Teaching Activity: CO$_2$ and Temperature: Is There a Connection?

Introduction: Ice cores provide the most direct tool for reconstructing the evolution of atmospheric carbon dioxide over the past decades. Ice cores were taken at several drilling sites in Antarctica and Greenland. After removal, the ice samples were taken to laboratories and the air bubbles were extracted from the ice in vacuum chambers, isolated and evaluated for concentrations of CO$_2$ and other gases. These gas bubbles were trapped at the time the ice was formed by the settling and layering of the accumulated snow. The Vostok Ice Research Station in Antarctica has provided large amounts of data on CO$_2$ concentrations as well as atmospheric temperatures for the same time period. Analysis of this data has led scientists to suggest a direct correlation between carbon dioxide levels and the temperature of the atmosphere. While many uncertainties still remain, scientists are concerned that if carbon dioxide concentrations continue to rise as a result of human activity, an above average rise the Earth's average global temperature could follow.

Objective:
- To evaluate the data from two graphs based on analysis of an ice sample taken by Russian scientists at Vostok Station in East Antarctica;
- To hypothesize about the correlation between CO$_2$ concentrations and global surface temperatures;

Important Terms: Ice core, evolution, carbon dioxide, air bubbles, Vostok, Antarctica, correlation, vacuum chamber, global average temperature, glacial, interglacial;

Materials: Copies of graphs from Vostok data back to 160,000 Yrs. BP (CO2 and temperature), paper/ pencil, **Student Activity Sheet**;

Procedure:
1. Read and discuss the **Introduction** and the graph of the Vostok data.
   - Explain to the class that the data on these graphs are based on analysis of an ice sample taken by Russian scientists at the Vostok Station in Antarctica. The ice sample, a core over one mile long, contained ice formed 160,000 years ago. Bubbles in the ice contained samples of the atmosphere for the same time period.

2. Focus on the graph and point out how the graph is formatted.
   - Check students ability to read the information from the two axes.
   - Call attention to the highs and lows of the graph and ask for possible correlations.

3. Students should be able to pick out the close correlation between the changes in greenhouse gas concentrations and the changes in the Earth's surface temperature.

- As CO_2 levels have risen, the global climate has warmed. Lower atmospheric concentrations of CO_2 have coincided with periods of global cooling.
- Low points on the graphs indicate ice ages; high points indicate interglacial periods.

4. Tell students they will be working with a partner on this activity.
   - Their task is to analyze the two graphs on the Vostok data that you have just introduced in class.
   - They are to use the questions in the **Analysis/Application** and **Drawing Conclusions** sections as a guide.
   - They are each to prepare a written statement in paragraph form of at least 500 words in which they do the following:
     - Suggest an explanation for the relationship between the two graphs;
     - Predict what the effects of a continued rise in carbon dioxide emissions over the next two decades could mean for the Earth;

5. Notify students that they should be ready to share their conclusions with the rest of the class.

LONG TERM VARIATIONS OF GLOBAL TEMPERATURE AND ATMOSPHERIC CARBON DIOXIDE
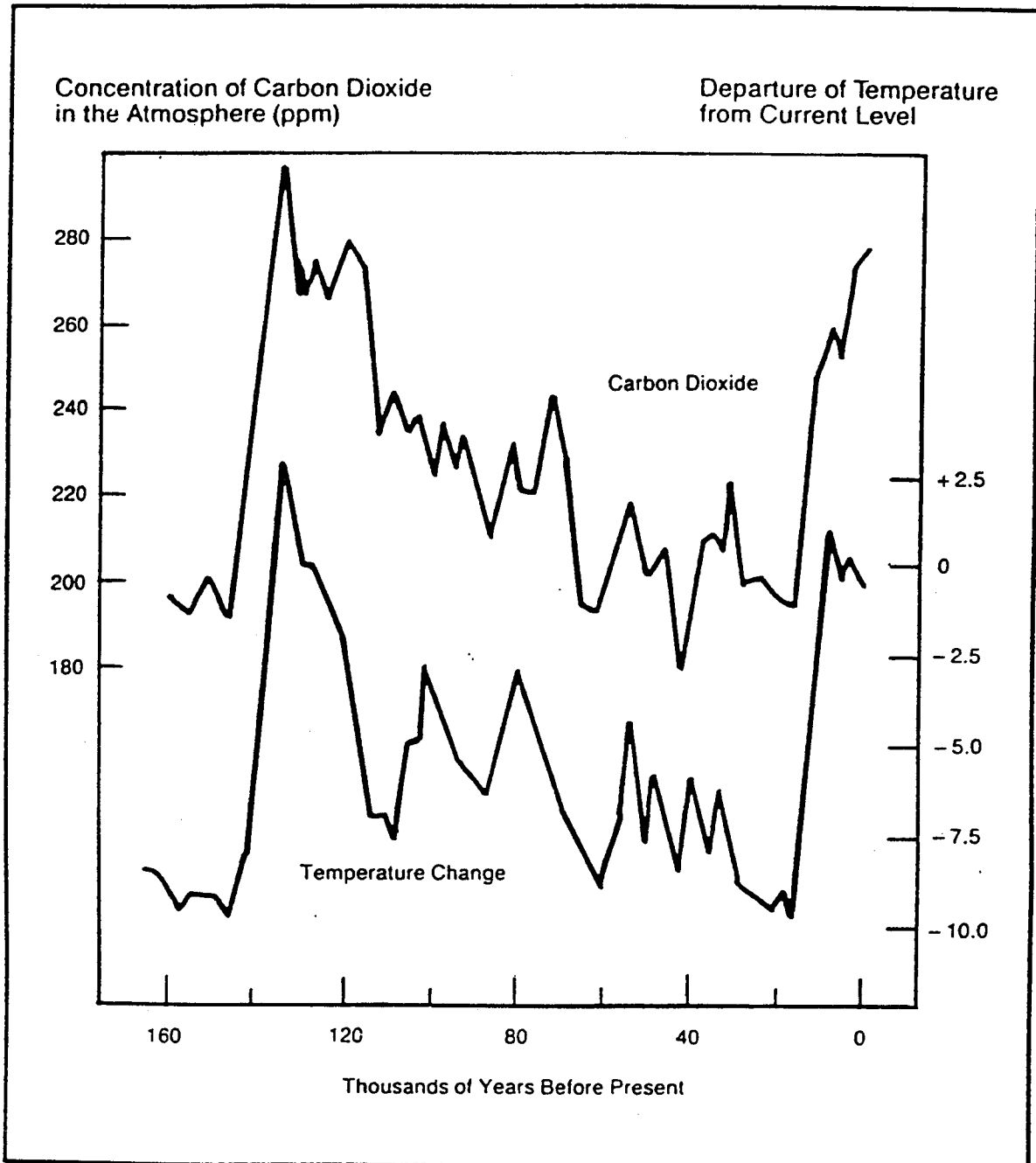
Source: J.M. Barnola, et al., "Vostok Ice Core Provides 160,000-year Record of Atmospheric CO_2," *Nature,* Vol. 329, NO.6138 (1987), p.410, as cited in World Resources Institute in collaboration with the United Nations Environment Program and the United Nations Development Programme, *World Resources,* 1990-91, (Oxford University Press, New York, 1990)

Student Activity Sheet: Carbon Dioxide and Temperature:

Is There a Connection?

Introduction: Ice cores provide the most direct tool for reconstructing the evolution of atmospheric carbon dioxide over the past decades. Ice cores were taken at several drilling sites in Antarctica and Greenland. After removal, the ice samples were taken to laboratories and the air bubbles were extracted from the ice in vacuum chambers, isolated and evaluated for concentrations of CO_2 and other gases. These gas bubbles were trapped at the time the ice was formed by the settling and layering of the accumulated snow. The Vostok Ice Research Station in Antarctica has provided large amounts of data on CO_2 concentrations as well as atmospheric temperatures for the same time period. Analysis of this data has led scientists to suggest a direct correlation between carbon dioxide levels and the temperature of the atmosphere. While many uncertainties still remain, scientists are concerned that if carbon dioxide concentrations continue to rise as a result of human activity, an above average rise the Earth's average global temperature could follow.

Objective:
- To evaluate the data from two graphs based on analysis of an ice sample taken by Russian scientists at Vostok Station in East Antarctica;
- To hypothesize about the correlation between CO_2 concentrations and global surface temperatures;

Procedure:
1. Read over the **Introduction** and discuss the graph with the teacher.

2. With a partner, analyze the two graphs from the Vostok data.
   - Use the questions in the **Analysis /Application** section and the **Drawing Conclusions** as a guide. Write your answers to the questions in the spaces provided.

3. Prepare a written conclusion in paragraph form of no less than 500 words in which you address the following two issues:
   - Suggest and explanation for the relationship you saw in the two graphs;
   - Predict what the effects of a continued rise in the CO_2 concentration over the next two decades could mean for the Earth.

4. Be prepared to share your written conclusion with the class.

Student Activity Sheet #1: Carbon Dioxide and Temperature:

                                                                                    Is There a Connection?

PART I: ANALYSIS/ APPLICATION

1. What does the vertical scale (Y axis) on the graph for temperature show?

   _____

   _____

2. What does the vertical scale (Y axis) on the graph for CO_2 show?

   _____

   _____

3. What does the horizontal sclae (X axis) on both scales indicate? _____

   _____

4. The concentration for CO_2 is given in *ppm*. Explain what ppm means. _____

   _____

   _____

5. If we place the Earth's average surface temperature today at about 60 degrees
      F. , how much colder was Antarctica 160,000 years ago ?_____

6. How much warmer has Antarctica been than it is now? When did that happen?

   _____

   _____

7. In the past 160000 years, when was the CO_2 concentration in the atmosphere
      about what it is now? (Give the approximate concentration in ppm and the
      year BP) _____

8. Over the past 160,000 years, when was the temperature at least as warm as it
      is now? (Give the approximate temperature and tear.) _____

   _____

9. What do the "valleys" in the temperature graph represent? _____

10. What do the "peaks" in the temperature graph represent? _____

11. How many major glacial periods have there been in the last 160,000 years?

   _____

12. When did the last ice age end? _____

13. When the earth was experiencing an ice age, what did the CO_2 concentration look like? _____

14. What did the CO_2 graph indicate during the interglacial periods?

_____

15. It would be very easy to draw a conclusion from this data. However, there is insufficient data to do so. What question remains to be answered?

_____

_____

_____

PART II: DRAWING CONCLUSIONS:

1. What conclusion can you draw from the data provided in these two graphs?

_____

_____

_____

_____

_____

2. If we assume that the CO_2 concentrations will continue to rise over the next few decades, what kind of effect should we expect it to have on the Earth's average surface temperature? _____

_____

_____

_____

_____

_____