Let the Chips Fall Where They May

Math

Background: The CO_2 record presented here is derived from three ice cores obtained at Law Dome, East Antarctica from 1987 to 1993. The Law Dome site satisfies many of the desirable characteristics of an ideal ice core site for atmospheric CO_2 reconstructions including negligible melting of the ice sheet surface, low concentrations of impurities, regular stratigraphic layering undisturbed at the surface by wind or at depth by ice flow, and high snow accumulation rate. Air bubbles were extracted using the "cheese grater" technique. Ice core samples weighing 500-1500g were prepared by selecting crack-free ice and trimming away the outer 5-20mm. Each sample was sealed in a polyethylene bag and cooled to -80°C before being placed in the extraction flask where it was evacuated and then ground to fine chips. The released air was dried cryogenically at -100°C and collected cryogenically in electropolished stainless steel "traps," cooled to about -255°C.

For this simulation, the students will use poker chips to represent 20-year slices taken from the ice core. The atmospheric CO_2 reconstructions presented here offer records of atmospheric CO_2 mixing ratios from 1006 A.D. to 1978 A.D. For ease of graphing, we started the data at 1000 A.D. and ended in 1980 A.D. We also included the atmospheric concentration of carbon dioxide in 2000 A.D. (not part of the actual ice core sample) to complete the graph.

Goal: Students apply the concepts of ice core analysis to measure atmospheric CO_2 concentrations from 1006 A.D. to 1978 A.D.

Objectives: Students will …

- Understand how ice cores can be used to measure atmospheric CO_2
- Analyze the amount of CO2 in the atmosphere over the last century
- Graph data that has been collected
- Analyze and interpret findings

Materials (for a class of 30 working in groups of 5):

- 6 ice core samples in containers (see teacher prep)
- 30 copies of Let the Chips Fall Where They May – Student Sheet
- 1 copy of Let the Chips Fall Where They May – Teacher Answer Key

Optional Activity

- 6 computers with Microsoft Excel
- 6 Data Tables from World Population video
- CSI Master Curriculum disk

Time Required: 45-60 minutes

Standards Met: S1, S5, M4, M6, M16

Procedure:

PREP

- Purchase the following materials from a local hardware store for the construction of the ice core samples:
  - 6 – 5 x 1½in pieces of PVC pipe
  - 12 – 1½in PVC solid end caps
  - 6 sets of 50 white poker chips
  - 1 fine-tip permanent black marker
  - 1 fine-tip permanent red marker
- Using the data in the below table, make 6 sets of core samples by writing the date on one side of the poker chip in black and the ppm CO_2 for that date on the other side of the chip in red.
- Place each set inside of one of the PVC containers and cap both ends.

DATE	PPM	DATE	PPM
1000	279.5	1520	283.1
1020	279.7	1540	283.1
1040	280.2	1560	282.2
1060	280.9	1580	279.7
1080	281.7	1600	276.4
1100	282.5	1620	275.3
1120	283.2	1640	276.1
1140	283.7	1660	276.5
1160	284.0	1680	276.4
1180	284.0	1700	276.7
1200	283.6	1720	277.0
1220	282.8	1740	276.9
1240	282.0	1760	277.6
1260	282.0	1780	280.1
1280	282.5	1800	282.9
1300	283.0	1820	284.2
1320	283.3	1840	284.6
1340	282.7	1860	286.3
1360	281.5	1880	290.8
1380	280.5	1900	296.7
1400	280.3	1920	303.2
1420	280.7	1940	309.3
1440	280.9	1960	316.9
1460	280.6	1980	350.6
1480	281.0	2000	370.0
1500	282.2		

IN CLASS

- Split the class into 6 groups of 5 students. Have one member of the group come to the supply area to pick up an ice core sample.
- Pass out a Let the Chips Fall Where They May – Student Sheet to each of the students.
- Have the groups open their ice core being careful not to spill the “sliced” samples.

- Starting at the 0 origin of the graph (X Y intersect), write 0. Complete the graph by recording 1000 A.D. to 2000 A.D. on the X-axis (date) and 270 ppm to 370 ppm (CO_2 Emissions) on the Y-axis. Put a line break between the 0 and the 270 ppm on the Y-axis (for the first interval). Have each student make a line graph by graphing the slices of the core sample on Graph 1. Make sure the students title the graph appropriately and label the X-axis and Y-axis with the correct units.
- After all the slices have been graphed, have the students answer the Questions for Thought.
- Have one student from each group return the core sample to the supply area.

Optional Activities:

- For an optional activity have the students create a graph using just the poker chips. They will have to determine how they will represent the scale for the X-axis and Y-axis (independent and dependent variables).
- Using Table 1 that was constructed from the information on the World Population video, have the students enter the population by year along with their CO_2 concentration (ppm) on the spreadsheet titled "Ice Core Spreadsheet" located on the instructor's CSI Master Curriculum disk. The instructor will have to load this program onto each of the computer before class begins.

Assessment:

- Successful completion of Let the Chips Fall Where They May – Student Sheet

Let the Chips Fall Where They May – Teacher Answer Key

Name: _____ Date: _____

Graph 1 –

Questions for Thought:

1. Summarize the data recorded in the graph above in one complete sentence.
   Answers will vary. Possible answers may include – From 1000 A.D. until around 1800 A.D., CO2 concentration stayed between 270 and 290 ppm but then rose sharply from 1800 A.D. to 2000 A.D. to a concentration close to 370 ppm.

2. What could account for the dip in the graph around the 1600's?
   The period from 1400 to 1800, characterized by expansion of mountain glaciers and cooling of global temperatures, especially in the Alps, Scandinavia, Iceland, and Alaska was titled "The Little Ice Age."

3. What could account for the rapid rise in the graph from 1980-2000 A.D?
   Answers will vary. Possible answers may include: The period from 1800 A.D. to 2000 A.D. was characterized by a rapid increase in industry and the development of the internal combustion engine, both which emit large amounts of CO_2.

If you have completed the Optional Activity using Table 1, answer the questions below.

4. From the spreadsheet graph that you made, how does population relate to CO_2 concentration during the last 1000 years?
   Answers will vary. Possible answers may include: As the population increases, the concentration of CO_2 also increases.

5. If you were to construct a model of what is causing climate change given only your spreadsheet graph, what would you conclude is causing climate change?
   Answers will vary. Possible answers may include: It appears that increases in population cause an increase in the greenhouse gas CO_2. Therefore, if we control population growth, we will reduce the affects of climate change.

Let the Chips Fall Where They May – Student Sheet

Name: _____ Date: _____

Graph 1
Title of Graph _____

Questions for Thought:

1. Summarize the data recorded in the above graph using one complete sentence.

2. What could account for the dip in the graph around the 1600's?

3. What could account for the rapid rise in the graph from 1980-2000 A.D.?

If you have completed the Optional Activity using Table 1, answer the questions below.

4. From the spreadsheet graph that you made, how does population relate to CO_2 concentration during the last 1000 years?

5. If you were to construct a model of what is causing climate change given only your spreadsheet graph, what would you conclude is causing climate change?

Table 1

Year (AD)	Population (millions)
1	170
200	190
400	190
600	200
800	220
1000	265
1100	320
1200	360
1300	360
1400	350
1500	425
1600	545
1700	610
1750	760
1800	900
1850	1211
1900	1625
1950	2515
2000	6073

WORKSHOP COPY

Let the Chips Fall Where They May – Student Sheet

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Graph 1
Title of Graph _____

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1. Summarize the data recorded in the above graph using one complete sentence.

2. What could account for the dip in the graph around the 1600's?

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