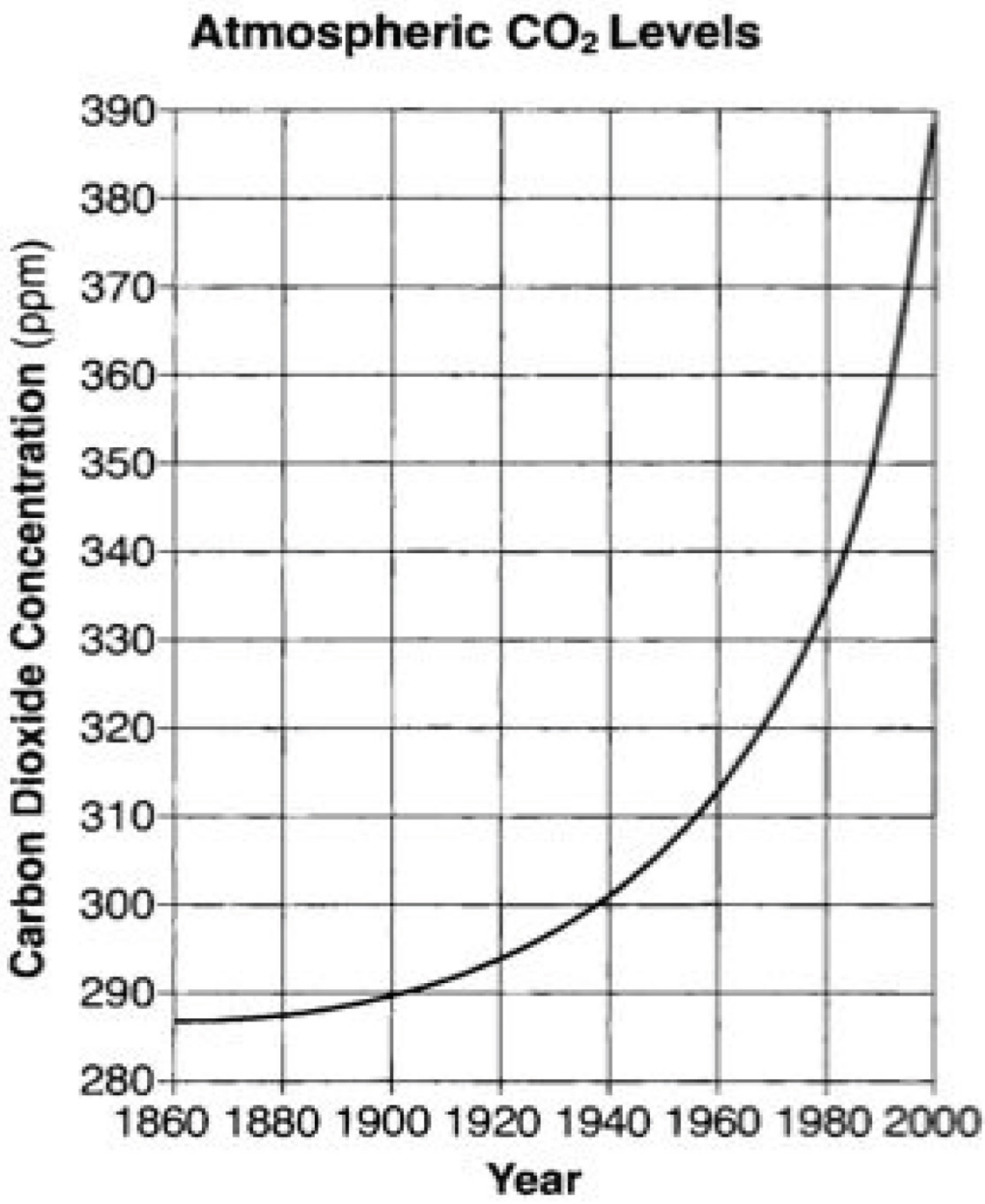


Image Credit: ***NASA Goddard Institute for Space Studies (GISS) Climate Change Research Initiative (CCRI) Applied Research STEM Curriculum Unit Plan, Future Temperature Projections***

3. The significant change in CO_2 concentration is most likely caused by _____. [1]
    1. decreased cloud cover, and is predicted to decrease average global temperatures
    2. decreased volcanic activity, and is predicted to increase average global temperatures
    3. increased use of fossil fuels, and is predicted to increase average global temperatures

Scoring

1. Award points as follows:
    - One point for accurate depiction of carbon entering the atmosphere
    - One point for accurate depiction of carbon leaving the atmosphere
2. Award one point for answer B
3. Award one point for answer C

Lesson 5: Model Man-Made Climate Change

Lesson Objective: Scholars can explain that through the use of carbon in Earth's surface, humans impact the temperature of Earth by adding carbon to the atmosphere and increasing the amount of greenhouse gases that are able to trap sunlight. Materials Needed

- For the teacher: Lighter
- For each group: Plastic wrap, infrared thermometer, three 500-mL beakers (or 16-oz mason jars), 3 floating candles, 200 mL of water, lighters (optional; you may decide whether scholars or the teacher will light the candles)

Prep

- Materials Prep:
    - Consider following modifications of the materials:
        - Provide beakers smaller than 500 mL for a heightened warming effect.
        - Reduce the water quantity in proportion to the new beaker size.
        - Substitute aluminum foil cover for the plastic wrap to avoid melting plastic.
        - Some infrared thermometers were not sensitive enough to record the temperature. As an alternative, use traditional thermometers and stick them inside the beakers every 2 minutes.

What are scholars doing in this lesson?

- Scholars practice improving and modifying scientific models as they model the addition of human impact on the carbon cycle.

Do Now

- Follow the **Do Now plan**.

Launch

- Remind scholars of the models they made and used to study the greenhouse effect. Ask:
    - How can we model human impact on the carbon cycle in relation to climate change?

        - What do you predict will happen as humans add carbon to the atmosphere?

Experiment

- Scholars follow the procedure below to set up and observe their models:
    - Add 200 mL of water to each jar.
    - Turn on the heat lamp to get warm while you finish prep.
    - Record the initial air temperature inside each jar using the infrared thermometer.
    - Set up each jar conditions:
        - Jar A: unlit floating candle, no cover
        - Jar B: unlit floating candle, plastic wrap cover
        - Jar C: lit floating candle, plastic wrap cover (let the candle go out in the jar)
    - Take the temperature by peeling off the plastic wrap and aiming the infrared thermometer at the air inside the beaker.
    - Take temperature every 2 minutes for approximately 20 minutes.
- Scholars record a drawing of their setup and label what each part of the model represents.
- As scholars are working, circulate and press groups to discuss the data gathered through the experiment and how it connects to human impact. Ask:
    - How is this model different than the one used to represent the greenhouse effect?
    - Which condition best represents human impact on the carbon cycle? How?

Discourse Debrief experiment/activity:

- Ask: What differences do we see between the three conditions?
- Ask: What does each condition tell us about factors that affect air temperature?
    - How does the burning of fossil fuels increase the temperature of the atmosphere?
- Ask: What does each piece of our model represent?
- Ask: What are the limitations of this model?
    - What could we add to this model to make it more accurate?

Make connections to the Essential Question:

- Ask: How could this model be used to describe what will happen to Earth if we do nothing about climate change?

Accountability (Exit Ticket) Scientists often use a “carbon bathtub” as an analogy of understanding human impact on our climate system:

The bathtub is a representation of Earth's climate system, and the water level represents the carbon dioxide in the atmosphere. If the tub can't drain fast enough, when too much water is added, the tub will overflow. You can't have more water coming into the tub than is draining out the bottom.

1. Explain how the "carbon bathtub" can be compared to human impact on climate change. Include evidence and reasoning to support your response. [3]

The "carbon bathtub" can be compared to human impact on climate change because just as humans can keep adding water to the tub by adjusting the nozzle, they also can add more CO_2 to the atmosphere by using fossil fuels. If humans keep adding CO_2 to the atmosphere, Earth's temperature will continue to rise unless we do something about it. Similarly, unless the drain is pulled on the tub, the water will overflow.

Scoring

1. Award points as follows:

    - One point for claim explaining the similarities between the "carbon bathtub" and human impact on climate change
    - One point for evidence cited from the diagram or from class
    - One point for justification/reasoning that further ties the two concepts together

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Lesson 6: What Will Happen to Weather?

Lesson Objective: Scholars understand that a rise in global temperatures increases the ocean temperature and the likelihood of larger storm formation due to more evaporation. Though it is not certain whether climate change will cause more hurricanes, there has been an increase in hurricane intensity. Materials Needed

- For the teacher: **Hurricane Maps** by University Corporation for Atmospheric Research
- For each scholar: **Hurricane Strength Data Sheet** or **Hurricane Number Data Sheet**, both by University Corporation for Atmospheric Research

Prep

- Intellectual Prep:
    - Review **Hurricanes and Climate Change: Everything You Need to Know** by NRDC.

What are scholars doing in this lesson?

- Scholars examine data to determine what a warmer ocean may mean for the development of hurricanes.

Do Now

- Follow the **Do Now plan**.

Launch

- Explain that climate change has been linked to the increased chance of extreme weather. Ask:
    - How could a change in climate increase extreme weather?
    - Would an increased chance of extreme weather affect us in NYC?
- In this data analysis investigation, scholars act as climate scientists by analyzing data on ocean temperatures and hurricane development to make predictions about what the world will look like in the future.

Research

- Show **Hurricane Maps** by University Corporation for Atmospheric Research and discuss.
- Show scholars a **map** of ocean temperature.
    - Compare the graphs of hurricane occurrence with that of ocean temperatures and discuss.
- Show the **Hurricanes 101 Video** by National Geographic (1 minute, 18 seconds).
    - Ask: How might global warming affect hurricanes?
- Divide your class and have half graph **Hurricane Number Data Sheet** and the other half graph **Hurricane Strength Data Sheet**, both by University Corporation for Atmospheric Research.
- As scholars are working, circulate and press scholars to describe their graphing results and possible impacts. Ask:
    - How might the number of hurricanes impact life on Earth?
    - How might the strength of a hurricane impact life on Earth?

Discourse Debrief experiment/activity:

- Ask: How does temperature affect hurricane formation?
    - How do we figure out this connection?
- Ask: Why do higher temperatures result in bigger hurricanes?
    - Press scholars to connect to their knowledge of the water cycle (more evaporation and greater ability to hold water in the air).

Make connections to the Essential Question:

- Ask: What is the impact of climate change on hurricane formation?
- Ask: What will happen in the future if climate change continues to worsen?

Make broader connections:

- Ask: How might this change in hurricanes affect humans and society?

Accountability (Exit Ticket) Directions: Read **Why Are Hurricanes Like Dorian Stalling, and Is Global Warming Involved?** by Inside Climate News.

1. Based on the text, how can global warming impact hurricane speed? Include evidence and reasoning to support your response. [3]

Global warming can slow down the speed of hurricanes and even cause hurricane stalling. When Earth's temperature rises, the difference between the temperature in the Arctic and the equator changes, and global winds slow down. Since hurricanes form where these winds are created, a slowdown in wind can cause the slowdown of hurricane speed.

2. Which of the following statement(s) are true? [1]

1. An increase in Earth's temperature will cause an increase in the amount of evaporation of the ocean during storm formation.

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2. An increase in Earth's temperature will decrease the intensity and the number of hurricanes each year.

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3. A decrease in Earth's temperature contrast between the Arctic and the equator may cause an increase in slow-moving hurricanes.

1. I
2. II
3. III
4. I and III
5. I, II, and III

Scoring

1. Award points as follows:

    - One point for claim that indicates a decrease in hurricane speed
    - One point for evidence from the text that supports the phenomenon
    - One point for justification/reasoning that further ties the increase in global temperature to a decrease in hurricane speed

2. Award one point for answer D.

Lesson 7: What Will Happen to Oceans?

Lesson Objective: Scholars understand that an increase in global temperatures will cause the ice caps to melt and glaciers to recede, increasing the sea level worldwide (due to arctic melting and thermal expansion of water) leaving coastal cities and

communities at risk for displaced land. Increased rates of CO_2 can also increase the ocean's temperature and its ability to take in carbon. When oceans absorb large amounts of carbon, they become more acidic, creating long-lasting impacts on oceanic wildlife and humans.

Materials Needed

- For each group: hot and cold water, 2 Erlenmeyer flasks, 4–6 antacid tablets, 2 balloons, bromothymol blue, string, ruler, plastic wrap, funnel, heat-resistant gloves

Prep

- Intellectual Prep:
    - Review **Ocean Acidification** by the National Oceanic and Atmospheric Administration.

What are scholars doing in this lesson?

- Scholars use available materials to determine the answer to a testable question about ocean acidification.

Do Now

- Follow the **Do Now plan**.

Launch

- Explain that many climate scientists use **glacier** recession and **sea level** evidence to communicate about climate change.
    - As a class, explore the **Global Ice Viewer** by NASA.
    - Ask: How could glaciers and sea levels be related to climate change?
        - Discuss the impact this can have on the environment and plant and animal life.
- Explain that while sea levels are a major concern for climate change, oceans are one of the largest carbon sinks (stores of carbon) and have been helping to buffer our carbon emission.
    - Ask: But what else will happen to our oceans if we continue to burn fossil fuels and ignore our emissions?
- Show the **Ocean Acidification Video** by Alliance for Climate Education (end at 0:40).
    - Ask: How does this excess CO_2 and additional heat affect oceans?
    - Define **ocean acidification** and **pH**.

Experiment Adapted from **Alka Seltzer Balloon Experiment** by Study.com

- Introduce scholars to the lab materials that are available:
    - Hot water and cold water
    - Antacid tablets, which produces carbon dioxide when mixed with water
    - Balloons
    - Bromothymol blue, a pH indicator solution (explain that it will change color to indicate acidity or basicity if scholars do not know)
- Have scholars work with a partner to brainstorm some testable questions to explore using these materials.
    - Explain: Below are two questions you could explore using the materials:
        - How does rising temperature affect carbon absorption?
        - How does CO_2 in the atmosphere affect pH?

[**Tip:** Allow scholars to explore other questions that work within the topic by adding other materials you have available in the classroom.]

- Exemplar procedure for studying the effect of rising temperature:
    - Fill one Erlenmeyer flask with cold water and one with hot water.
    - Add an antacid tablet to each flask.
    - Measure non-absorbed CO_2 by capping the flask with a balloon to catch the non-absorbed CO_2.
    - Measure the balloon using a string and rule.
- Exemplar procedure for studying the effect of acidification:
    - Fill two Erlenmeyer flasks with water.
    - Add five drops of bromothymol blue to each flask.
    - Drop an antacid tablet into one flask and cap it with plastic wrap.
    - Observe the color change in the water.

[**Tip:** Have scholars complete multiple trials using different amounts of antacid tablets.]

- As scholars are working, circulate and press scholars to describe how their experimental setup will help answer their testable question. Ask:
    - What does each part of your experiment represent?
    - What do your results tell you about the impact of climate change on oceans?

Discourse Debrief experiment/activity:

- Have scholars share out the results of their experiments.
    - Ask: What happens to the ocean when there is a high amount of CO_2 in the atmosphere?
- Ask: What does the antacid tablet represent in this model?
- Ask: What is a limitation of the model you used in your experiment?
    - How might we alter this model to make it more representative of climate change?

Make connections to the Essential Question:

- Ask: If we do nothing about climate change:
    - How would an acidic ocean affect plant and animal life?
    - How would an acidic ocean affect our human life?

Make broader connections:

- Ask: What can we do to prevent the absorption of CO_2 into the ocean?
    - How will rising sea levels impact absorption of CO_2 into the ocean?
- As a group or as a class, look at the sea level predictions found at **Surging Seas Mapping Choices** by Climate Central.
    - Read **Sea Level Rise and Storm Surge Threats for New York** by Climate Central and discuss NYC's sea level rising plan.

Accountability (Classwork)

- Use a checklist during the activity and discourse to check in with scholars' ability to draw conclusions from analyzing data and make cause/effect connections involving systems.

Lesson 8: What Will Happen to Human Lives?

Lesson Objective: Scholars understand that climate change has many impacts on Earth, many of which will significantly change human lifestyle. Materials Needed

- For each pair: **Climate Change Eyewitness Accounts** by World Wide Fund for Nature
- For each scholar: computer

Prep

- Intellectual Prep:
    - Review **Climate Change Eyewitness Accounts** by World Wide Fund for Nature.
- Materials Prep:

Prepare a map to be used during the activity that depicts how the impacts in one location affect other areas.

- Determine if you would like to offer one to two websites that scholars will use for their in-class research. If so, send the links to scholars in advance of class.

What are scholars doing in this lesson?

- Scholars investigate how climate change will impact humans in six regions of the world by reading and analyzing eyewitness accounts from different people.

Do Now

- Follow the **Do Now plan**.

Launch

- Will all humans on Earth be impacted by climate change in the same way?
    - Have scholars share out some predictions on how humans in different parts of the world may be affected.

Activity Adapted from Climate Change Eyewitness Accounts by **World Wide Fund For Nature**

- Divide the class into pairs and give each pair a **Climate Change Eyewitness Account**.
    - Pairs should look up the location of their account, read the scenario, and answer the following questions in their notes:
        - How would you describe the environment of your location?
        - What plants and animals are affected in your region? How are they affected?
        - How has climate change impacted the way humans interact with the environment?
        - What steps is your eyewitness trying to take to mitigate climate change?
- Each pair shares out key points for about 1–2 minutes, starting with Pohnpei.
    - While scholars share out, display a map connecting the locales, depicting how the impacts in one location affect other areas.

- As scholars are working, circulate and press scholars to make connections between the activity and the previous lessons of climate change impact on land, oceans, and weather. Ask:
    - Why is their environment being impacted this way by climate change?
    - Are there other ways your eyewitness can reduce the impact of climate change in their location?

Discourse Debrief experiment/activity:

- Ask: What is the diagram on the board showing about climate change?
- Ask: Which impacts on the environment are felt seriously in other regions?
- Ask: What positive impacts could climate change bring?
- Ask: Are there factors other than climate change that could have impacted the environment described?
    - What actions are people taking to reduce the impact of climate change?

Make connections to the Essential Question:

- Ask scholars to respond to the Essential Question using strong evidence presented from all Explain lessons.

Accountability (Exit Ticket) A change in climate has many potential effects for Earth. Three effects are identified in the “Climate Change Effect” column of the table below.

1. Complete the chart below by filling in at least one answer per box. [3]

Climate Change Effect	Resulting Impact
Warmer oceans	**Weather:** An increase of extreme weather like hurricanes, especially the intensity of hurricanes.
Ocean acidification	**Oceans:** An increase in the acidity of the water, providing a toxic environment for ocean plants and animals.
Rising sea levels	**Land:** Coastal cities will be covered in water as the sea level rises over the land next to oceans.

2. Choose one answer above and describe how this impacts human interaction with the environment. [1]

With more extreme weather, humans might experience more damage to buildings and their homes, making it difficult to survive.

If the ocean cannot support animal or plant life, humans who depend on the ocean for resources will have less food to eat.

If water covers coastal cities, many humans will need to move inland to avoid flooding, which might create overcrowding.

Scoring

1. Award one point for each resulting impact due to climate change (up to three points).
2. Award one point for describing an accurate and logical effect on human life.

Lesson 9: Green Energy

Lesson Objective: Scholars understand that most energy can be derived naturally and that there are advantages and disadvantages of using nonrenewable or renewable energy sources. Examining energy sources can provide possible solutions to the impact of climate change.
Materials Needed

- For each group: chart paper, markers
- For each scholar: computer

Prep

- Intellectual Prep:
    - Review **Renewable Energy Explained** by U.S. Energy Information Administration.
    - Review the **Carbon Footprint website home page** and consider sharing with your class.

What are scholars doing in this lesson?

- Scholars research different forms of energy to create short presentations on their advantages and disadvantages.

Do Now

- Follow the **Do Now plan**.

Launch

- Ask scholars how much energy they think they use every day, and where all that energy comes from.
    - Give scholars time to brainstorm and provide some examples of energy use they may not be thinking about.
    - Ask:
        - Is some of your energy use harming the planet in some way?
        - Is some of it “neutral”? Have you ever heard of “green” energy? What is it?
        - How does using energy benefit you?

- Ask:
    - What other types of energy should be considered outside of fossil fuels?
        - Define **nuclear energy**, **hydropower**, and **solar energy** as some examples.
    - What factors must be addressed when considering solutions that impact society?

Activity

- Divide the class into groups and assign one energy type to each group:
    - Geothermal
    - Hydropower
    - Solar
    - Wind
    - Coal
    - Natural gas
    - Nuclear
- Scholars research their assigned energy type online and prepare a 2-minute presentation for the class.
    - The presentation should consider the economic, social, and environmental impacts of using that energy source, both positive and negative.
- When scholars are finished with their work, bring them back together and allow groups to present their information.
    - While one group presents, the rest of the class should take notes on the other types of energy they did not read about.

Discourse Debrief experiment/activity:

- Ask: Which sources could be considered better for the planet? Why?
    - Define **renewable energy**. As a class, determine which energy sources studied are “green” (renewable) vs. **nonrenewable**.
- Ask: Why are fossil fuels used so widely globally?
    - How are fossil fuels dangerous?
        - Define **fracking**.

Make connections to the Essential Question:

- Ask: What will happen if we continue to use fossil fuels as our main energy source?

Make broader connections:

- Ask: Why do we not always use the greenest energy sources?
- Ask: How might energy consumption change based on where you live?
- Ask: How could you encourage others in our community to reduce their carbon footprints?
    - Why might it be hard to convince people to reduce their emissions?

Accountability (Exit Ticket) Directions: Read the information on **Tidal Energy** by National Geographic and answer the questions that follow.

1. Identify two advantages and two disadvantages of using tidal energy. [4]

Advantages of Using Tidal Energy	Disadvantages of Using Tidal Energy
1. Tides are predictable, so energy production will be consistent. 2. Some turbine blades turn slowly so animals will not likely get caught.	1. The change in water level might harm marine plant and animal life. 2. It might change the salinity of the lagoon which can affect the organisms that live there.

2. Tidal energy can be classified as a _____ energy source. Circle the correct response below. [1]

renewable **nonrenewable**

Scoring

1. Award one point for each scientifically accurate and logical advantage and disadvantage listed (up to four points)
2. Award one point for circling “renewable”

Lesson 10: Lifestyle Changes

Lesson Objective: Scholars can explain how carbon emissions and contribution to climate change vary based on lifestyle. They understand how simple changes to a person’s lifestyle can significantly reduce the amount of carbon emitted into the atmosphere each year. Materials Needed

- For each scholar: computer, **Environmental Impact Sheet (page 64)** by The NEED Project, calculator

What are scholars doing in this lesson?

- Scholars calculate their carbon footprint.

Do Now

- Follow the **Do Now plan**.

Launch

- Ask: How much energy do you use every day?
    - Ask: Does your energy use contribute to climate change?
        - Introduce the concept of a **carbon footprint**.
    - Ask: If you could not change to a renewable energy source, what else could you do to **conserve** energy?

Activity

- Scholars identify the five machines or appliances they use that use the most electricity, such as computer/phone charger, game console, TV, computer, fridge, air conditioner, microwave, lamp, oven, etc.
    - Scholars do research to find the wattage of their devices and record it on their **Environmental Impact Sheet (page 64)** by The NEED Project.
    - Scholars estimate how many hours per year they use each device.
    - Scholars calculate the CO_2/year they release based on these appliances.
    - Have scholars use a carbon footprint calculator to estimate total energy consumption based on their lifestyle.
- As scholars are working, circulate and press scholars to evaluate the small changes they and others could make to reduce their carbon footprint. Ask:
    - Could you reduce your use of this appliance to reduce your carbon footprint? How?
    - How could you convince others to change their lifestyle to reduce their carbon footprint?

Discourse Debrief experiment/activity:

- Have scholars share their calculated carbon footprints. Ask:
    - What was the largest contributor to your carbon footprint?
        - Was this surprising?
- Ask: How can you reduce your carbon output?
- Ask: How could you encourage others in our community to reduce their carbon footprints?
    - Why might it be hard to convince people to reduce their emissions?
- Ask: What other strategies could we use to get people to reduce their electricity consumption?

Make broader connections:

- Ask: How might energy consumption change based on where you live?

Accountability (Exit Ticket)

1. Identify three ways that the average person could reduce their carbon emissions. [3]

Possible Exemplars:

Turn off TV when no one is watching it.

Turn down the heat when not at home.

Turn off appliances when not being used (keep fridge closed, close dishwasher, turn off radio).

Switch to energy-efficient appliances.

Install solar panels.

Scoring

1. Award one point for each scientifically accurate and logical strategy (up to three points).

Lesson 11: Responding to Skeptics

Lesson Objective: Scholars can make a strong argument for climate change that is supported by facts and outside resources that explain the phenomena and its impact. Scholars understand that effective communication about climate science can help protect Earth's resources and environment. Materials Needed

- For the teacher: Twitter account or Google Doc substitute, tweets and quotes about climate change

Prep

- Materials Prep:
    - Set up a Google Doc for the class to input their tweets (share out via email) or set up a class Twitter account, if desired
    - Find a variety of quotes and tweets from various public figures that address climate change. Look for differing viewpoints and include quotes that are not supported by scientific evidence.

[**Modification Tip:** Use live tweets through Twitter search or through an app such as **Twitterfall**. Reply to these tweets using your class Twitter account or have scholars create their own fake tweets using a **Twitter Generator Website**.]

What are scholars doing in this lesson?

- Scholars respond to a variety of statements made by public figures about climate change. Scholars apply their understanding from the unit to respectfully refute and disprove unsubstantiated claims.

Do Now

- Follow the **Do Now plan**.

Launch

- Explain that as technology's reach expands, one of the most common places to find the climate debate raging is on social media. Despite climate change being widely accepted in the scientific community, people are still arguing based on vested interests and ignorance or distortion of the facts. Ask:
    - How would you respond to someone who argued that climate change isn't real?

Activity

- Scholars are given tweets and quotes and work with a partner to compose responses in the form of tweets (Twitter posts).
    - Tweets may support or refute each original statement.
    - Each tweet must include at least one piece of reputable outside information (such as a link to a relevant picture, website, or data point).
- Scholars submit their tweets on a Google Doc or Google Form.
    - Teachers choose the strongest, most persuasive tweets to post on a class Twitter page.
- As scholars are working, circulate and press scholars to be concise and accurate in their responses. Ask:
    - What is one powerful piece of evidence you could use to respond to this tweet?

Discourse Debrief experiment/activity:

- Have scholars share their tweets with the class. Focus primarily on the statements scholars disagreed with or deemed inaccurate. Ask:
    - Where is the misunderstanding in the original comment?
    - What information do they need in order to revise their thinking?
    - What makes the source you are using persuasive? How do you know it is reliable?

Make broader connections:

- Ask: Why is social media a good outlet for responding to climate change skeptics?
    - What other types of social media could be used to respond to climate change?

Accountability (Exit Ticket)

1. Compose an answer to the Essential Question: What will happen to the Earth if we do nothing about climate change? Include at least three pieces of evidence and reasoning to support your response. [5]

Earth will be significantly impacted by climate change if we do nothing about it: The impact on oceans, weather, and land will risk the ability for humans, animals, and plants to survive. When humans burn fossil fuels, there is an increase in greenhouse gases in the atmosphere, which allows more sunlight to be trapped that warms the planet. As Earth's temperature rises, the ocean temperature will rise creating risk for coastal land, ocean acidification, and frequency of extreme weather.

When temperature and ocean temperature rises, the polar ice caps and glaciers will melt and increase the overall amount of water, increasing the sea level. Many coastal cities on sea level will become flooded and unavailable for people to live in. Additionally, when the ocean temperature rises, it increases its ability to function as a carbon sink. With more carbon in the ocean, it becomes more acidic, posing risks to the animals and plant life living there. Furthermore, higher oceanic temperatures will increase the ability for hurricanes to form due to increased evaporation of seawater.

Humans will have difficulty finding resources like food and shelter as these effects of climate change begin to impact their daily lives. If we do not do anything about climate change, we risk seriously impacting our lifestyle and ability to survive on Earth.

Scoring

1. Award points as follows:

    - One point for a claim that identifies a scientifically accurate reason for what will happen to Earth if nothing is done about climate change
    - One point for evidence that supports the claim and explains how climate change occurs and/or its impacts (up to three points)
    - One point for a concluding sentence or paragraph that summarizes their explanation

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Unit Vocabulary

Vocabulary List

- **climate change**
- **global warming**
- **bias**
- **propaganda**
- **greenhouse effect**
- **atmosphere**
- **greenhouse gas**
- **climate variation**
- **carbon sink**
- **fossil fuels**
- **industrial revolution**

- **carbon emissions**
- **absorption**
- **ocean acidification**
- **pH**
- **sea level**
- **glacier**
- **nuclear energy**
- **hydropower**
- **renewable energy**
- **nonrenewable energy**
- **solar energy**
- **fracking**
- **carbon footprint**
- **conservation**