Chapter 16: Essay

Debating Climate Change

Certain atmospheric gases trap solar heat through a process called the *greenhouse effect*, which is described in Chapter 16. These "greenhouse gases" act like blankets to keep our planet warm—if not for these gases our planet would be a chilly −18°C. The most significant greenhouse gas is water vapor. Because of the water cycle—the constant movement of water between the oceans, air, and land—the amount of water vapor worldwide remains fairly constant. Changes occur only in response to changes in the average global temperature—greater warmth means more water vapor, while cooler temperatures mean less.

Next in significance is carbon dioxide, CO_2. Direct and indirect measurements show a steady increase in atmospheric CO_2 levels since humans began large scale burning of carbon- based fuels starting with the industrial revolution in the early 1800s. Atmospheric CO_2, however, has not been rising as fast as one might expect, given the amount of CO_2 emitted by human activities. Thus, scientists estimate that about half of the CO_2 we produce is absorbed by the oceans as well as by vegetation, which uses carbon dioxide in photosynthesis.

Because CO_2 is a potent greenhouse gas, one would expect that increasing levels in the atmosphere would result in an increase in the average global temperature. This, in turn, would alter the many climate systems around our planet. Some areas, for example, would become wetter, while others might experience a greater number of droughts. This alone would introduce significant challenges to communities. Most feared, however, is "runaway" climate change. In such a scenario, changes in the global climate would stimulate an acceleration of further changes in what is called a "positive feedback loop." For example, as temperatures get warmer, more water vapor enters the atmosphere. Because water vapor is a greenhouse gas, the global temperatures would rise further leading to even more water vapor going into the atmosphere and hence even warmer temperatures, and so on. Under such a scenario, land-locked ice caps would be expected to melt. This would raise the sea level by many meters inundating all coastlines and the billions of people who live there— a slow but sure disaster of epic proportions.

^ Figure A

The potential effects of global warming are uncertain. Many different scenarios are possible.

These are the fears. But are these fears founded upon reliable evidence? How certain are scientists that human CO_2 output is inducing increases in global temperatures? And are modern temperatures actually increasing? Are the chances of runaway climate change significant enough to warrant a reworking of our energy infrastructure? These are important and legitimate questions now being asked by the general public, which includes corporate executives as well as our political leaders.

There is often, however, a disconnect between what scientists are willing to say and what the general public wants to hear. The scientist may be asked for a definitive statement, such as "Human-induced global climate change is a problem." But the scientist knows he or she can do no better than to speak in terms estimated probability and that even facts are subject to interpretation.

Consider how physical data reveal a direct relationship between levels of atmospheric CO_2 and global temperatures over the past 400,000 years as shown in **Figure B**. For some, this settles the direct relationship between atmospheric CO_2 and global temperatures as a fact. Others will look deeper to note that past temperatures reliably go up some 600 years *before* CO_2 levels go up. To them it may become a fact that increasing CO_2 does not cause global warming. But CO_2 doesn't have to be the cause. Rather, once warming starts, the oceans can begin to release more CO_2, which is a potent greenhouse gas, thus creating a significant warming positive feedback loop. Then again, it could be emphasized that increased water vapor—not the CO_2 —acts as the most significant feedback propagator. However, more water vapor in the atmosphere also leads to greater cloud cover, which has a cooling effect. And so, the investigation would continue from one point/counterpoint to the next.

To the scientists, the world is anything but black and white. They understand the value of slow and careful deliberations as well as the need for evidence that is quantifiable, not anecdotal. Further, they understand the value of having their conclusions subject to the scrutiny of peer review. External verification is key because we all can be led by our biases, consciously or unconsciously.

For people seeking firm black or white conclusions, consider how easy it would be to stop and focus upon a single interpretation of data that best aligns with one's personal worldview. For example, what conclusions might an oil executive be willing to accept compared to the president of a small island nation whose highest elevation is 10 meters above sea level? Objectivity is difficult to achieve, even for scientists. But what separates the scientist is his or her drive to learn what's actually happening over what they might wish to be happening. This, in turn, requires the objectivity-driven scientific method and a spirit of open-minded exploration (**Figure C**).

Through the study of chemistry you have become equipped to understand many aspects of climate science. Water, for example, has an amazing ability to absorb heat because of the way in which atoms within each water molecule are bonded (Chapters 6 and 8). Also, carbon dioxide is more than just a greenhouse gas—it also reacts with water to

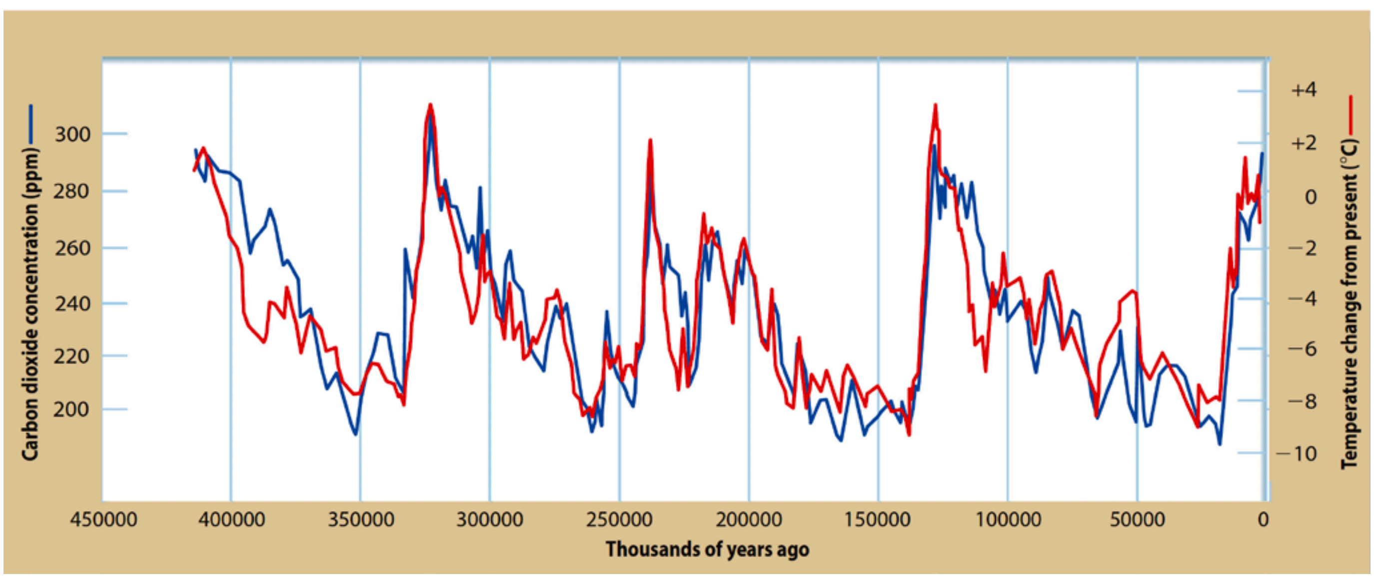
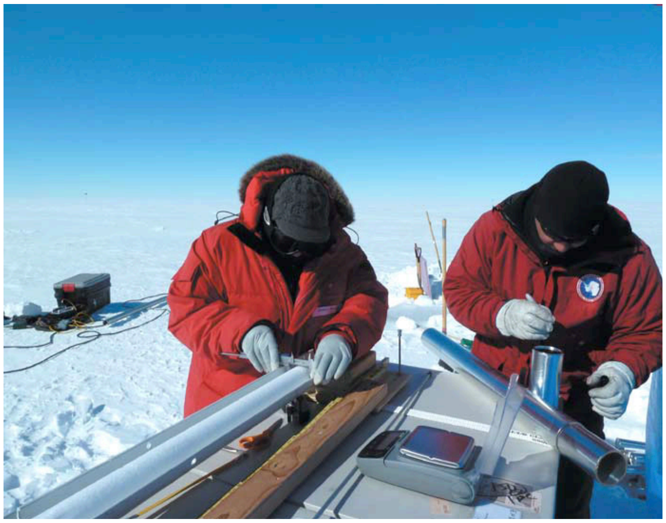


Figure B

Levels of atmospheric carbon dioxide and global temperatures appear to be closely related to each other.



^ Figure C

Climate scientists study an ice core containing ancient air captured within Greenland's ice cap. While there are many details of climate science that still puzzle us, there are also many details we understand quite well. Puzzlement in one area does not invalidate our overall successes.

form carbonic acid, which lowers the pH of our alkaline oceans (Chapter 10). Isotopes (Chapters 4 and 5) are a most powerful tool for allowing us to study past climates. Fossil fuels are valuable to us because they are so energy rich (Chapter 12). Alternative energy sources, however, offer many advantages, which we explore in Chapter 17. And agricultural best practices can be used to help protect the environment while also providing us nutrition (Chapter 15).

Climate science is not politics—it is a science. Yet climate science is now revealing potential dire consequences, such as rising sea levels. What we need, more than ever, is an open-minded dialogue between science and society. Your efforts to learn chemistry is a very positive step in that direction.

TABLE A Opposing Viewpoints of Human-Induced Global Climate Change

POINT
1. There has been no significant global warming over the past century. Temperatures have actually been cooling since 1998.
2. If there has been significant global warming, humans are not to blame. The most likely causes include changes in Earth's orbit and fluctuations in the Sun's energy output.
3. There is no definitive proof that humans have had a significant impact on global climate. Regulations on human activities, therefore, would be an unnecessary expense and harmful to the economy, especially for developing nations where energy needs are growing the fastest.
4. Alarm about global climate change is a movement whose underlying goal is to push forward a partisan political agenda.
COUNTER POINT
1. There has been a long-term warming trend. In 1998, a powerful El Nino created an unusual warm spell. For only a few subsequent years the temperatures were cooler.
2. To a significant extent, humans are responsible primarily due to their output of carbon dioxide, which is a potent greenhouse gas. The evidence on this is extensive and has proven highly compelling to the vast majority of climate scientists.
3. The potential for runaway climate change is risky enough to warrant action. But even if there is no climate change we would benefit from the development of green technologies in terms of new jobs, decentralized energy sources, clean energy for the developing world, and good stewardship of the environment.
4. The denial of global climate change is a movement spearheaded by the fossil fuel industry working to protect its financial interests.

Think and Discuss

1. What is the difference between "climate" and "weather" and which is easier to predict?

2. Some temperature gauges used for measuring global temperatures can be found in urban areas where they are affected by surrounding heat sources. Why would moving such a gauge to a more rural setting be a bad idea?

3. Two systems of regulating CO_2 emissions are the carbon tax and the emissions trading scheme (ETS), also known as cap and trade. Search online for information on both of these systems and discuss the pros and cons of each.

4. Scientists tend to think quietly in the confines of their laboratories rather than out loud on a wide-open political platform. At what point should a scientist be compelled to do otherwise? Should all scientists be taught some political skills in training for their careers?

Author Responses to Think and Discuss

1. Climate is the long-term averaging of weather. The weather changes on a daily basis and is difficult to predict with much accuracy beyond several days. We can be fairly sure, however, of our prediction that the climate of Vermont next January will be quite cold—even though whether it will be sunny on a particular day next January, however, is beyond our knowing.

2. These gauges are being used to measure changes in temperature over a long period of time. To move the gauge to a different setting would be to end the experiment for that particular gauge.

3. The carbon tax puts a price on carbon at the source, such as the gas station. Yes, gasoline prices would go up. The collected money, however, is then shared equally among all citizens or used to reduce the tax burden. Those who are carbon thrifty make money. Those who are carbon-wasters pay extra. Money from this system can also be used to subsidize the protection of rainforests in developing countries.

An ETS system sets a cap on the national output of carbon dioxide. CO_2 *emission permits are then provided to* CO_2*-emitting companies—sometimes free of charge or sometimes at a reduced rate to companies with the strongest lobbyists. Each permit allows only a limited amount of* CO_2 *release and the value of all the permits adds up to the national cap. Companies are then allowed to buy and sell these permits from one another. Financial penalties are placed on those who exceed their limits. However, a cap on* CO_2 *emission also means that no less than that cap will likely ever be produced.*

4. Scientists conduct research, be it basic or applied, for the benefit of society. That would make it their responsibility to speak up if they believe their findings could help protect society from some calamity. The Nobel Prize winning chemist Linus Pauling did just that in the 1960s as he petitioned against above-ground testing of nuclear bombs. Political skills are important for all citizens, even those who happen to be scientists.