Lesson 7: How do cars impact CO_2 in the atmosphere?

MS Climate Change Unit

Previous Lesson….Where we've been: We know human activities that burn fossil fuels release greenhouse gases, like CO_2, and that greenhouse gases warm Earth's temperature.

T	**This Lesson….What we are doing now:** This lesson explores how cars impact CO_2 in the atmosphere.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), *New Questions* and **Next Steps**
L7: How do cars impact CO_2 in the atmosphere? (1.5 periods) S *Building toward* ↓ *NGSS PEs: MS-ESS3-4*	Watch air pollution travel across the planet in real time The Internal Combustion Engine video A Year in the Life of Earth's CO2 World Annual Car Production 2004 - 2014 data table World Car Production 1898 - 2007 Greenhouse Gas Levels in the Atmosphere Fast Facts on Transportation Greenhouse Gas Emissions Carbon Dioxide Emissions from Burning of Fossil Fuels	**Analyze and interpret data…** by constructing, analyzing, and interpreting graphical displays of data showing changes in the numbers of cars and CO2 in the atmosphere over time to identify linear and nonlinear relationships.	We know cars are one of the things that burns fossil fuels in order to run, and one product of this is CO_2, which is one of the "greenhouse gases". We reason that the more cars there are, the more there is likely to be CO_2 in the atmosphere. We want to find out the basics about how cars produce CO_2 and what happens to it once it leaves the car. We can use that information to understand how cars could cause an increase in CO_2 in the atmosphere. We've figure out: • Almost all motor vehicles (cars, trucks, planes, trains, etc.) we've driven the past hundred years rely on fuels that contains carbon and hydrogen that make combustion engines run. • The fuels come from underground and are from the ancient remains of organisms whose bodies contained carbon, which is why they are called fossil fuels. • When we drive, fuel gets burned up and CO_2 is released into the atmosphere along with other emissions. • The CO_2 that is produced stays in the atmosphere and can trap heat. *We wonder whether an increase in fossil fuels used by cars around the world could be contributing more CO_2 in the atmosphere.* **First, we decide to look at data on the amount of cars on the road from around 1900, when car production started, to the present day.** We don't know how many cars there are on the road, and whether that's increased over time. We look at recent data and it looks like it's increasing, but we can't tell how fast. We plot the data and then compare our graph to past data and we can see that car production has increased a lot since 1900. **Next, we decide to compare the number of cars with the amount of CO_2 emissions in the atmosphere.** We analyze a graph on greenhouse gas levels over the past 2000 years and we see they are increasing, including CO_2. We notice that the pattern in this graph is similar to the pattern of the increase in the number of cars. It is also similar to the pattern of the graph we saw earlier about Earth's temperature—a recent fast and big increase! We have a Building Understandings discussion as a class to clarify what we've figure out. We figure out that: • The number of vehicles, which burn fossil fuels, and the amount of CO_2 in the atmosphere have a similar

			pattern and are both increasing a lot and at a fast rate. • The US, China, and India are among the highest emitters of CO_2. • In the US, transportation is one of the highest sources of greenhouse gas emissions and passenger vehicles release the highest amounts. *We are wondering:* • *Is there a causal relationship between the CO_2 and temperature?* • *We still want to have a real-world experience that shows that increasing CO_2 increases temperature compared to room air.* **We decide that we need to do an investigation to get concrete experience that CO_2 traps heat and increases temperature.**

Next Lesson….Where we're going: We want to explore how more CO_2 in the atmosphere causes global warming.

Getting Ready: Materials Preparation

Materials For Each Group

- Data Sheet (color, 1 per 2 students-class copy)

Preparation of Materials (15 min.)

- Data Sheet (color, 1 per 2 students-class copies)
- Print Student Activity Sheet (1 per student)
- Review and bookmark on teacher computer/smartboard to show as a class:
  - The Internal Combustion Engine video: https://www.youtube.com/watch?v=5tN6eynMMNw
  - Online simulation: A Year in the Life of Earth's CO2
  - Watch air pollution travel across the world in real time: http://www.sciencemag.org/news/2016/11/watch-air-pollution-flow-across-planet-real-time

Materials For Each Student

- Student Activity Sheet (1 per student)

Safety

- N/A

Getting Ready: Teacher Preparation

Background Knowledge

Stated in Lesson 6, students will most likely already be familiar with the terms climate change, global warming, and greenhouse gases. However, they have not made a concrete connection between global temperature and the increase of CO_2, due to an increase in cars on the road.

Alternative Student Conceptions

Students may think that CO_2 diffuses from the car into the air and disappears. They do not think that a gas like CO_2 will travel to the upper atmosphere and have an effect on the temperature of the Earth.

Linking Our Understanding to Scientific Terminology

- Combustion
- Emissions

Learning Plan: How do cars impact CO_2 in the atmosphere? (65 min)

1. (5 min) Begin with 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 do we now understand from yesterday's lesson?
- ➔ We had some ideas about how to investigate our questions. What were our ideas?

Listen for *student responses* [2] that refer to what we figured out last time, such as:

- ➔ *The greenhouse effect works by greenhouse gases, like CO_2, absorbing heat. If humans release more CO_2 into the atmosphere then it will absorb more heat and increase temperatures on Earth.*
- ➔ *We figured out that fossil fuels are part of the Carbon Cycle, which moves carbon.*
- ➔ *The waste product of burning fossil fuels is CO_2.*
- ➔ *All of the graphs showing human activity from the start of the Industrial Revolution match rate of change in the global warming chart.*

2. (5 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. Remind students that CO_2 released into the atmosphere travels around the world by showing the real-world visualization:
"Air pollution travel across the planet in real time":
http://www.sciencemag.org/news/2016/11/watch-air-pollution-flow-across-planet-real-time

After discussing the observed patterns of where and how much pollution is currently circulating the globe, ask students what we should figure out about cars and carbon dioxide air pollution.

Suggested Prompts:

- ➔ What do you think we could/should do to help us decide whether the burning of fossil fuel is contributing to more CO_2?
- ➔ What kind of data will we need?

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

- ➔ *We will need to know if more cars are driving on the road.*
- ➔ *We could find out the amount of CO_2 given off from different countries.*
- ➔ *We could find out if the CO_2 level in the atmosphere has risen over time.*

Teacher Supports & Notes

Strategies for this Consensus Building Discussion

1: The goal of this discussion is to put students in the driver's seat. Use the prompts to help students recall and restate what we as a class figured out in the last lesson. Their ideas should motivate what we are going to need to do next, in this lesson.

Strategies for this Initial Ideas Discussion

2: In this discussion, students should lay out the path for the activities they will engage in today. Use the prompts to ensure that students do the heavy lifting to generate ideas.

Differentiation Strategies and Alternate Activities

3: Students may continue to struggle with words to describe a pattern or trend in the graph. You may need to give more specific prompts or sentence stems.

3. (10 min) Now that students have moved to greenhouse gases (GHGs), they need to connect a real-life example of how human activities that burn fossil fuels, like driving cars, release GHGs into the atmosphere.
(1 to 2 min,) Ask students for an example of a human activity in their everyday life that releases greenhouse gases, especially CO_2.

Suggested Prompts for group discussion:
- ➔ How did you get to school today?
- ➔ Did anyone take a car or bus to get to school?

Suggested Prompts before the video:
- ➔ Where does a car get its energy?
- ➔ What comes out in car exhaust after it burns fuel?
- ➔ What is the source of that product?

Watch a video "Science please: The internal combustion engine" about how CO_2 is produced from cars. Give prompts first:
https://www.youtube.com/watch?v=5tN6eynMMNw

After watching the video, students will collaborate in groups and share with the class.[4]

Suggested Prompts after the video:
- ➔ What comes out in car exhaust after it burns fuel?
- ➔ What is the source of that product?

Listen for *student responses* such as:
- ➔ *Cars take in fossil fuel, release energy, and produce CO_2.*
- ➔ *Cars take in gasoline and produce CO_2 after burning it.*

4. (15 min) Now provide each student with a copy of the Student Activity Sheet and a copy of the Data Sheet for each pair of students:

Ask students what they notice about the "World Annual Car Production" data table and if they can see a pattern in the data. Remind students that scientists build graphs from collected data so that they can observe patterns and trends. Ask students to make a graph using the data table information (Fig. 7.1) on their Student Activity Sheet.[5]

5. (5 min) Once students have created their graph, have them look for patterns and/or trends in their graph and compare their graph to the "World Car Production 1898-2007" graph (Fig. 7.2). Students should record their observations on their Student Activity Sheet.

Suggested Prompts:
- ➔ What pattern or trend do you observe in the graph?
- ➔ What do you notice about the trend as time passes?

Additional Guidance

4: You could also show students the A global simulation of CO2 in the atmosphere (throughout one year). This may support the map and stimulate questions about wind currents and the change of CO_2 in the atmosphere in the summer compared to the winter.

Additional resources:
World Passes 400 PPM Threshold Permanently graph and global flow of CO2 visualization

Listen for *student responses*, such as
- ➔ *The slope of the line is steeper as time goes on.*
- ➔ *The number of cars produced in the world is increasing.*
- ➔ *The number of cars has increased faster in the last 20 years than the previous 80 years before then.*

6. (5 min) Students then compare the graphs of car production in the world with the "Greenhouse Gas Levels in the Atmosphere" graph (Fig. 7.3). Students record their responses on their Student Activity Sheet.

Suggested Prompts:
- ➔ Do you see any patterns in each of the graphs or not?
- ➔ How do the two graphs compare?
- ➔ How do the trends of each graph compare to each other?

Listen for *student responses* such as:
- ➔ *The two graphs each show an increasing trend.*
- ➔ *Both graphs increase around the same time and in a similar pattern (early 1900s to recent times)*

7. (5 min) After students have shared, connecting the two graphs, "What have we figured out so far?"

Suggested Prompts:
- ➔ At this point, what new information and knowledge have we gained about the number of cars and the amount of CO_2 in the atmosphere?
- ➔ Where do you think all these cars are in the world?
- ➔ How do the number of cars connect to the CO_2 level in the atmosphere?

Listen for *student responses* such as:
- ➔ *We know that cars and CO_2 have both increased a lot, especially in the last 100 years.*
- ➔ *Is the number of cars in other countries similar to the U.S.?*

Record and post what we figured and what we are wondering: Examples:
- The number of cars is increasing.
- The CO_2 in the atmosphere is increasing.
- The rate of car production in the world follows a similar trend to the rate of CO_2 concentration in the atmosphere.

Additional Guidance

5: If students struggle to change the text into a graph, students may need to build a quick data table before building the graph.

8. (10 min) Ask students to analyze the "1 Billion Cars in Operation" (Fig. 7.4), "Transportation GHG Emissions in the U.S." (Fig. 7.5) and "CO_2 Emissions from Burning Fossil Fuels" (Fig. 7.6).
Ask students what patterns they observe in the data. Students record observations on their Student Activity Sheet.

Suggested Prompts:

- ➔ After comparing Figures 7.4, 7.5, 7.6, what patterns, if any, do you observe in the data?
- ➔ Do you see a connection between the location of cars in the world and the highest CO_2 emissions in the world? Explain.
- ➔ What do you note about transportation in the U.S. and GHG emissions?

Listen for *student responses* such as:

- ➔ *We see that the location of the cars in the world match the locations of the greatest CO_2 emissions in the world.*
- ➔ *Almost all of the countries with the greatest number of cars has the highest emissions of CO_2.*
- ➔ *In the U.S., transportation is one of the top GHG emitters, which comes mainly from cars and trucks.*

9. (5 min) Before dismissing students, ask them to brainstorm what our next steps should be in our investigations.[6]

Suggested Prompts:

- ➔ What should we make sure to do in our next science class?
- ➔ What do we need to investigate next time we meet?
- ➔ How can we connect our new knowledge to answering our big question?

Listen for *student responses* such as:

- ➔ *We now want to know if we can demonstrate that more CO_2 in the air raises its temperature.*
- ➔ *Is there a way to show that more CO_2 makes the atmosphere temperature higher?*

Formative Assessment Opportunities

6: Ask students to complete the last question on their activity page - what they think we should do in the next lesson.

Alignment With Standards

Building Toward Target NGSS PE

- **MS-ESS3-4:** Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

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-ESS3-4)
WHST.6-8.1: Write arguments focused on discipline content. (MS-ESS3-4)
WHST.6-8.9: Draw evidence from informational texts to support analysis, reflection, and research. (MS-ESS3-4)

Mathematics -
6.RP.A.1: Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-ESS3-4)*
7.RP.A.2: Recognize and represent proportional relationships between quantities. *(MS-ESS3-4)*
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-ESS3-4)*
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-ESS3-4)*