or Antarctica. The deepest ice cores drilled to date reach down to ice that was deposited more than 800,000 years ago, which is why the graph can show data going back that far. The zoom-in on the right shows the carbon dioxide concentration directly measured in Earth's atmosphere since the late 1950s.

Even without knowing anything about the role of carbon dioxide, the graph should certainly grab your attention. For one thing, the many ups and downs visible in the graph for the past 800,000 years show that the carbon dioxide concentration varies substantially through natural processes. But notice that in all of those ups and downs, the concentration never rose above about 300 parts per million until just a couple of centuries ago. Now, the zoom-out shows the concentration rising by some 2 to 3 parts per million per year, a rate at which it will pass 400 parts per million by 2015 and 500 parts per million by about 2060. Clearly, something dramatic is happening to the carbon dioxide concentration.

The dramatic change should lead you to ask other questions. First, you might wonder whether the carbon dioxide concentration is important, and the answer is revealed by the notes on the main graph. The same ice core data that allow reconstruction of the past carbon dioxide concentration also allow reconstruction of past temperatures on Earth, and comparison reveals that the carbon dioxide concentration and the temperature tend to rise and fall in tandem. That is, past ice ages were marked by low carbon dioxide concentrations, while past warm periods were marked by higher concentrations. This leads to the question of whether the change in carbon dioxide concentration *causes* the changes in temperature. Although this graph alone does not answer that question, other statistical studies, which we'll discuss in Chapter 7 (see Focus, p. 273), provide strong evidence that there is indeed a cause and effect.

If the cause and effect are real, then the current dramatic rise in the carbon dioxide concentration should be cause for great concern. During many of the past warm periods, Earth's average temperature was several degrees warmer than it is today, so the fact that the carbon dioxide concentration is now skyrocketing suggests that the same might happen to our planet's temperature. Moreover, notice that the past data show that the changes in concentration (and temperature) often happen quite rapidly, suggesting that the process can feed back on itself. In that case, there's a strong risk that we have already started a process that may cause Earth's temperature to rise rapidly and dramatically over the coming decades.

The remaining question is whether the current rise in the carbon dioxide concentration is a natural phenomenon like the past rises or something being caused by humans. On this point, there is no doubt. By carefully studying the isotopic makeup of the carbon dioxide in the atmosphere and comparing it to that of various carbon dioxide sources, scientists have found that added carbon dioxide is coming primarily from the burning of fossil fuels.

Perhaps you've heard debate about whether global warming is a real or imagined threat. With a bit of extra information, such as knowing that the added carbon dioxide comes from human activity, Figure 3.46 makes clear that there's nothing imaginary about it.

QUESTIONS FOR DISCUSSION

1. Study Figure 3.46 carefully. How does the carbon dioxide concentration today compare to that of 1750? How does that of 1750 compare to that during the past 800,000 years? What conclusions can you draw from your answers to these questions?

2. In the past, a carbon dioxide concentration of 300 parts per million accompanied global average temperatures as much as about 9°F (5°C) higher than the global average temperature today. What do you think would happen if Earth's temperature rose that much over the next century? Is that a worst-case scenario? Explain.

3. Discuss some of the factors that will affect the future concentration of carbon dioxide in the atmosphere. What do *you* think should be done to slow or stop the growth in the carbon dioxide concentration?

4. Find the latest data for the atmospheric carbon dioxide concentration. Is the level still rising? How fast is it rising?

5. The graphs in Figure 3.46 summarize a great deal of scientific data. How important are clear graphics to our understanding of these data? Defend your opinion.