Introduction

Formative Assessment Exemplar - ESS.3.5

Introduction:

The following formative assessment exemplar was created by a team of Utah educators to be used as a resource in the classroom. It was reviewed for appropriateness by a Bias and Sensitivity/Special Education team and by state science leaders. While no assessment is perfect, it is intended to be used as a formative tool that enables teachers to obtain evidence of student learning, identify gaps in that learning, and adjust instruction for all three dimensions (i.e., Science and Engineering Practices, Crosscutting Concepts, Disciplinary Core Ideas) included in a specific Science and Engineering Education (SEEd) Standard.

In order to fully assess students' understanding of all three dimensions of a SEEd standard, the assessment is written in a format called a cluster. Each cluster starts with a phenomenon, provides a task statement, necessary supporting information, and a sequenced list of questions using the gather, reason, and communicate model (Moulding et al., 2021) as a way to scaffold student sensemaking. The phenomenon used in an assessment exemplar is an analogous phenomenon (one that should not have been taught during instruction) to assess how well students can transfer and apply their learning in a novel situation. The cluster provides an example of the expected rigor of student learning for all three dimensions of a specific standard. In order to serve this purpose, this assessment is NOT INTENDED TO BE USED AS A LESSON FOR STUDENTS.

Because this assessment exemplar is a resource, teachers can choose to use it however they want for formative assessment purposes. It can be adjusted and formatted to fit a teacher's instructional needs. For example, teachers can choose to delete questions, add questions, edit questions, or break the tasks into smaller segments to be given to students over multiple days.

Of note: All formative assessment clusters were revised based on feedback from educators after being utilized in the classroom. During the revision process, each cluster was specifically checked to make sure the phenomena was authentic to the DCI, supporting information was provided for the phenomena, the SEPs, CCCs, and DCIs were appropriate for the learning progressions, the cluster supported student sensemaking through the Gather, Reason, and Communicate instructional model, and the final communication prompt aligned with the cluster phenomena. As inconsistencies were found, revisions were made to support student sensemaking. If other inconsistencies exist that need to be addressed, please email the current Utah State Science Education Specialists with feedback.

General Format:

Each formative assessment exemplar contains the following components:

1. Teacher Facing Information: This provides teachers with the full cluster as well as additional information including the question types, alignment to three dimensions, and answer key. Additionally, an example of a proficient student answer and a proficiency scale for all three dimensions are included to support the evaluation of the last item of the assessment.
2. Students Facing Assessment: This is what the student may see. It is in a form that can be printed or uploaded to a learning platform. (Exception: Questions including simulations will need technology to utilize during assessment.)

Accommodation Considerations:

Teachers should consider possible common ways to provide accommodations for students with disabilities, English language learners, students with diverse needs or students from different cultural backgrounds. For example, these accommodations may include: Providing academic language supports, presenting sentence stems, or reading aloud to students. All students should be allowed access to a dictionary.

References:

Moulding, B., Huff, K., & Van der Veen, W. (2021). *Engaging Students in Science Investigation Using GRC*. Ogden, UT: ELM Tree Publishing.

Teacher Facing Info

Teacher Facing Information

Standard: ESS.3.5

Assessment Format: Online Only (Requires students to have online access)

Phenomenon

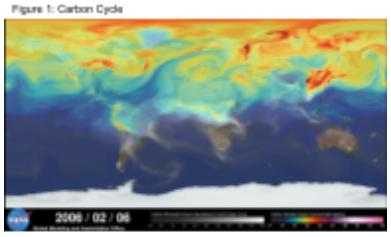


Figure 1 shows the levels of carbon within the atmosphere with blue colors showing low levels of carbon and red showing higher levels, the highest levels of carbon would be in pink.

Video 1: Carbon Emissions Super Computer Data from 1 year.

NASA | A Year in the Life …

Proficient Student Explanation of Phenomenon:

Due to an increase in carbon emissions, global temperatures are expected to continue to rise causing an overall increase in global temperatures overtime.

Predict what will happen to the four main Earth spheres if this trend continues:

Effect of Carbon Dioxide			
Atmosphere	Hydrosphere	Geosphere	Biosphere
Human activity will continue to increase carbon dioxide concentrations.	Carbon flows between each of the other spheres and can flow from the atmosphere back into water (hydrosphere)	Carbon reservoirs have fluctuated over time due to alterations to Earth systems, Carbon from soils has been disrupted and pumped into the sky	Increased carbon in the atmosphere leads to decreased carbon in the soil which will make it harder for plants to grow and animals/humans to eat.

How can humans manage these effects? use Video 2: https://www.youtube.com/watch?v=nvAoZ14cP7Q
The Soil Story by Kiss the Ground (and/or Refer back to the phenomena video if needed.)

Management of Carbon Dioxide: Humans need to get the carbon cycle back into a proper balance. Apply a thin layer of compost to the top of the soil, planting trees and cover crops, stop massive tilling and begin regenerative agriculture.

Cluster Task Statement

In the questions that follow, you will predict effects on the four Earth's spheres based on trends in

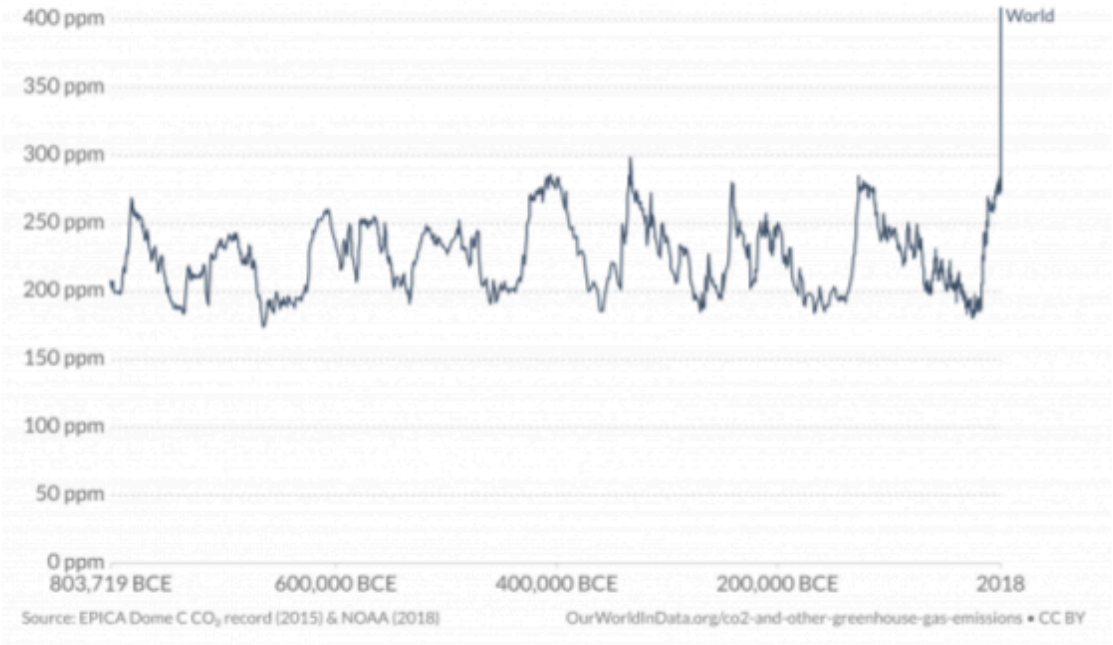
carbon and temperature data.

Supporting Information

Video 2: https://www.youtube.com/watch?v=nvAoZ14cP7Q
The Soil Story by Kiss the Ground

https://ourworldindata.org/atmospheric-concentrations

Graph 1: Atmospheric CO_2 Concentration



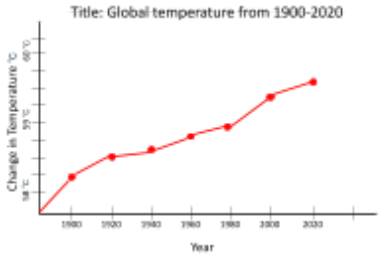
Global average long-term atmospheric concentration of carbon dioxide (CO_2), measured in parts per million (ppm). Long-term trends in CO_2 concentration can be measured at high-resolution using preserved air samples from ice cores. (Our World in Data, EPICA, 2018)

Cluster Questions

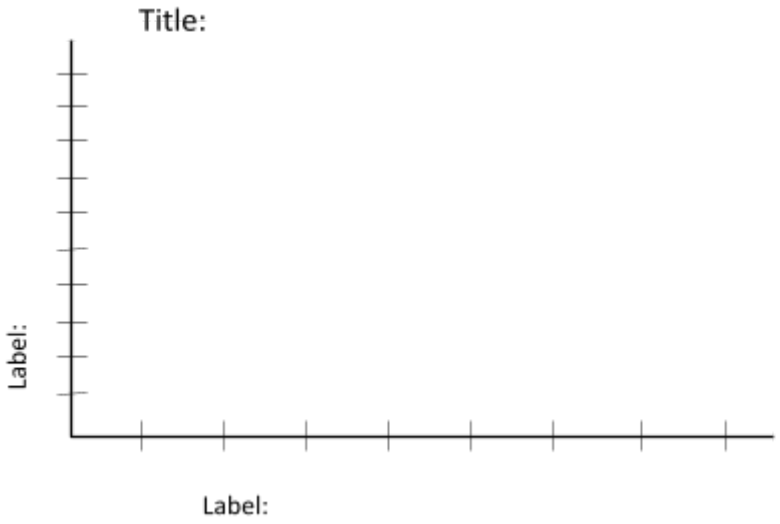
Gather:
Cluster Question #1
Question Type: graphing
Addresses:
__x__ DCI: ESS3.D
_x___ SEP
____ CCC
Answer:

Item: Graph the following data, include a title and labels for your graph.

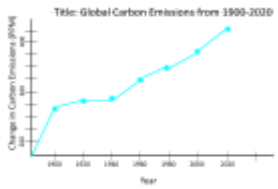
Global Temperature Data in degrees Celsius (NOAA) https://www.ncdc.noaa.gov/cag/global/time-series	
Year	Temperature
1900	58.3 ℃



1920	58.5 ℃
1940	58.6 ℃
1960	58.7 ℃
1980	58.9 ℃
2000	59.3 ℃
2020	59.5 ℃

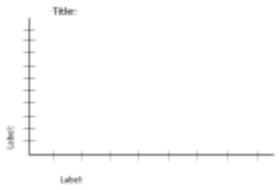


Gather:
Cluster Question #2
Question Type: graphing
Addresses:
__x__ DCI: ESS2.D
__x__ SEP
____ CCC
Answer:



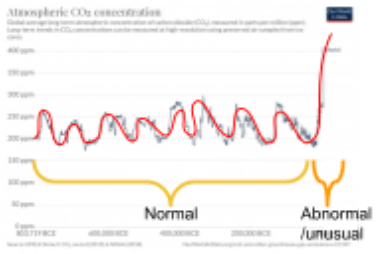
Item: Graph the following data, include a title and labels for your graph.

Global Carbon Emission Data in Parts per Million (PPM)https://gml.noaa.gov/ccgg/trends/data.html	
Year	Atmospheric CO_2
1900	265 ppm
1920	270 ppm
1940	275 ppm
1960	316 ppm
1980	338 ppm
2000	369 ppm
2020	414 ppm

<table>
<tr>
<td></td>
<td>  </td>
</tr>
<tr>
<td>Reason:
Cluster Question #3
Question Type: short answer
Addresses:
_x___ DCI: ESS2.D, ESS3.D
_____ SEP
_x___ CCC
Answer:
As carbon emissions increase, global temperatures increase.

In the system, temperature and carbon emissions interact in a direct way</td>
<td>Item: Compare and contrast the data from the graphs you created in question 1 and 2. Complete the following statements using the word bank.

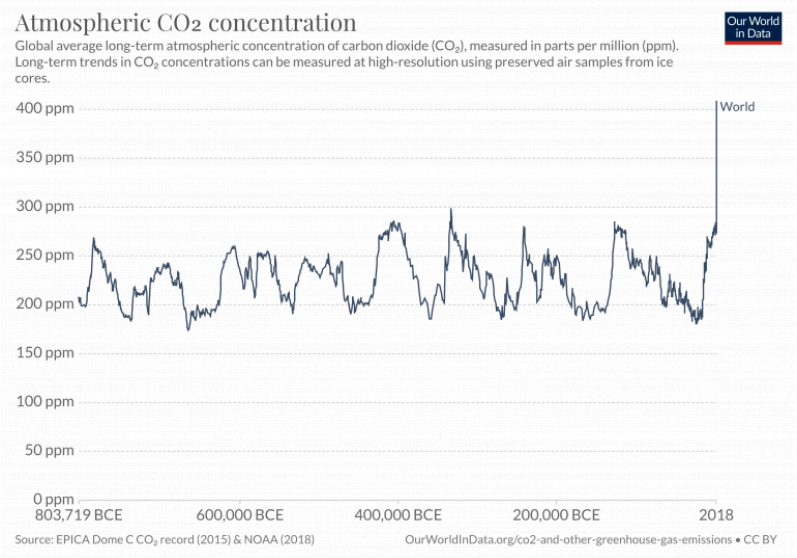
word bank
<table><tr><td>increase</td><td>decrease</td><td>temperature</td><td>carbon emissions</td><td>direct</td><td>indirect</td></tr></table>
As carbon emissions _____, global temperatures _____.

In the system, _____ and _____ interact in a(n)_____ way.</td>
</tr>
<tr>
<td>Reason:
Cluster Question #4
Question Type: modeling/labeling
Addresses:
_x___ DCI: ESS2.D, LS2.B
_x___ SEP
_x___ CCC
Answer:
 

The end part of the graph that shows a sudden increase in carbon is abnormal, it’s not following the same up/down</td>
<td>Carbon emissions are known to fluctuate (rise and fall) throughout the year. This is a normal trend as carbon cycles from the air (atmosphere) into the soil (geosphere), into water (hydrosphere) or through animals (biosphere). Long-term global carbon emission concentrations are measured using ice cores.

Graph 1: Atmospheric CO_2 Concentrations</td>
</tr>
</table>

pattern as indicated by a normal carbon fluctuation/cycle.



This question consists of 3 parts:

a) Add a line Graph 1 to indicate how temperature would have changed since BCE times.
b) The graph shows a pattern of increasing and decreasing carbon levels, this up/down pattern is considered normal. Highlight which area of the graph indicates a normal pattern for the Carbon cycle
c) Highlight any other areas that lack this up/down pattern as unusual/abnormal. How do you know this part of the graph is abnormal?

Communicate:
Cluster Question #5
Question Type: table grid/long answer
Addresses:
__x__ DCI: LS2.B, ESS2.D, ESS3.D
__x__ SEP
_x___ CCC
Answer:

Effect of Carbon Dioxide			
Atmosphere	Hydrosphere	Geosphere	Biosphere
Human activity will	Carbon flows	Carbon reservoirs	Increased carbo

Item: If the global trend of carbon continues on its current path, what is expected to happen to global temperatures? Explain why...

Predict what will happen to the four main Earth sphere if this trend continues:

Effect of Carbon Dioxide			
Atmosphere	Hydrosphere	Geosphere	Biosphere

How can humans manage these effects? Use Video 2 to help you answer: https://www.youtube.com/watch?v=nvAoZ14cP7Q
The Soil Story by Kiss the Ground (and/or Refer back to the phenomena video if needed.)

continue to increase carbon dioxide concentrations.	between each of the other spheres and can flow from the atmosphere back into water (hydrosphere)	have fluctuated over time due to alterations to Earth systems, Carbon from soils has been disrupted and pumped into the sky	n in the atmosphere leads to decreased carbon in the soil which will make it harder for plants to grow and animals/humans to eat.

How can humans manage these effects? use Video 2: https://www.youtube.com/watch?v=nvAoZ14cP7Q
The Soil Story by Kiss the Ground (and/or Refer back to the phenomena video if needed.)

Management of Carbon Dioxide: Humans need to get the carbon cycle back into a proper balance. Apply a thin layer of compost to the top of the soil, planting trees and cover crops, stop massive tilling and begin regenerative agriculture.

Proficiency Scale

Proficient Student Explanation:

Effect of Carbon Dioxide			
Atmosphere	Hydrosphere	Geosphere	Biosphere
Human activity will continue to increase carbon dioxide concentrations.	Carbon flows between each of the other spheres and can flow from the atmosphere back into water (hydrosphere)	Carbon reservoirs have fluctuated over time due to alterations to Earth systems, Carbon from soils has been disrupted and pumped into the sky	Increased carbon in the atmosphere leads to decreased carbon in the soil which will make it harder for plants to grow and animals/humans to eat.

How can humans manage these effects? use Video 2:
https://www.youtube.com/watch?v=nvAoZ14cP7Q
The Soil Story by Kiss the Ground (and/or Refer back to the phenomena video if needed.)

Management of Carbon Dioxide: Humans need to get the carbon cycle back into a proper balance. Apply a thin layer of compost to the top of the soil, planting trees and cover crops, stop massive tilling and begin regenerative agriculture.

Level 1 - Emerging	Level 2 - Partially Proficient	Level 3 - Proficient	Level 4 - Extending
SEP: Does not meet the minimum standard to receive a 2.	**SEP:**Use and/or develop a model of simple systems with uncertain and less predictable factors. Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. Develop and/or use a model to predict and/or describe phenomena. Develop a model to describe unobservable	**SEP:** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits	**SEP:** Extends beyond proficient in any way.

	mechanisms.	and limitation	
CCC: Does not meet the minimum standard to receive a 2.	**CCC:** Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.	**CCC:** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.	**CCC:** Extends beyond proficient in any way.
DCI: Does not meet the minimum standard to receive a 2.	**DCI:** Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.	**DCI:** Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.	**DCI:** Extends beyond proficient in any way.
DCI: Does not meet the minimum standard to receive a 2.	**DCI:** Greenhouse gases in the atmosphere absorb and retain the energy radiated from land and	**DCI:** Geological evidence indicates that carbon reservoirs have fluctuated over time due to alterations to Earth	**DCI:** Extends beyond proficient in any way.

	ocean surfaces, thereby, regulating Earth's average surface temperature.	systems including changes to the atmosphere, ocean absorption, and carbon uptake in plants. The time scales of these changes varied from a few to millions of years. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations leading to a stronger greenhouse effect and ocean acidification.	
DCI: Does not meet the minimum standard to receive a 2.	**DCI:** 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.	**DCI:** Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.	**DCI:** Extends beyond proficient in any way.

(Student Facing Format on following page)

Student Assessment

Name: _____ Date: _____

Stimulus

Figure 1: Carbon Cycle

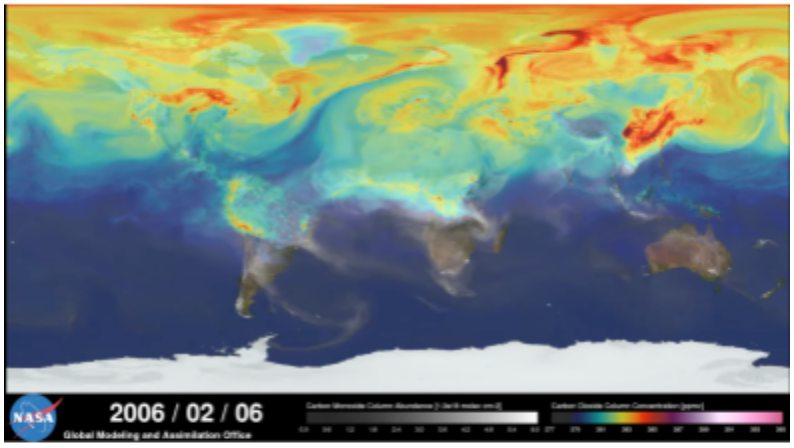
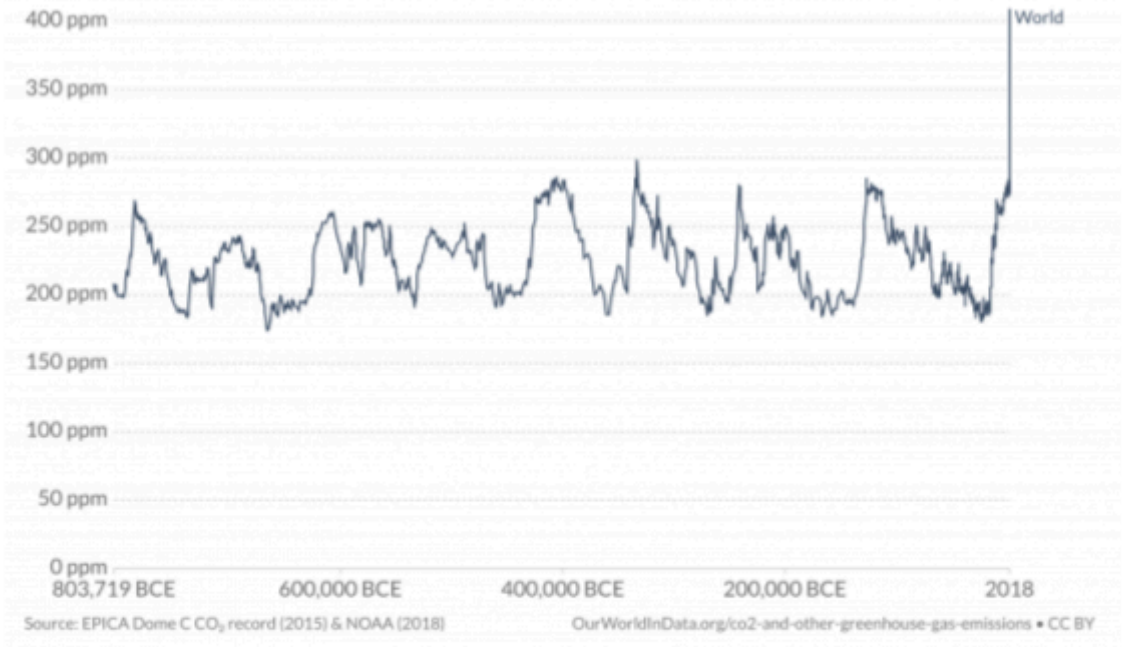


Figure 1 shows the levels of carbon within the atmosphere with blue colors showing low levels of carbon and red showing higher levels, the highest levels of carbon would be in pink.

Watch: Video 1: Carbon Emissions Super Computer Data from 1 year.
https://www.youtube.com/watch?v=x1SgmFa0r04

Graph 1: Atmospheric CO_2 Concentration



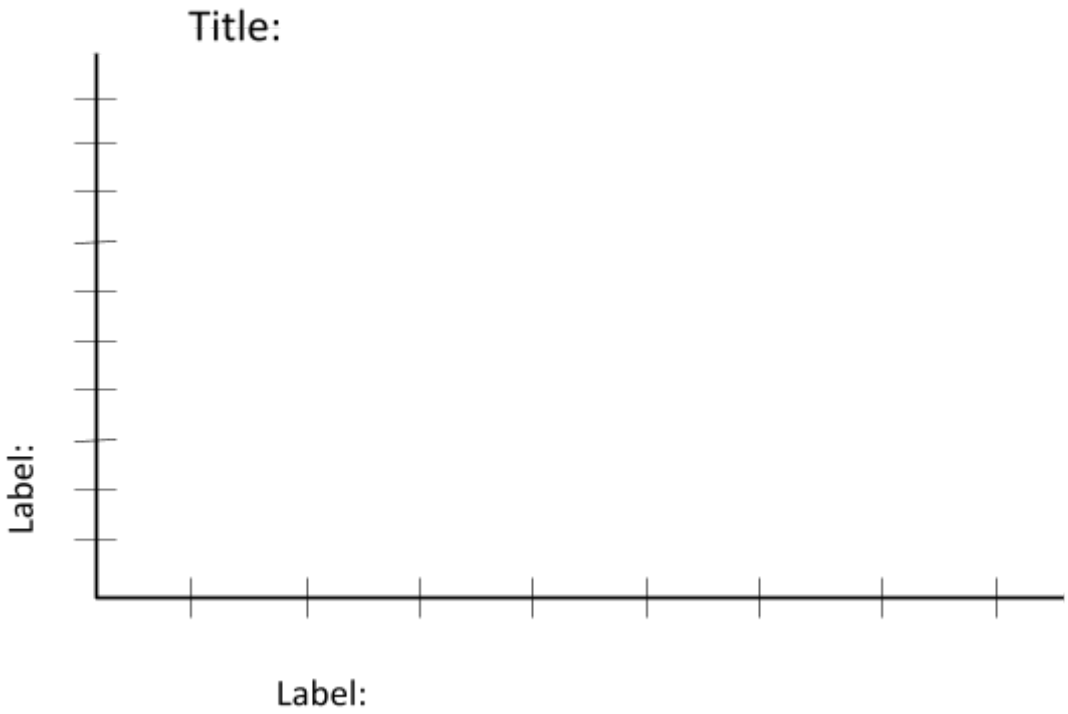
Global average long-term atmospheric concentration of carbon dioxide (CO_2), measured in parts per million (ppm). Long-term trends in CO_2 concentration can be measured at high-resolution using preserved air samples from ice cores. (Our World in Data, EPICA, 2018)

Your Task

In the questions that follow, you will predict effects on the four Earth's spheres based on trends in carbon and temperature data.

Graph the following data, include a title and labels for your graph.

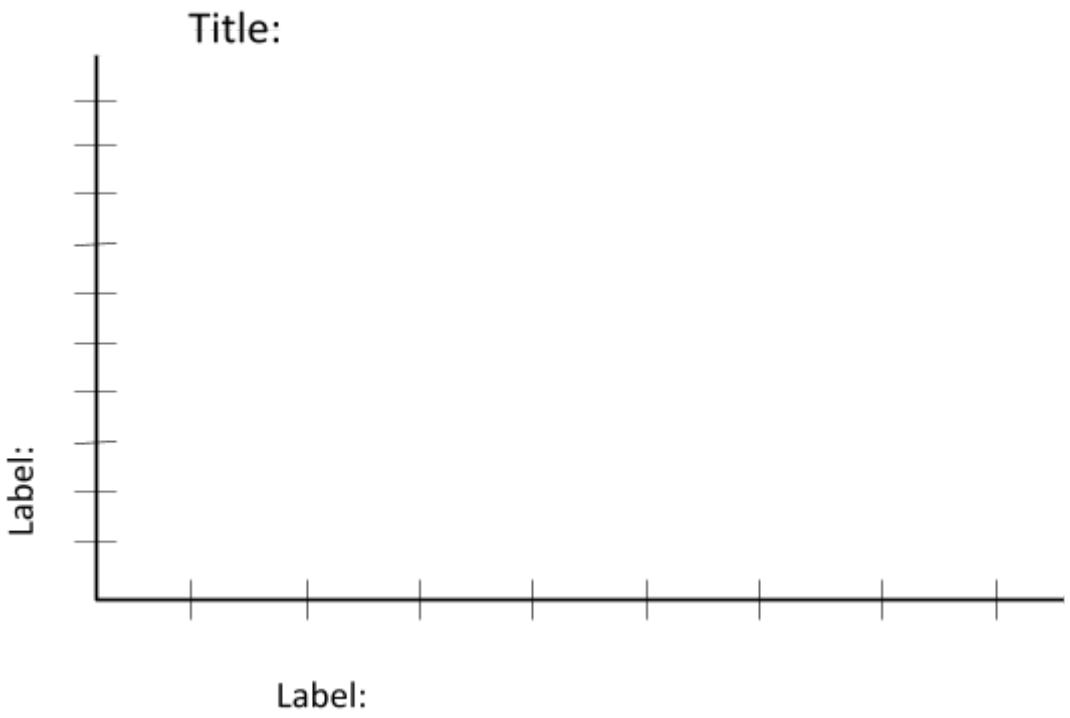
Global Temperature Data in degrees Celsius (NOAA) https://www.ncdc.noaa.gov/cag/global/time-series	
Year	Temperature
1900	58.3 ℃
1920	58.5 ℃
1940	58.6 ℃
1960	58.7 ℃
1980	58.9 ℃
2000	59.3 ℃
2020	59.5 ℃



Question 2:

Graph the following data, include a title and labels for your graph.

Global Carbon Emission Data in Parts per Million (PPM)https://gml.noaa.gov/ccgg/trends/data.html	
Year	Atmospheric CO_2
1900	265 ppm
1920	270 ppm
1940	275 ppm
1960	316 ppm
1980	338 ppm
2000	369 ppm
2020	414 ppm



Question 3:

Compare and contrast the data from the graphs you created in question 1 and 2. Complete the following statements using the word bank.

word bank

increase	decrease	temperature	carbon emissions	direct	indirect

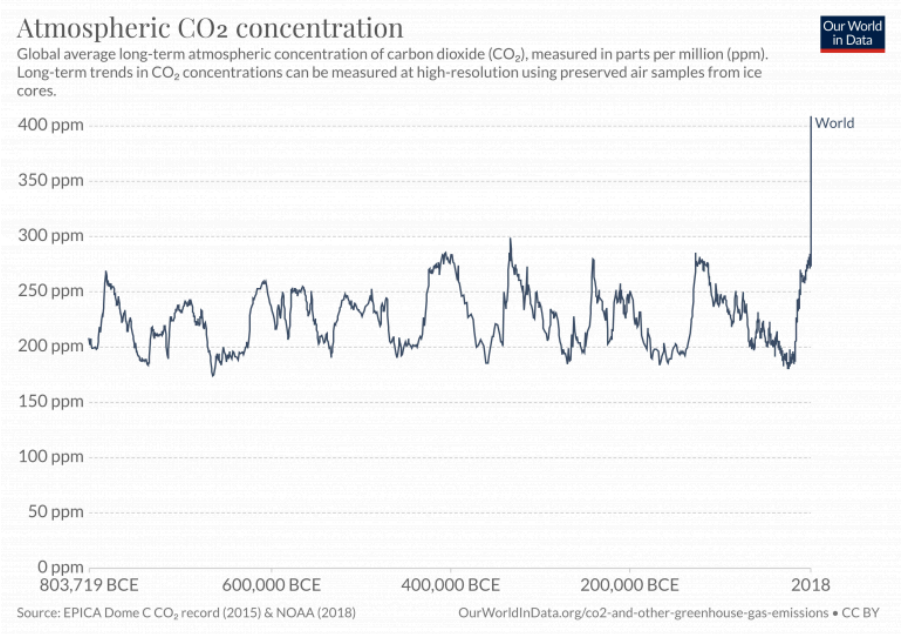
As carbon emissions _____, global temperatures _____.

In the system, _____ and _____ interact in a(n)_____ way.

Question 4:

Carbon emissions are known to fluctuate (rise and fall) throughout the year. This is a normal trend as carbon cycles from the air (atmosphere) into the soil (geosphere), into water (hydrosphere) or through animals (biosphere). Long-term global carbon emission concentrations are measured using ice cores.

Graph 1: Atmospheric CO_2 Concentrations



This question consists of 3 parts:

a) Add a line Graph 1 to indicate how temperature would have changed since BCE times.
b) The graph shows a pattern of increasing and decreasing carbon levels, this up/down pattern is considered normal. Highlight which area of the graph indicates a normal pattern for the Carbon cycle
c) Highlight any other areas that lack this up/down pattern as unusual/abnormal. How do you know this part of the graph is abnormal?

Question 5:

This question consists of 3 parts:

a) If the global trend of carbon continues on its current path, what is expected to happen to global temperatures? Explain why...

b) Predict what will happen to the four main Earth sphere if this trend continues:

Effect of Carbon Dioxide			
Atmosphere	Hydrosphere	Geosphere	Biosphere

c) How can humans manage these effects? Use Video 2 - The Soil Story by Kiss the Ground to help you answer(and/or Refer back to the phenomena video if needed.): https://www.youtube.com/watch?v=nvAoZ14cP7Q