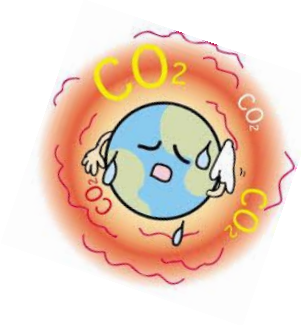
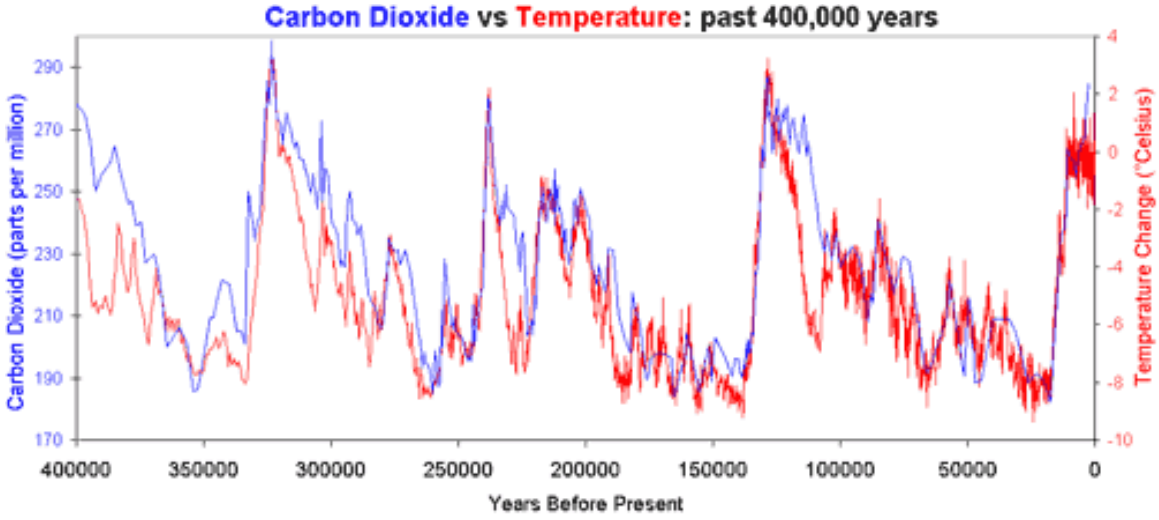
Student Sheet 1



PROBLEM SOLVING ACTIVITY: CO_2 AND TEMPERATURE: WHAT'S THE CONNECTION?

Earth's climate has varied widely over its history, from ice ages (glacials), characterized by large ice sheets covering many land areas to warm periods with no ice at the poles (interglacials). Several factors have affected past climate change, including changes in the output of solar energy, volcanic activity and changes in the composition of the atmosphere. Data from Antarctic ice cores reveals an interesting story for the past 400,000 years. During this period, CO_2 and temperatures are closely connected, which means they rise and fall together. However, based on Antarctic ice core data, changes in CO_2 follow changes in temperatures by about 600 to 1000 years. This has led some people to conclude that CO_2 simply cannot be responsible for current global warming and is a popular myth put forward by ***climate skeptics***.



This statement does not tell the whole story. The early changes in temperature during this period are explained by changes in the Earth's orbit around the sun, which affects the amount of sunlight reaching the Earth's surface. In the case of warming, the lag between temperature and CO_2 is explained as follows: as ocean temperatures rise, oceans release CO_2 into the atmosphere. This release increases the warming trend, and causes even

more CO_2 to be released. In other words, increasing CO_2 levels become both the cause and effect of further warming. This positive feedback is necessary to trigger the shifts between ice ages and interglacials since changes in the Earth's orbit are too weak to cause such a large difference. Additional positive feedbacks which play an important role in this process include other greenhouse gases, and changes in ice sheet cover and vegetation patterns. While changes in the orbital cycles triggered the initial warming, overall, more than 90% of the glacial-interglacial warming occurred ***after*** that atmospheric CO_2 increase and CO_2 is still the principal control knob governing Earth's temperature.

ANALYSIS/APPLICATION: Use the information in the introduction and from your analysis of the graph to answer the following:

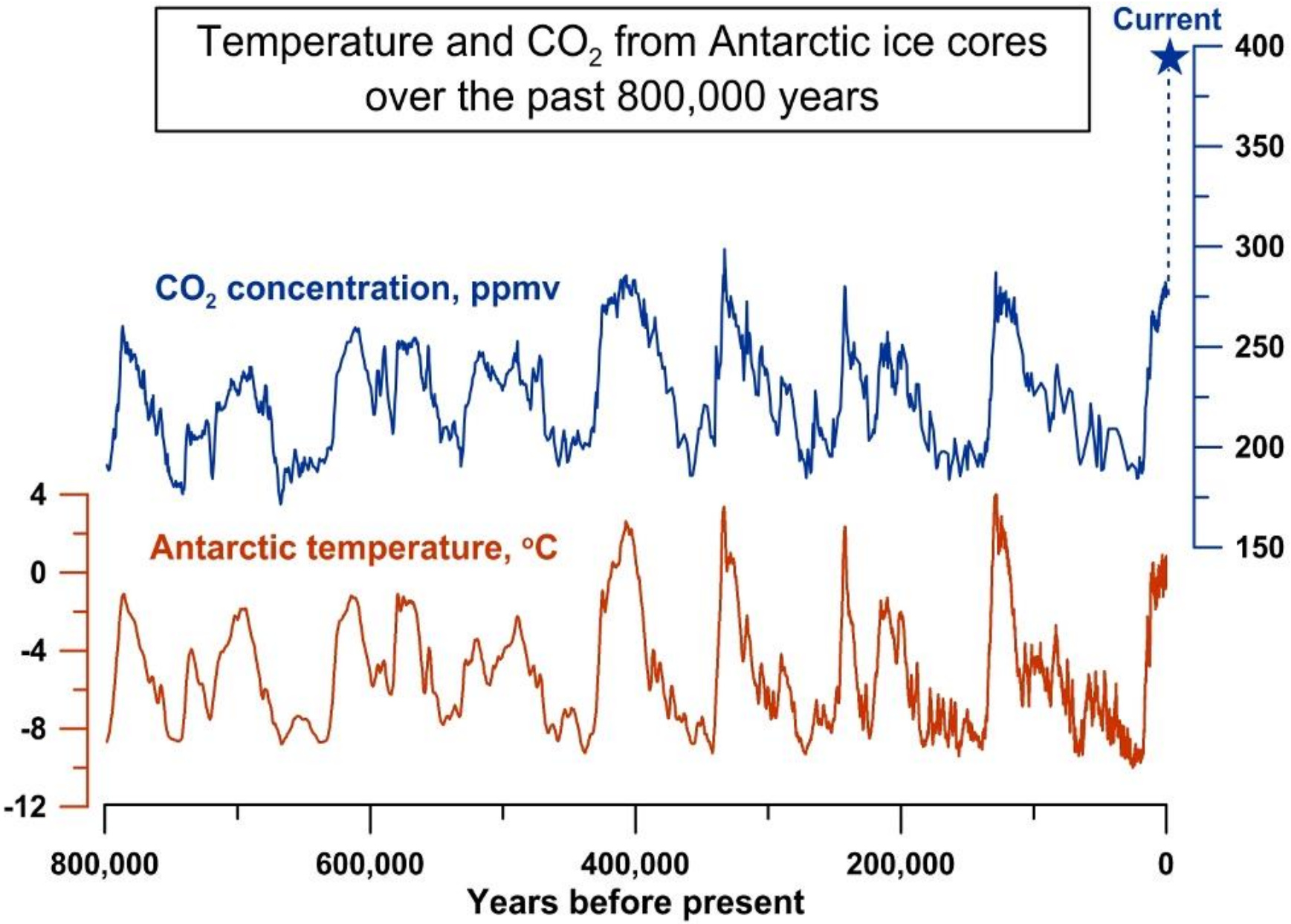
1. What does the X-axis for temperature show?
2. With the global average temperature today at 60 °F, how much colder was Antarctica 400,000 years ago?
3. How much warmer has Antarctica been than it is now? When did that happen?
4. In the 400,000 years, when was the CO_2 concentration in the atmosphere about what it is now? Give the concentration in ppm and the year BP.
5. Over the past 400,000 years, when was the temperature at least as warm as it is now? Give the approximate temperature and year.
6. What do the "valleys" on the graph represent?
7. What do the "peaks" on the graph represent?
8. How many major glacial periods have there been in the last 400,000 years?
9. When did the last ice age end?
10. When the Earth was experiencing an ice age, what did the CO_2 concentrations look like?
11. What did the CO_2 graph indicate during the interglacial periods?
12. It would be easy to draw a conclusion from this data. However, there is insufficient information to do so. What other questions remain to be answered?

Student Sheet 3

CONCLUSIONS:

1. What correlation is obvious from the data on the graphs?
2. What mistake do climate skeptics make when they say things like:
   - "CO_2 lags temperature……"
   - "It's the Sun……."
   - "It's not bad……."
   - "There is no consensus……."

3. If we assume that CO_2 concentrations will continue to rise over the next few decades, what kind of effects should we expect it to have on the Earth's average temperature?
4. What secondary effects could be the result of your answer in number 3 above?


Temperature and CO_2 from Antarctic ice cores over the past 800,000 years
Current
400
350
300
250
200
150
CO_2 concentration, ppmv
4
0
-4
-8
-12
Antarctic temperature, °C
800,000
600,000
400,000
200,000
0
Years before present