Graphing Quaternary Carbon Dioxide

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**Overview**

In this student-directed activity, each student (or pair) will graph one 10,000 year section of CO2 data from the Antarctic Vostok or EPICA Dome C ice cores or Mauna Loa Observatory. Some of these individual graphs will contain a picture with a caption that will be added to the graph to make an infographic. Students will then line up all the graphs chronologically in the hallway to create a 67’ long graph of CO2 concentrations over the past 800,000 years. Students will then work in teams to analyze the data and make inferences about climate.

This activity is designed for middle school, but could easily be incorporated into high school or college lessons.

**Colorado State Standards**

**6th grade Science**

*Earth Science*

1b. Gather, analyze and communicate evidence from text and other sources that explains the formation of Earth’s surface features.

*Life Science*

1a. Interpret and analyze data about changes in environmental conditions – such as climate change – and populations that support a claim describing why a specific population might be increasing or decreasing.

1b. Model equilibrium in an ecosystem, including basic inputs and outputs, to predict how a change to that ecosystem such as climate change might impact the organisms, populations, and species within it.

**7th grade Science**

*Earth Science*

2b. Identify and describe the impact of major geologic events on life on Earth.

2c. Identify and describe major events in Earth’s geologic history.

2d. Use direct and indirect evidence to determine the sequence of events in geologic time.

*Life Science*

5a. Interpret and analyze data from the fossil record to support a claim that organisms and environments have evolved over time.

5b. Analyze and critique the evidence regarding the causes and effects of a mass extinction event.

5c. Analyze and interpret data that show human evolution.

**8th grade Science**

*Earth Science*

2a. Develop, communicate and justify an evidence-based scientific explanation to account for Earth’s different climates.

4c. Use models to explain the relative motions of Earth, Moon, and Sun over time.

*Life Science*

1b. Analyze and interpret data about human impact on local ecosystems.

**Objectives**

1. Graph the level of carbon dioxide in Earth’s atmosphere in 10,000 year increments.

2. Combine individual graphs with graphs made by other students in order to build an historical record from 800,000 years ago to the present as a timeline in the hallway.

3. Evaluate the data looking for trends and anomalies (things that don’t fit the pattern.)

4. Identify ice ages by looking at the hallway graph.

5. Use the “infographics” to identify evolutionary and geologic events through geologic time.

5. Use the “infographics” to make inferences about other time periods where similar events may have occurred.

**Materials**

* Print (in color) the “Graphing Paleoclimate Data Cards” document. Cut each 10,000 year data set apart to make 80 cards for students to use.
* Print “Graphing Paleoclimates Graph Paper” and make 80 2-sided copies, one for each data set. *Note: You can use the blank graph paper, or the paper that has the axes pre-set, depending on the needs of your students*.
* Print the “Paleoclimate Graph Conclusions” document. Make enough 2-sided copies for each student to have their own.
* A 70 foot long section of hallway that is available to hang the individual graphs to make one long graph. It would be preferable that this hallway be in an area that will not disturb other classes when students are out in the hall looking at the graph and discussing it. (Perhaps in a cafeteria?)

**Procedures**

***Part 1 – Graphing the Data- Day 1***

*Note to the teacher: The data sets come from the attached Excel document which includes all the Vostok Ice Core data as well as the Mauna Loa Observatory data. The student data has been edited down to make it more manageable for middle school students to graph it. I have removed many “intermediate” data points between highs and lows, but tried to keep the integrity of the data by including as many highs and lows as possible. All relevant data references are included on the Excel spreadsheet.*

Determine how you will need to divide the 80 data sets between your class periods so that all 80 sets will be graphed by the end of the day. *(Example: If you have 6 sections of science with 30 students in each section, you will need to put your students in pairs, and each pair will graph one data set. On the other hand, if you only have 3 sections of science with 20 students per section, each student will do their own graph, and 20 students will need to complete 2 graphs.)*

Some of the data sets include a picture with a caption. Students with pictures need to cut out the picture (including the caption) and tape or glue it to their finished graph in a manner that does not occlude the line they have graphed.

If you have your first period class start with the most recent data sets, they will be able to put them up in order from the beginning of your hallway. The next period class can then continue with the next sets of data, and so on, until you have a completed graph in the hallway by the end of the day.

***Part 2 – Analyzing the Data – Day 2***

Do a “graph walk” to draw out the following observations from the students.

* Above 200 ppm CO2 = warmer climate
* Below 200 ppm CO2 = ice age
* It takes longer to get rid of CO2 than it does to add CO2; thus, it takes longer to cool down than it does to warm up.
* Cycles of increased and decreased CO2 typically take thousands or 10’s of thousands of years
* The current spike in CO2 is NOT normal

Hand out a copy of the Paleoclimate Graph Conclusions to each person. Group students into heterogenous teams of about 4 students/team. For special needs or English Language Learners, use the modified handout.

Step 1: Have teams divide the list of conclusions between themselves, and circle the topics they are responsible for before they head to the hall. Each student will find infographics related to their topic during the “scavenger hunt” and fill in the reason for the event. They should estimate an “eyeball average” for the CO2 level on that section of the graph. An example will look like this when a student is finished with it:

10. Global Dust Storms

*CO2 level:* below 200 ppmv

*Temp:* cold

*Reason*: Dust storms blow dirt high into the atmosphere because the dense, cold air moving off of ice sheets causes severe wind.

3. Acidic Oceans

*CO2 level:* above 220 ppmv

*Temp:* warm

*Reason:* More carbon dioxide in the atomosphere causes more CO2 to be dissolved in the oceans. Carbonic acid in the ocean results in acidic oceans and dissolving of sea shells and coral.

Step 2: Have teams reassemble in the classroom to share their scavenger hunt findings, and write the data onto their conclusions sheet.

Possible team roles could be:

* **Seeker** – helps teammates find missing information
* **Vocabulary Vendor** – brings a dictionary and looks up words on the infographic that people don’t know
* **Antarctic Arbitrator** – facilitates discussion if people don’t agree on answers
* **Climate Change Coordinator** – in charge of keeping the team focused and on task; directs the team to make deeper observations and question possible connections

Set the behavior expectations before allowing students to go to the hallway with the graph. Examples include:

* Help teammates.
* Use inside voices.
* Try to stay away from other people when possible. There are many places on the graph where the same thing happens. Spread out.
* When your team is finished, sit together in a designated location and finish the back side of the conclusions page together. Be sure you are discussing, and not simply copying someone else’s answers.

**Differentiation**

* Special needs modifications: some students may need the axes of the graph completely filled in ahead of time in order to be successful. In addition, some of the data sets have fewer data points to graph, so these students could receive a smaller data set. Working with partners and teams will alleviate most of the problems these students will encounter.
* G/T and Advanced students: These students can receive a larger data set, or if you need some students to make 2 graphs, these students typically work faster and could complete extra graphs. The most recent data set is the most difficult to graph. For the conclusions, there is an extension opportunity where students conduct individual research on some aspect of the graph that interests them. Instead of writing a paragraph, they could use a technology tool to create a brief presentation of their findings (PowToons, Voki, Padlet, Scrumblr, VoiceThread, etc.)
* English Language Acquisition students: Pairing these students with verbal students will help them understand. The pictures with the infographics will also help them.

**Extensions and Assessment**

1. Students can research a topic of interest from the graph, and write a summary or produce some other product depicting what they discovered.

2. Collect the conclusions handout, and read the reasons for the events to check for understanding.

3. Have students work in teams to create a skit to demonstrate their understanding of a positive feedback that will influence climate.

4. If you have specific standards you are trying to meet (example: mass extinctions or human impacts on the environment) you can use this activity as a “jumping off” point to move into that particular topic.