Lesson Plan: Is it Hot in Here?
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Target Grade: 6th

Teacher Prep Time: 1 hour 10 minutes (This accounts for 1 hour to create the simulation cards, but this only needs to be done once)

Lesson Time: 4 hours 20 minutes (we recommend doing this lesson over four days, however Parts 1 and 2 or Parts 3 and 4 can be completed back-to-back)

- Part 1:
  - 20 min – (a) Beginning Thoughts
  - 30 min – (b) CO_2 Simulation
- Part 2:
  - 40 min – (a) Analyzing CO_2 Levels
  - 30 min – (b) Factors Influencing CO_2 Levels
- Part 3:
  - 70 min –Sources and Carbon Neutral Processes
- Part 4:
  - 60 min – (a) Presentations
  - 10 min – (b) Reflection Questions

Lesson Overview: In this lesson, students will analyze a simulation used to visualize how and when carbon dioxide (CO_2) traps heat in the atmosphere. Using data from a graph as well as the simulation, they will understand that CO_2 levels in the atmosphere have been rising, causing the global temperature to increase. In groups, students will analyze one of seven different CO_2 factors to determine if their factor is a CO_2 source or carbon neutral. They will then give their classmates an informal presentation describing the carbon flow within their factor (including light and heat energy interactions), how their factor influences global CO_2 levels, and (if their factor is a source) how to reduce CO_2 emissions.

Learning Objectives:

- Students will be able to describe how light/heat energy interacts with atmospheric CO_2 and how this affects global temperatures.
- Students will explore one factor (electricity, transportation, respiration, photosynthesis, deforestation, fires, or cement production) and be able to analyze a graph to determine how humans have affected this factor and how it influences atmospheric CO_2 levels.
- Students will be able to explain their factor to the rest of the class using appropriate vocabulary.
- Students will understand that CO_2 production in one area will have global effects.

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

- **Science and Engineering Practice**
  - #4 Analyzing and Interpreting Data

        - Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
            - Analyze and interpret data to determine patterns and relationships.
            - Distinguish between causal and correlational relationships in data.
- **Disciplinary Core Idea**
    - ESS3.D Global Climate Change
        - Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.
- **Crosscutting Concept**
    - #5 Energy and Matter
        - In grades 6-8, students learn matter is conserved because atoms are conserved in physical and chemical processes. They also learn within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.
- **Environmental Principal and Concept**
    - #4 There are no Permanent or Impermeable Boundaries that Prevent Matter from Flowing Between Systems
        - The exchange of matter between natural systems and human societies affects the long-term functioning of both.
            - **Concept A.** The effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of the resulting byproducts.
            - **Concept B.** The byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect.
            - **Concept C.** The capacity of natural systems to adjust to human-caused alterations depends on the nature of the system as well as the scope, scale, and duration of the activity and the nature of its byproducts.

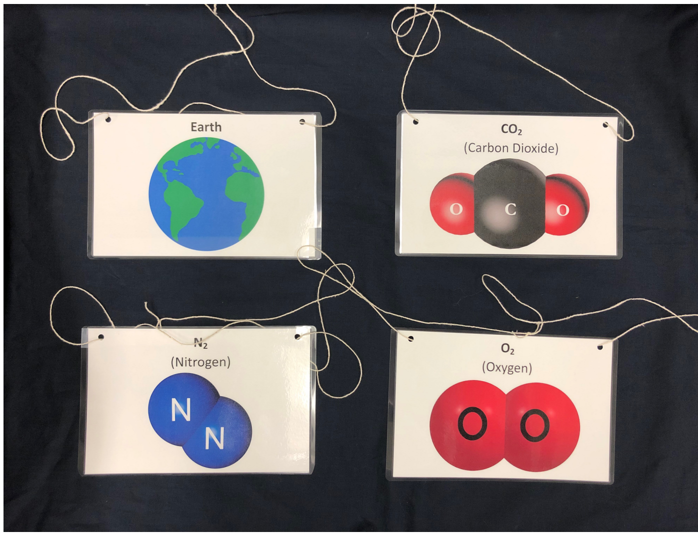
Where This Lesson Fits in: This lesson should be done after discussing the difference between weather and climate, and at the start of the unit on climate change. For this lesson, students are expected to know that energy and matter cannot be created or destroyed (review of 5-PS1-2). In addition, students should know that during respiration, animals breathe in O_2 and give off CO_2, and during photosynthesis, plants take in CO_2 and give off O_2 (review of 5-PS3-1). Lastly, they should also understand that energy can be transferred from one form to another, specifically light energy to heat energy (review of 4-PS3-2).

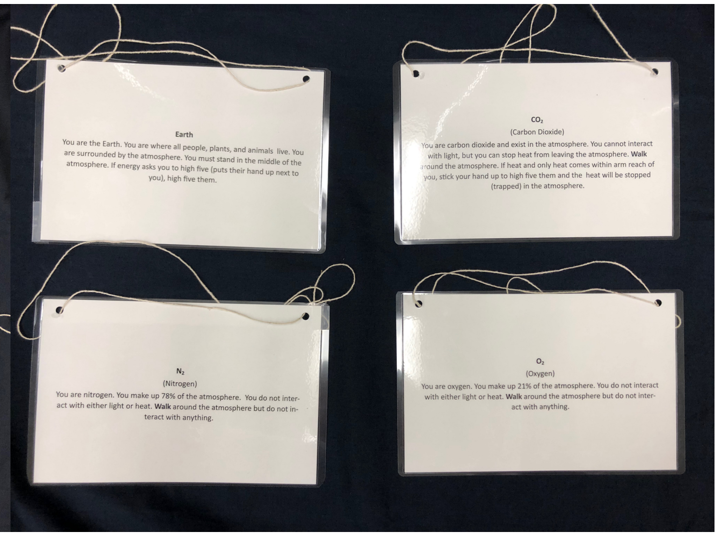
Materials Needed: (Students will do the initial activity as a class and then will be split into 7 equal groups for Parts 3 and 4.)

- There are two options for creating the "atmosphere": a chalk circle or a yarn circle

- For the chalk circle you, will need:
    - Meter measuring tape (at least 11 m long)
    - Chalk
- For the yarn circle, you will need:
    - ~34.5 m of yarn (any type) tied together to create a circle ~11 m in diameter

- Set of CO_2 simulation necklaces with instructions:
    - One Earth, two O_2, two N_2, six CO_2, eight light/heat energy, and twenty blank laminated cards (8.5 in × 5.5 in), hole punched and tied with string.
        - Quarter page (4.25 in × 2.75 in) cards can be used, but the larger size is recommended to make them easier to see.
        - Light/heat energy necklaces are reversible. They are folded in half, stuck together with tape to create a pocket, and the instructions are placed in the inside pocket.
        - The blank cards are not used for the initial simulation, they will be used when students act out their factor


Earth
CO_2
(Carbon Dioxide)
O C O
N_2
(Nitrogen)
N N
O_2
(Oxygen)
O O



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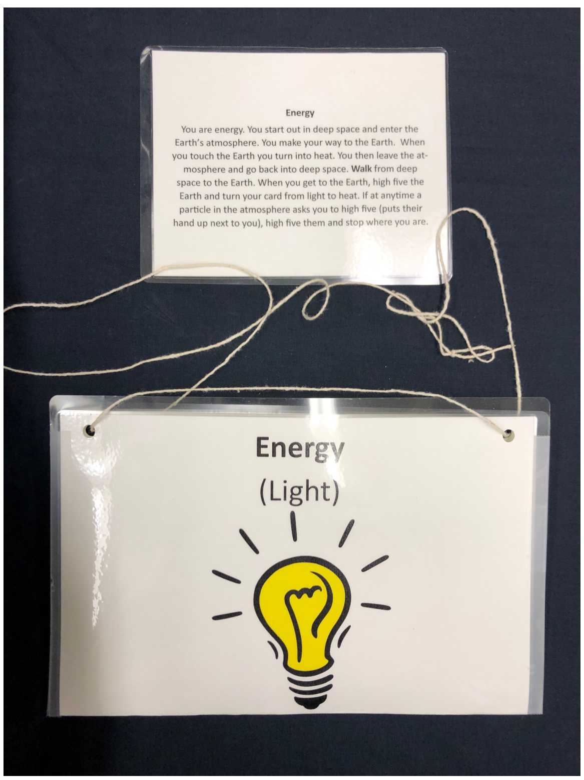
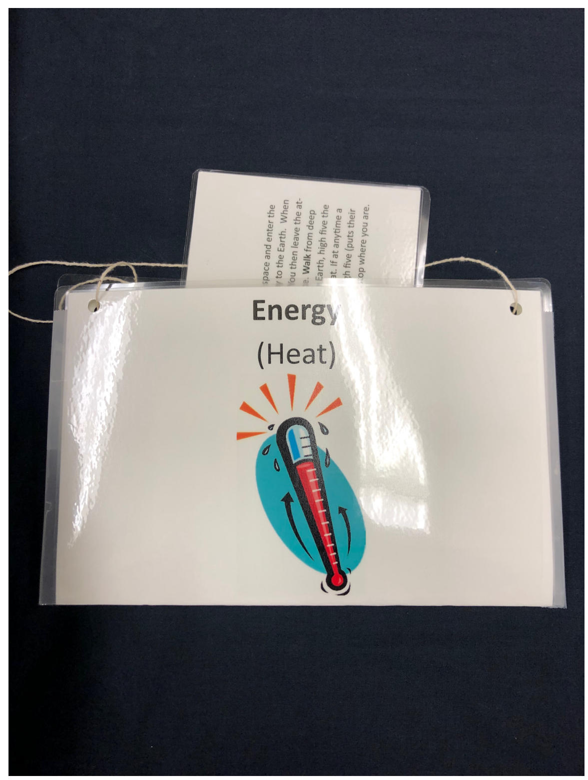
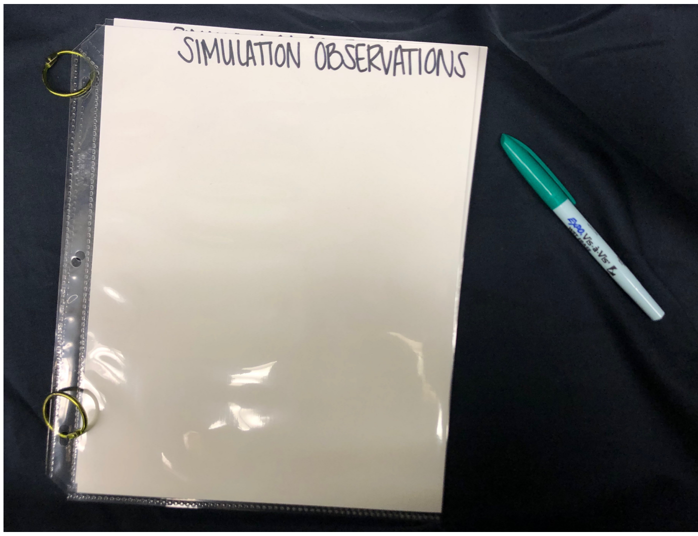
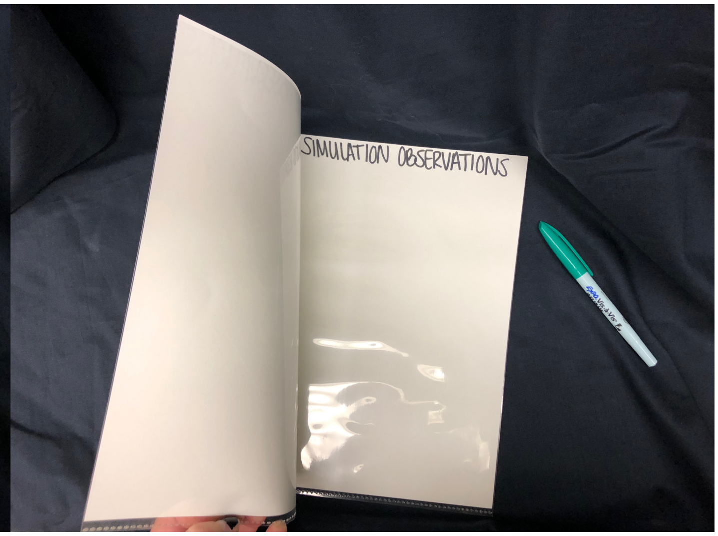

Energy
You are energy. You start out in deep space and enter the Earth's atmosphere. You make your way to the Earth. When you touch the Earth you turn into heat. You then leave the atmosphere and go back into deep space. Walk from deep space to the Earth. When you get to the Earth, high five the Earth and turn your card from light to heat. If at anytime a particle in the atmosphere asks you to high five (puts their hand up next to you), high five them and stop where you are.
Energy
(Light)

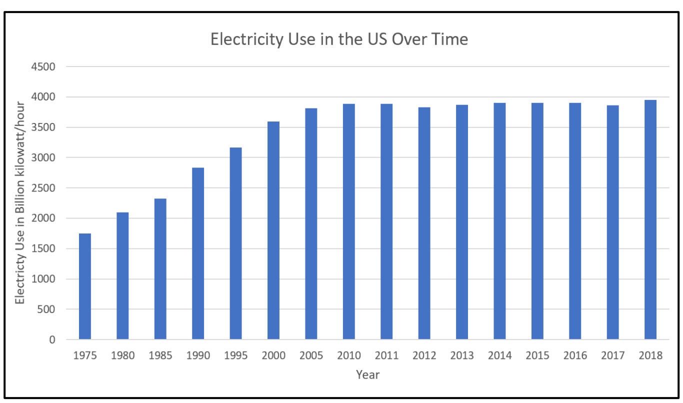

Energy
(Heat)

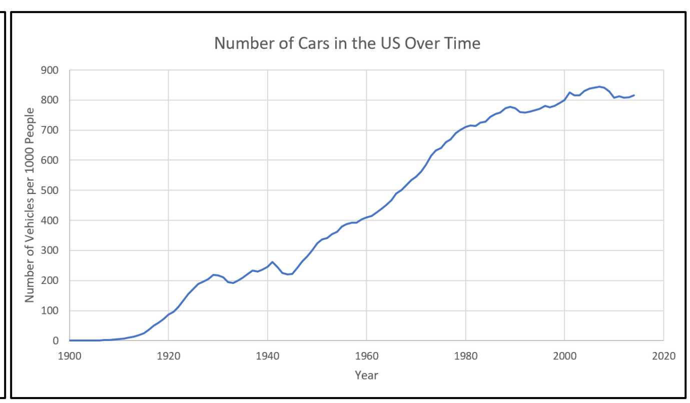
- Wet erase markers. (2 per group)
    - Used for writing on the blank cards
- 3 cardstock sheets the teacher will use for recording student observations about the simulation.
    - These aren't absolutely necessary. We recommend using something like the picture below (cardstock in sheet protectors held together with binder rings to create a notebook), so it can be saved and reused, but any paper will work.

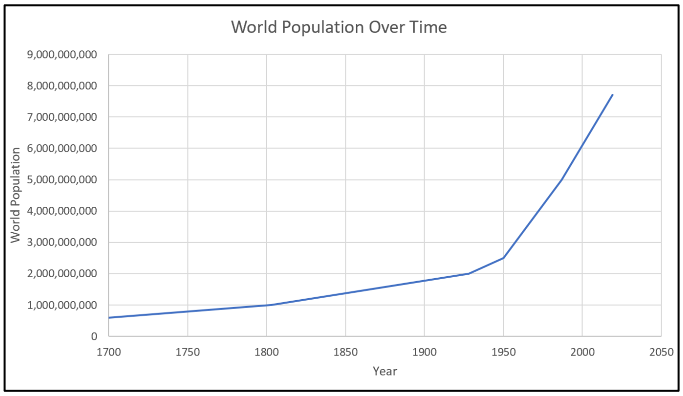


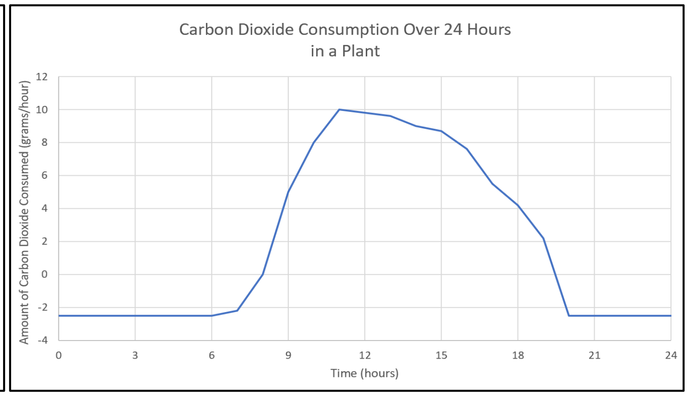


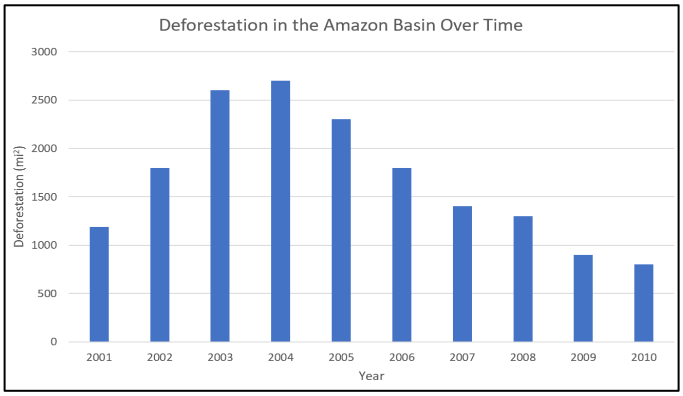
- Student worksheet (1 per student)
- Factor graphs and readings (one per student per each group)
    - Students will receive a graph and a reading of only one of seven possible factors: electricity, transportation, respiration, photosynthesis, deforestation, fires, or cement production

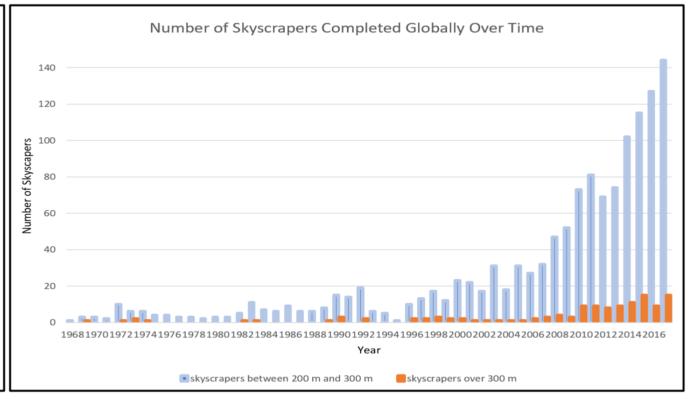


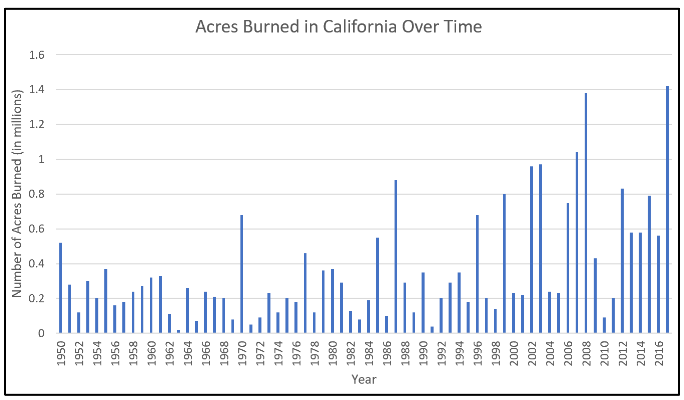










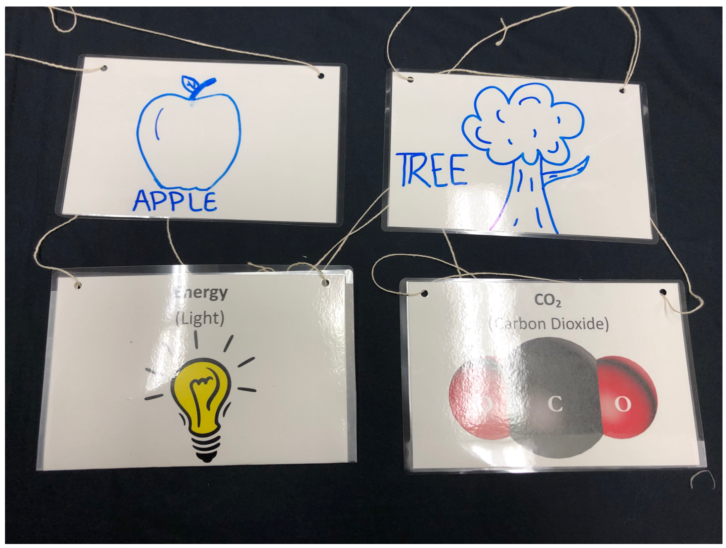


- PowerPoint with example graphs (parts 1 & 2) and picture of carbon flow (part 3)
- Document camera

Teacher Prep:

- Part 1 a: Beginning Thoughts
  - Have example notebook set up under document camera to provide example answers for students.
- Part 1 b: CO_2 Simulation
  - For chalk atmosphere, draw a circle on the playground blacktop ~11 m in diameter (~36 ft).
  - For yarn atmosphere, have yarn tied into a circle that is ~34.5 m in circumference (~113 ft = ~38 yards).
    - A circle that is any smaller than this will be too cramped for the students to walk around and observe anything about the simulation.

- Have Earth, molecules, and light/heat energy necklaces ready for the simulation.
  - You will only need two CO_2 molecule necklaces for the first simulation.
- Part 2a: Analyzing CO_2 Levels
  - If Part 1 and Part 2 are completed on different days, create another circle (either chalk or yarn) of the same size and using the same material from Part 1.
    - If Parts 1 and 2 are completed on the same day, you can use the same circle.
  - Have necklaces ready for the second run of the simulation.
    - This time you will need 6 CO_2 molecules.
- Part 2b: Factors Influencing CO_2 Levels
  - Have the PowerPoint with the following graphs ready: Atmospheric CO_2 Levels, Sea Height Variation, Monthly Mean Temperature Anomalies.
  - Have 7 sets of graphs ready to hand out to students.
- Part 3: Sources and Carbon Neutral Processes
  - Have PowerPoint with example carbon flow picture ready to show students.
  - Create a set of example cards for the apple tree carbon flow to act out for students.
    - 1 tree, 1 apple, 1 light/heat energy, 1 CO_2 molecule



  - Have 7 sets of readings ready to hand out to students.
  - Have the necklaces from the simulation available for the students to use.
  - Have the blank laminated cards and wet erase markers available for students to create factor-specific cards
- Part 4a: Presentations
  - Set out CO_2 simulation necklaces (including blank cards).
    - Have wet erase markers for students who were unable to create their cards during Part 3
- Part 4b: Reflection Questions
  - Have example notebook set up under document camera to provide example answers for students.

Lesson Sequence:

Part 1(a): 20 minutes	**Beginning Thoughts** 1. Tell students that you are about to begin a unit on climate change and in order to do that, there are a couple of concepts that they have previously learned that they should recall. 2. Remind students that they should have recently discussed the difference between weather and climate. Have them fill out an answer to question 1 in their notebook using their own words. 3. Have a few students share their ideas and discuss similarities between their descriptions. Try to lead students to understand that the main difference between the definitions of the two words is time. 4. Fill out the definition for each word in an example student notebook (questions 2 and 3) under the document camera. o **Weather**: Atmospheric conditions (heat, dryness, sun, rain, etc.) at a specific time and place. o **Climate**: Weather conditions in a certain area over a long period of time. 5. Read question 4 (Can energy be created or destroyed?) to the students and ask them to vote by raising their hands who thinks the answer is yes/no. o *Teacher note:* This lesson is not meant to teach that energy cannot be created or destroyed. This question is just a reminder for them of a key concept that they should already know. If you have not spent time on conservation of energy, students may answer "yes" (energy can be created or destroyed). In this case, reach out for an object near you. Ask them, "In order for this object to move, what will I have to do? Expected Student Response (ESR): Give it energy from my hand to move it. Where did I get my energy to move my hand? ESR: From the food I ate today. Where did the energy from my food come from?" Lead them to understand that this is a series of energy transfers rather than energy being created, and thus the answer to question 4 is "no." 6. Read question 5 (Can matter be created or destroyed?) to the students and have them vote on the yes/no answer. o *Teacher note*: Again, this lesson is not meant to teach that matter cannot be created or destroyed. If you have not spent time on conservation of mass, students may answer "yes" (matter can be created or destroyed). If this is the case, reach out for the same object and ask them how it was created. Leading them to understand that everything is made up of matter that is never created or destroyed, but just built upon each other or transferred between different forms. 7. Remind students that all living things are composed of primarily one type of atom, carbon. Have students help you fill in the blanks for question 6 by realizing that carbon atoms cannot be created or destroyed when they are transferring between organisms. o All living things contain **carbon** atoms, which are not **created** nor **destroyed** when they move from one organism to another. Instead, they are **transferred**.

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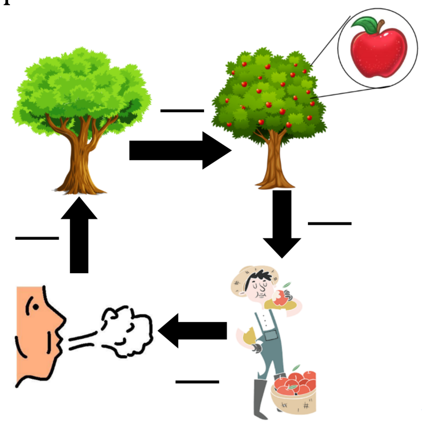
<tr><td></td><td>8. Show students the diagram on the bottom of page 1 and ask them what each of the pictures represents.

9. Remind students that all living things contain carbon atoms, and working individually, they are going to write out the steps for how carbon is transferring between the organisms in the diagram. Tell them that they can start at any arrow they'd like as long as they number them 1-4 on the blanks and write the corresponding step on the lines to the right of the diagram.
10. Walk around while students are filling out the blanks and pick up two examples that correctly show a carbon flow but start at two different points.
11. Place these examples under the document camera and have the class walk through the carbon flow with you and decide if each step is valid. Lead them to realize that the steps are the same, but since it is a cycle, they can start at any point.</td></tr>
<tr><td>Part 1(b): 30 min</td><td>CO_2 Simulation
1. Direct students' attention to the top of page 2 of their packet and tell them that one way that carbon exists in the atmosphere is in the form of CO_2. Tell them that we are going to run a simulation to learn how CO_2 behaves in the atmosphere.
2. Tell students that some of them will be playing a role in the simulation, and the others will need to watch carefully to make observations. Everyone will eventually get a chance to participate in the simulation.
o Tell the students that when you hand out the necklaces, there is a set of instructions either on the back of the necklace, or, for those playing the role of energy, inside the pocket of the necklace. They will need to read the instructions to themselves while you talk to the students making observations.
o Students should not share their instructions with anyone who does not have a matching necklace.
3. Distribute necklaces for the simulation (15 students total):
o Earth (1 necklace): Stands in the middle of the "atmosphere" and when asked by energy to high five, they must do so.
o O_2 molecule (2 necklaces): Wander throughout the atmosphere. Student should not interact with other students in the simulation, but also should not particularly avoid interactions either. Their motion is to be completely random.</td></tr>
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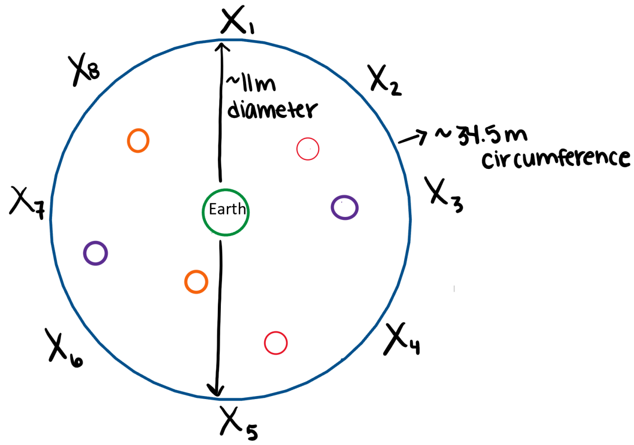
- N_2 molecule (2 necklaces): Wander throughout the atmosphere. Student should not interact with other students in the simulation, but also not particularly avoid interactions either. Their motion is to be completely random.
- CO_2 molecule (2 necklaces): Wander throughout the atmosphere. Student cannot interact with light energy, but when light energy becomes heat, their job is to stop it from leaving the atmosphere. If heat energy comes within arm's reach of a CO_2 molecule, they can reach their arm out to high five the heat. This will stop the heat energy in its place.
- Light/Heat energies (8 necklaces): Energy will start as light. Give each student playing energy a number (1-8) so they can enter the atmosphere when you call out their number. Each student playing energy will start outside the line of the atmosphere (in space) and make their way into the atmosphere and down to Earth. Upon reaching Earth, they will reach out their hand for a high five and flip their necklace from light to heat. Once becoming heat, they will attempt to exit the atmosphere. If at any time a particle reaches their hand out for a high five, they must high five them and stop in their place. They then will not interact with any other particles. If they successfully make it out of the atmosphere, they should take off their necklace and hand it to you. Each energy will only enter the atmosphere once per simulation run.

4. After distributing the necklaces to the students participating in the simulation, gather the remaining students around you. Tell them that each group of students has a different role. Write the roles on the board (O_2, N_2, CO_2, Energy(light/heat), and Earth) Their job will be to observe the simulation from space (outside the line of the atmosphere) and tell you what they observe.
5. Take 1 minute with each group (N_2 and O_2, CO_2, energy, and Earth) **separately** (except N_2 and O_2, they can be grouped together) to check that they understand their role and their actions before going outside. While you are talking to the groups, have the students in charge of making observations group together to discuss what they think is going to happen. They should also split up and assign themselves to a group (e.g. N_2, O_2, etc.) to carefully watch and determine that group's role.
6. Take your students outside to the area where you have set up the atmosphere. If you are making a yarn circle, have students grab the edges of the yarn, pull it out to a full circle, and set it on the ground. Make sure that you bring something to write down the students' observations.
   - We recommend a notebook of laminated sheets that can be reused (see the materials list for an example).
7. Tell students that you will run the full simulation <u>at least</u> two times to give them enough time to discover each student's purpose in the simulation.
8. Have each group set up for start of the simulation in the locations shown in the picture below.

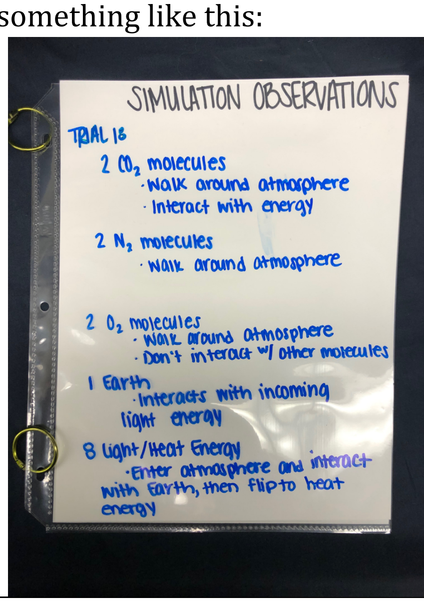


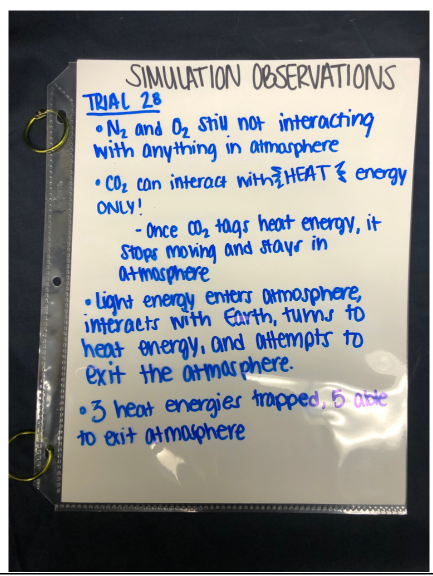
X = Light Energy

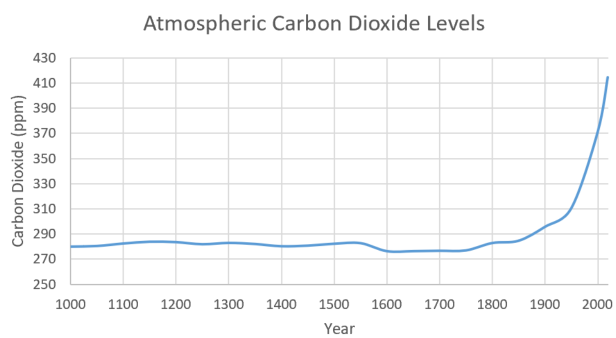
Colored circles represent the CO_2, O_2, and N_2 molecules that can be randomly positioned around the atmosphere

Earth should be in the center of the circle

9. Once all of the students are prepared to start the simulation, tell them that you will say "go" and all molecules are free to start moving. Remind students that they should be walking, not running, and that this isn't a game of tag that they are trying to win by avoiding giving high fives. When you call out a number (number 1-8, leave about 3-5 seconds in between each number), the corresponding light energy is free to enter the atmosphere.
   - Remind the students making observations to focus on the group that they decided on in the classroom and to be ready to tell you how these roles interacted with other roles. It will be most beneficial for them to stand on the line of the atmosphere to see the interactions.
10. Start the simulation. Let it run until all heat energies are frozen or have returned their necklace.
11. Ask all students to freeze where they are and ask the students responsible for making observations what they've noticed. As they tell you their observations, write them down in your laminated notebook.
12. Students should be able to tell you the number of each object participating, what their role in the simulation was, how they interacted with the other objects, and how many heat molecules were trapped by CO_2. They will likely not make all of the necessary observations the first time, so you should run the simulation again. Your notes from their observations should look something like this:

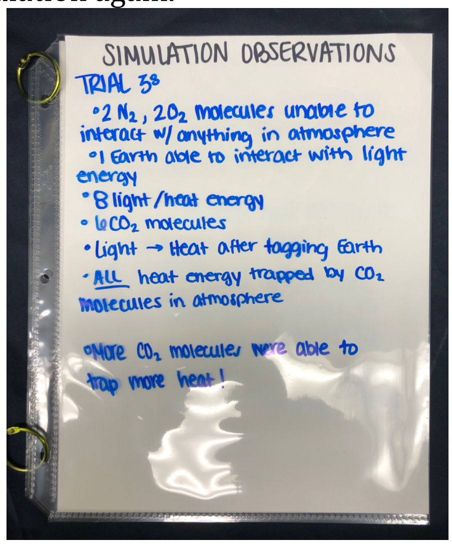




	13. Once all of the necessary observations have been made, take the students back into the classroom and have page 2 of the example student notebook open under the document camera. 14. Tell the students that we now need to analyze our model to figure out what it means, and we will fill out the answers to questions 8-14 together. 15. Read each question to the class, have them come up with the answer, and write it down in the example notebook. All of the answers should have been covered in the class observations, so if they struggle to remember an answer, place the class observations under the document camera to remind them. 16. Read question 15 to the class (is this [CO_2 trapping heat] beneficial to our environment?) and ask them to vote yes/no. If there is disagreement, allow both sides to share their reasoning. Students should realize that without CO_2 being able to trap heat, Earth would get too cold and we would freeze. Then have students fill out question 16.
Part 2(a): 70 minutes	**Analyzing CO_2 Levels** 1. Open the graphs PowerPoint to the first slide (Atmospheric CO_2 Levels) and have students open their notebooks to page 2. Tell students that the graph they are seeing on the PowerPoint is the same one that is in their notebooks on the bottom of the page. Have students analyze the graph by filling in the answers to questions 17-19 on their own.  2. After students are finished, have them share out their answers and write them in to the example notebook under the document camera. They should realize that the trend of the graph shows that since ~1800, CO_2 levels have dramatically increased. 3. Ask students if they think this graph shows United States specific data or a worldwide trend and why (question 20). The students should be able to explain that it is a worldwide trend since CO_2 is a gas and can move freely and without borders (question 21). 4. Tell students to think about the simulation that they created the previous day. Ask them how they could change the simulation to reflect the information they just received from the graph (question 22). 5. Once they've agreed that they need to add more CO_2 molecules to the atmosphere, distribute the same necklaces from the previous day and add 4 more CO_2 molecules (for a total of 6 CO_2). This time make sure to give students who did observations the previous day a chance to participate in the simulation. 6. Take the students outside to the atmosphere set up and run through the simulation at least one time. You should have another group of students

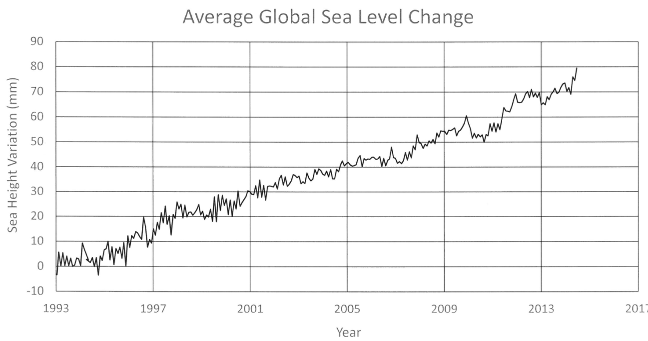
make observations so that you can record them on the class observations page.

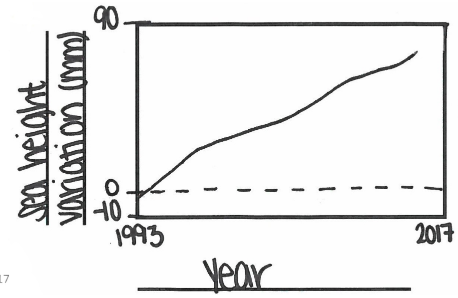
- The most important note is the number of heat energies that are trapped. You should see that more heat is trapped in the atmosphere since more CO_2 molecules have been added.
- If students do not make all of the necessary observations the first time, run the simulation again.



7. After the simulation is complete, take students back in the classroom. Ask them to explain what happened during the simulation (question 23). They should be able to tell you that more CO_2 molecules were added, and more heat was trapped.
8. Applying what they just learned, have the students answer questions 24 and 25 together.
   - Adding CO_2 molecules to the atmosphere traps **more** heat in the atmosphere
   - Trapping more heat in the atmosphere should lead to **higher** temperatures
9. In groups, have students brainstorm for a few minutes the types of evidence that would prove that the Earth's temperature is rising (question 26). Have groups share one idea they came up with until you are given "sea levels rising" and "atmospheric temperatures" as examples.
   - If students are having trouble coming up with these ideas, you can prompt them with questions like "If you have a glass of ice, what happens when you leave it sitting out on a table?" or "If you wanted to make some pasta, you'd have to put some liquid water in a pot on the stove. What happens when you apply heat to that water?"
10. Pull up the graphs PowerPoint again to slide 2 (Average Global Sea Level Change). Ask the students what the graph is showing and what the trend is. Then have them discuss if this supports that global temperatures have been increasing.

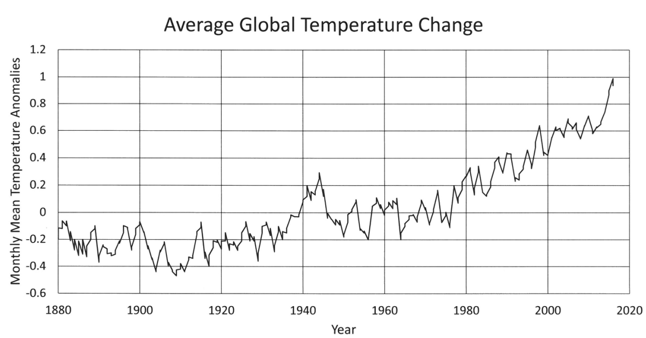
11. Have students sketch the graph into their notebooks using the guide on the bottom of page 3.

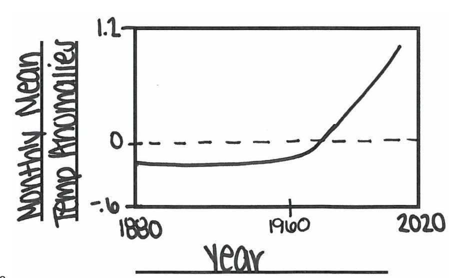




- Tell students that these should just be rough sketches of the graphs. You may need to introduce the term “baseline”, which is the zero, or starting point, of the graph. Starting from zero will help students understand what it means for the graph to be negative or show increasing and decreasing trends.

12. Flip to the next slide (Average Global Temperature Change) and ask the students what this graph is showing and what the trend is. Then have them discuss if this supports that global temperatures have been increasing.
    - You may need to define the word anomaly and explain that “monthly mean temperature anomalies” means that scientists measured the temperature during a certain month and averaged how far the temperature was from the previous years.
    - They may realize that the graph is negative from 1880 to 1940, meaning that global temperatures were colder than average during that period of time.
13. Have students roughly sketch the graph into their notebooks using the guide on the bottom of page 3.





14. Using the graphs, ask the students if scientists were able to observe evidence that the Earth’s temperature is rising (question 27).

Part 2(b): 30 min

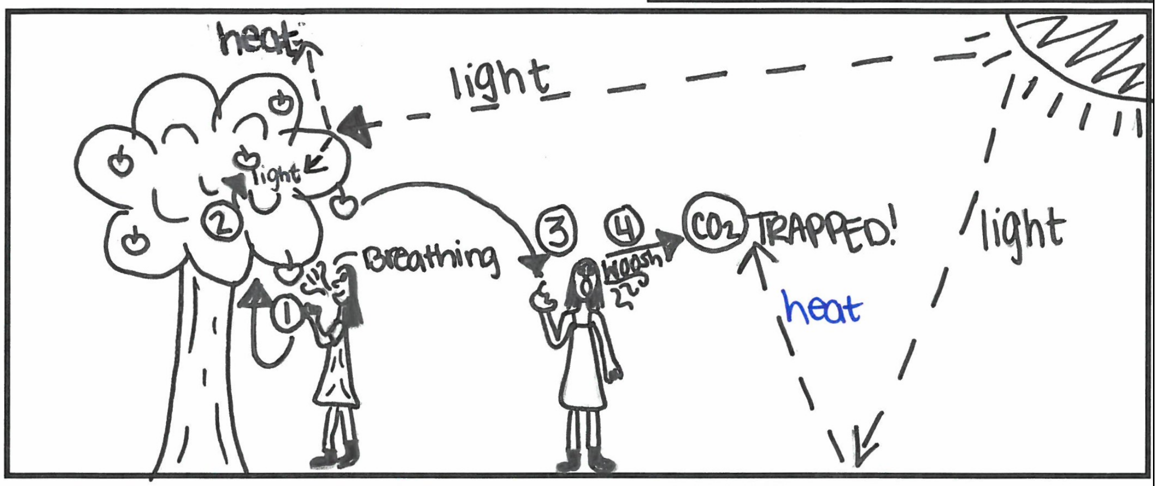
Factors Influencing CO_2 Levels

1. Tell students that now we know that Earth’s temperature has indeed been rising and we need to figure out what could be causing this. Flip back to slide 1 (Atmospheric CO_2 Levels). In order to do this, we need to look back at the graph of atmospheric CO_2 levels found on page 2 in their notebooks.
2. Ask students in what year the CO_2 levels started to drastically increase (question 28). ESR: ~1800.

	3. Ask students why this is important. They should realize that because CO_2 levels have increased, more heat has been able to be trapped in the atmosphere. This is leading to an increase in global temperatures. 4. In groups, have them come up with factors that could have caused this global CO_2 increase and write them in the blanks on question 29. Have one student from each group share an idea that they generated and write it in a blank on the example notebook under the document camera. Tell students that if they were missing ideas in any of the blanks, they can use one from the example notebook. 5. For questions 30-32, you will define the terms for the students and write them in the example notebook for the students to copy down. o A process or activity through which CO_2 is released into the atmosphere is called a **source.** o A reservoir that take up CO_2 from another part of its natural cycle is called a **sink.** o A process that does not change the overall level of CO_2 in the atmosphere is called **carbon neutral.** 6. Tell the students that you will now split them into 7 groups. Each group will receive a different factor that may or may not influence CO_2 levels (CO_2 source or carbon neutral). They will first be given a graph that they will analyze and use to answer questions 33-35 in their packet. o The 7 possible factors are (listed in order from most difficult to least difficult): **Electricity** (source), **Fires** (either source or carbon neutral, depending on what is burning), **Deforestation** (source), **Transportation** (source), **Cement Production** (source) **Photosynthesis** (carbon neutral), and **Respiration** (carbon neutral). o We suggest that when splitting your groups, you put them with mixed ability levels. If you have groups that you think will struggle more, give them the less difficult factors (photosynthesis and respiration). 7. Hand each group their graphs. There will be one graph for each student in the group. See the materials list for the graphs for each group. 8. Once a group has finished analyzing the graph, check in with them to find out how they predict their factor will affect CO_2 levels and global temperature (question 35). 9. If time permits, allow groups to share out their factor, what trend their graph shows, and how they think this relates to global temperatures
Part 3: 70 minutes	**Sources and Carbon Neutral Processes** 1. Have students get into their groups and remind them that in the last session they were all given a factor that may or may not influence CO_2 levels. Tell them that today they will be reading an article about their factor to further analyze how their factor influences CO_2 levels. 2. Have students open their packets to page 5 and read through the instructions at the top of the page together. Tell them that question 38 requires them to draw a picture of how carbon flows for their factor. They will draw something similar to the apple diagram on page 1 of their packets. They will need to number their steps and show carbon being

transferred with solid arrows. They will also need to show how light and heat energy interact with CO_2 molecules or other objects related to their factor using dashed arrows.

- Tell the students that you will show them an example drawing using the carbon flow for the apple tree that they have already looked at. This picture should be in your PowerPoint on slide 4.



3. As a class, call on your students to tell you the carbon transfer that occurs for each step, starting with Step 1. Then discuss how light and heat interact with CO_2.
    - Step 1: Human breathes out CO_2 that the tree takes in.
    - Step 2: Tree uses that CO_2 to grow and produce apples.
    - Step 3: Human eats the apple and incorporates the carbon into their body.
    - Step 4: Human breathes out CO_2.
    - Light energy comes into the atmosphere from the sun, interacts with the Earth and transfers to heat energy.
    - Some of the heat energy is trapped by the CO_2 that the human breathed out.
    - Plants need light to help them grow; light energy comes in from the sun and hits the tree. Some of this light energy is used by the tree and some of it comes off as heat.
4. Remind students that the second part of the instructions tells them that they will need to describe their factor and act out their carbon flow for the rest of the class. They will have access to the necklaces used on the first day of the simulation as well as blank necklaces that they can write on and use for their presentation. They will also be able to enlist up to three students to help them with their carbon flow if needed, but each group will be in charge of doing their own narration.
5. Show students the example blank necklaces and wet erase markers they will use and tell them that you will give them an example of how they should act out their carbon flow.
6. Grab a light/heat energy necklace, a CO_2 necklace, and the example laminated necklaces in which you've drawn a tree on one and an apple on the other. Call on 3 student volunteers to help you.

- Place the students in a line. Student 1 does not need a necklace. Student 2 will wear the tree necklace and crouch down to the ground. Student 3 will wear the apple necklace and stand behind Student 2 until instructed. You will hold on to a CO_2 card and a light/heat energy card.
- Start at Student 1 and say, “This is a human who breathes out CO_2.” Move the CO_2 molecule card away from Student 1 towards Student 2.
- Say, “This tree takes in the human’s CO_2 to help it grow.” Have Student 2 “grow” (stand up) as you place the CO_2 necklace around their neck.
- Say, “This tree now produces apples that contain carbon atoms.” Have Student 3 stand side-by-side with Student 2 and take the CO_2 necklace off Student 2.
- Say, “The human comes back and eats the apple off the tree, incorporating the carbon into their body.” Have Student 3 move to stand next to Student 1.
- As you place the CO_2 necklace around Student 1’s neck, say, “The human breathes out CO_2 into the atmosphere.”
- Place the light energy card around your neck. Say, “Light energy comes in from the sun, interacts with the Earth and turns to heat energy.” Flip the necklace to the heat side.
- Say, “This heat energy is now able to trap the CO_2 that the human breathed out.”

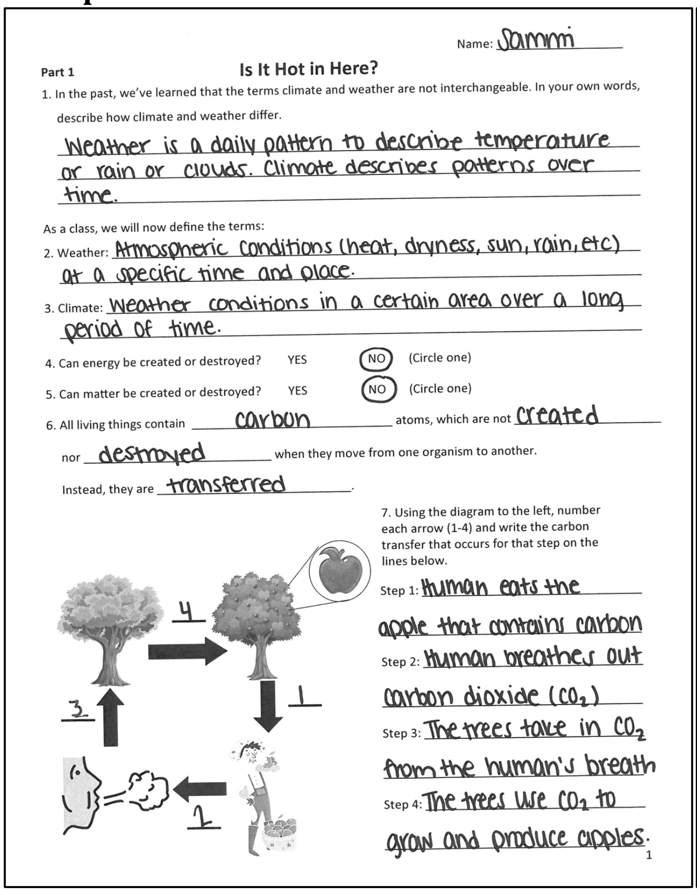
7. Tell the students that now that they’ve seen examples of both the drawing and the acting out of the carbon flow, they are ready to try it on their own. Once they have completed the reading, questions, and the drawing, they must check in with you before moving on to plan out their presentation.
8. As you pass out the set of readings to each group, encourage them to read it out loud together, highlight any words they do not understand, and write any questions they have about the reading on the bottom of the second page to clarify with you later.

	9. As each group is completing the reading, continue to rotate around and spend ~3-minute sessions with each group so they can ask you to clarify anything they don't understand in the reading.
	10. Once a group has completed their questions 36, 37 and drawn their picture, they should call you over so you can check for understanding of their carbon flow before they move on to the writing portion (question 39).
	  o Remind them to include all of the words on the checklist in their writing.
	  o These drawings will not be shared as part of their informal presentation, but they are just to help with their understanding of their factor.
	11. Upon completing question 39, the students can move on to working on their presentation.
	12. If the students have finished their necklaces and have decided how they will act out their carbon flow and there is still time left, they should practice their presentations in their groups.

Part 4(a): 30 minutes	**Presentations** 1. Have the students get into their factor groups and tell them that they will have ~5 minutes to put the finishing touches on their presentation and practice it. 2. If any groups did not get a chance to create their factor-specific necklaces during Part 3, set out the blank necklaces and wet erase markers for them. 3. While the groups are practicing, set up the document camera with page 7 of the example notebook open to follow along with the presentations. 4. You should also give each group a Post-it note or piece of paper with a number (1-7) on it to place them in the correct presentation order. o We recommend presenting in the following order: Electricity, Transportation, Respiration, Photosynthesis, Deforestation, Fires, Cement Production. 5. When you're ready to start, tell the students that you have given each group a number and that number corresponds with the order in which they will be presenting. Remind them that when they present, they can only use a maximum of 3 student volunteers. They will have 2 minutes between each presentation to prepare themselves and their student volunteers. 6. As each group presents, the class should have their notebooks open to page 7 to write down the presenting group's factor, whether it is a CO_2 source or is carbon neutral, and one piece of information they learned from the group. 7. When each group is finished, the class will confirm the group's factor and whether or not it is a CO_2 source or carbon neutral, and you can write it in the example notebook. They will also be able to ask any clarifying questions to the presenting group. 8. Allow two students to share one thing they learned after each presentation. 9. Once all of the groups have finished presenting, tell the students that they've done a great job and you've learned a lot from them about factors influencing CO_2 levels.

Part 4(b): 10 minutes	**Reflection Questions** 1. As a class answer the reflection questions (questions 35-38) together. For question 39 (what is one thing that you as a 6th grader can do to reduce the amount of CO_2 that you produce?), have students individually write down an answer, and then choose ~5 students to share their answers to remind them that there are many ways that we can reduce our CO_2 emissions.

Example Student Work:



Name: Sammi

Part 1

Is It Hot in Here?

1. In the past, we've learned that the terms climate and weather are not interchangeable. In your own words, describe how climate and weather differ.

Weather is a daily pattern to describe temperature or rain or clouds. Climate describes patterns over time.

As a class, we will now define the terms:

2. Weather: Atmospheric conditions (heat, dryness, sun, rain, etc) at a specific time and place.

3. Climate: Weather conditions in a certain area over a long period of time.

4. Can energy be created or destroyed? YES (NO) (Circle one)

5. Can matter be created or destroyed? YES (NO) (Circle one)

6. All living things contain carbon atoms, which are not created nor destroyed when they move from one organism to another. Instead, they are transferred.

7. Using the diagram to the left, number each arrow (1-4) and write the carbon transfer that occurs for that step on the lines below.

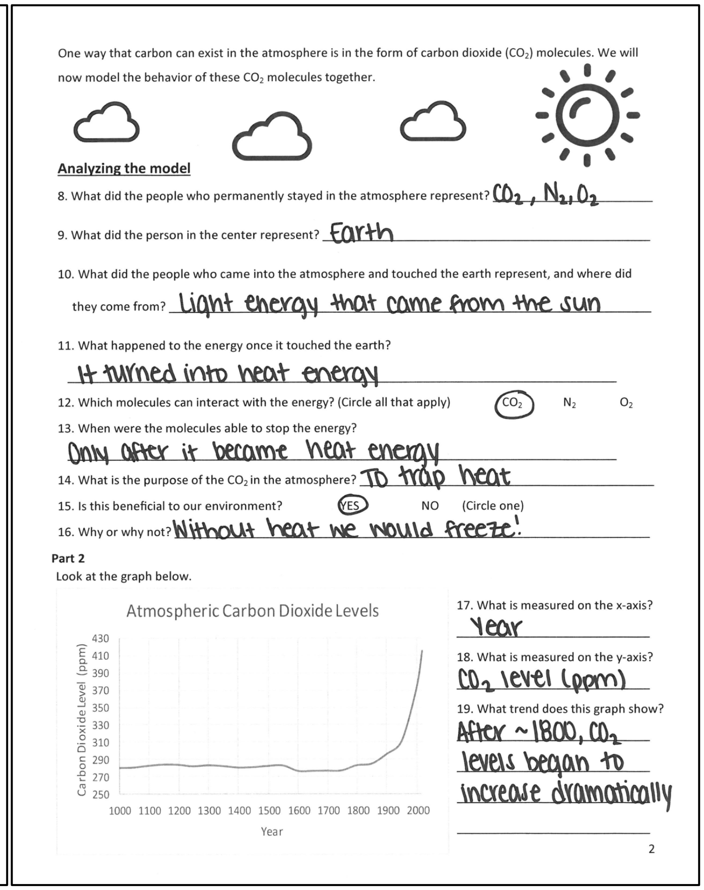
Step 1: Human eats the apple that contains carbon

Step 2: Human breathes out carbon dioxide (CO_2)

Step 3: The trees take in CO_2 from the human's breath

Step 4: The trees use CO_2 to grow and produce apples.

1



One way that carbon can exist in the atmosphere is in the form of carbon dioxide (CO_2) molecules. We will now model the behavior of these CO_2 molecules together.

Analyzing the model

8. What did the people who permanently stayed in the atmosphere represent? CO_2, N_2, O_2

9. What did the person in the center represent? Earth

10. What did the people who came into the atmosphere and touched the earth represent, and where did they come from? Light energy that came from the sun

11. What happened to the energy once it touched the earth? It turned into heat energy

12. Which molecules can interact with the energy? (Circle all that apply) (CO_2) N_2 O_2

13. When were the molecules able to stop the energy? Only after it became heat energy

14. What is the purpose of the CO_2 in the atmosphere? To trap heat

15. Is this beneficial to our environment? (YES) NO (Circle one)

16. Why or why not? Without heat we would freeze!

Part 2

Look at the graph below.

17. What is measured on the x-axis? Year

18. What is measured on the y-axis? CO_2 level (ppm)

19. What trend does this graph show? After ~1800, CO_2 levels began to increase dramatically

2

20. Do you think the graph (on page 2) is showing United States specific data, or is it showing a worldwide trend? It's probably a worldwide trend.

21. Why? Gas molecules (like CO_2) can move freely and without borders.

22. How can we change our model to match the information presented on the graph?
We should add more CO_2 molecules to the atmosphere.

Let's test our simulation again, to include our changes!

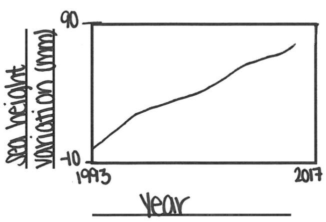
23. Explain what happened during the second run of the simulation.
More CO_2 was added and more heat was trapped.

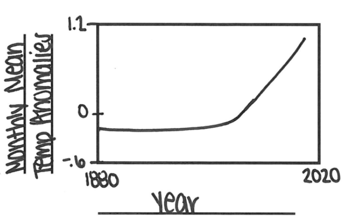
Relationship between CO_2 levels and heat

24. Adding CO_2 molecules to the atmosphere traps (more) less heat in the atmosphere. (Circle one)

25. Trapping more heat in the atmosphere should lead to (higher) lower temperatures. (Circle one)

26. Let's brainstorm where we could look for evidence to prove that the Earth's temperature is rising?
Sea levels rising
Global Temperatures





27. Did scientists observe these things? (YES) NO (Circle one)

What's causing this?

Look back at the graph on page 2.

28. In what year did the CO_2 levels start to drastically increase? ~1800

29. We know that matter cannot be created or destroyed. So what are some factors that might have caused the global rise in CO_2 levels?

Overpopulation | more factories
cars | less trees

30. Any process or activity through which CO_2 is released into the atmosphere is called a source.

31. A reservoir that takes up CO_2 from another part of its natural cycle is called a sink.

32. A process that does not change the overall level of CO_2 in the atmosphere is called carbon neutral.

Ask your teacher for a graph. With your group, you will now explore 1 factor that is either a **source** or is **carbon neutral.**

33. What information is plotted on your graph? Our graph shows electricity use in the U.S. over time.

34. Does your graph show a trend? If so, what is it? Yes, electricity use rose steadily until ~2010 and has since leveled off.

35. How do you think that your graph is related to global CO_2 levels and how will this influence global temperature? (Make sure to use the words "source" or "carbon neutral.")
Producing electricity probably gives off CO_2 from the factories, making it a source. Since the U.S. has been using more electricity, more CO_2 is being produced. This will cause global temperatures to rise.

Part 3

Obtain the article that corresponds to your graph from your teacher and complete the following tasks:

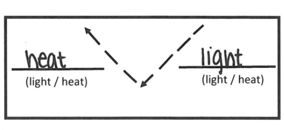
A. Analyze the graph(s) and associated reading to determine if your factor is carbon neutral or a CO_2 source, how your factor affects CO_2 levels, and answer questions 36-39.
B. Be able to act out the portion of the carbon flow that your source or sink affects. This will need to include:
   i. How carbon flows (is conserved)
   ii. How energy interacts with carbon dioxide
   iii. Your prediction on how this will affect the temperature and why
   iiii. How people can reduce the effects if your factor is a source or explain how your factor is carbon neutral

Analyzing our carbon factor

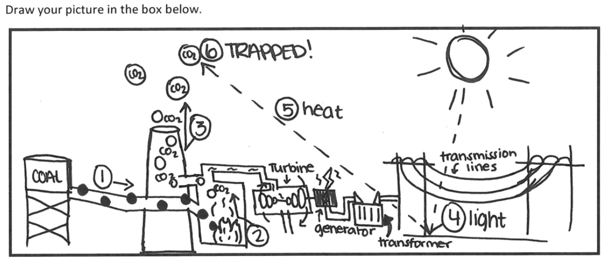
36. Our factor is electricity (Insert factor) which is (a CO_2 source) carbon neutral. (Circle one)

37. Look back at question 35. Did your reading support or dispute your hypothesis about global CO_2 levels and temperatures and why?
Support - our reading states that burning fossil fuels (like coal and natural gas) to produce electricity releases large amounts of CO_2, making it a source. This has contributed to a rise in global temperatures.

38. Draw a picture in the box on the next page to describe the flow of carbon for your factor.
- Label the steps by using numbered, solid arrows to show where carbon is transferred (similar to the apple tree example on page 1).
- Use dashed arrows to show the light/heat energy path. You need to show how light/heat energy interacts with CO_2 or objects related to your factor.
  - Refer to the diagram to the right to see the dashed arrows. Label on the diagram which arrow represents light and which represents heat.
- If the energy is stopped, write "trapped".



Draw your picture in the box below.



39. In words, describe the part of the carbon flow that your factor affects.
Electricity is generated when fossil fuels are burned. ① Coal (a fossil fuel) is transported to a power plant where it ② is burned, releasing ③ CO_2 into the air. ④ Light energy from the sun hits Earth and is transferred to heat energy ⑤. ⑥ This heat energy traps the CO_2 released from the power plant. More fossil fuels burning will cause more CO_2 to be released, thus increasing global temperatures. This completes the carbon flow, showing that electricity production is a CO_2 source.

In your description, please include the following words:
- [x] Carbon flow(s)
- [x] Source or Carbon Neutral
- [x] Light
- [x] Heat
- [x] Trapped
- [x] Temperature

In your group, decide how you will act out your factor's carbon flow. You will have access to the cards we used in our original simulation as well as blank cards. You can label the blank cards with factor-specific objects to help your classmates visualize your carbon flow. You as a group will need to narrate the carbon flow, so if you need more people to stand in as objects or molecules, you may enlist the help of **no more than three** of your classmates.

In your presentation, please describe what your factor is, any important vocab words your classmates should know, how your factor affects CO_2 levels and global temperatures, and at least one way to reduce CO_2 emissions if your factor is a source.

You may write a script/notecard to help you, but it should not take more than 4 minutes.

Part 4

Carbon factor presentations to the class

Group 1: Transportation which is **(a CO_2 source)** carbon neutral
Factor (Circle one)

One piece of information that I learned from this group:

All-electric cars do not produce CO_2 directly, but their electricity source they charge from might.

Group 2: Respiration which is a CO_2 source **(carbon neutral)**
Factor (Circle one)

One piece of information that I learned from this group:

The CO_2 we breathe out came from the food we eat, which got its carbon from the air, making this a carbon neutral cycle

Group 3: Photosynthesis which is a CO_2 source **(carbon neutral)**
Factor (Circle one)

One piece of information that I learned from this group:

Plants produce CO_2 at night when there is no light for photosynthesis.

Group 4: Deforestation which is **(a CO_2 source)** carbon neutral
Factor (Circle one)

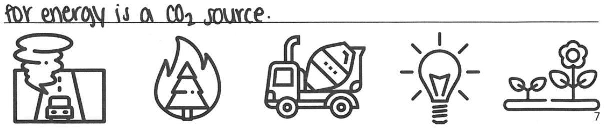
One piece of information that I learned from this group:

People cut down forests and replace it with farms. Cows produce methane (CH_4), which is even more harmful than CO_2!

Group 5: Fires which is **(a CO_2 source)** **(carbon neutral)** Depends!
Factor (Circle one)

One piece of information that I learned from this group:

A forest fire is carbon neutral, but burning fossil fuels for energy is a CO_2 source.



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Group 6: Cement Production which is **(a CO_2 source)** carbon neutral
Factor (Circle one)

One piece of information that I learned from this group:

cement and concrete are different - cement powder is used to make concrete. Burning the cement powder produces CO_2.

Reflection Questions

35. Have humans affected the amount of CO_2 in the atmosphere? **(YES)** NO (Circle one)

36. Have humans contributed to the rise in global temperatures? **(YES)** NO (Circle one)

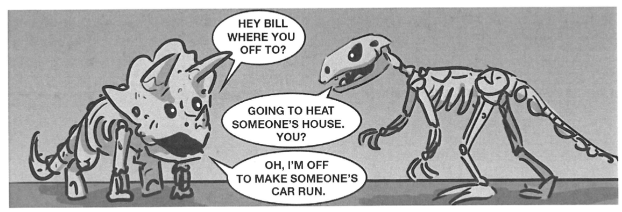
37. If people in the United States use a lot of electricity and drive their cars every day, does this have an effect on the people in Canada? Why or why not?

Yes! Both electricity production and transportation are CO_2 sources. The CO_2 released is a gas that is able to move without borders and will affect the people in Canada.

38. To solve the global warming problem, who will need to be involved? All people and countries across the globe.

39. What is one thing that you as a 6th grader can do to reduce the amount of CO_2 that you produce?

Bike to school!



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