Chapter 4

At Odds with Science

Don't be misled by titles like *Environmental Science* or *Earth Science*. Despite their names, these books may not be teaching science at all. Science sets out to discover what "is." Many environmental texts skip past the "what is" to arrive at the "ought to be."

For example, scientists don't know whether greenhouse gases are causing the Earth to get warmer. The acid rain scare has turned out to be exaggerated. Garbage disposal is not a crisis. But the environmental section of the teaching guide *Science Is…* encourages children to change their behaviour anyway: "If you've decided to do a few little things–like walking or biking instead of taking a car, or turning off the lights when you don't need them, or recycling—then you're already helping to stop the greenhouse effect, acid rain, energy waste, and landfill overflow."[1]

While global warming is treated as a fact in classrooms, scientists themselves are still exploring it as a question. They are using the existing body of scientific knowledge, from geology to atmospheric chemistry, to figure it out. Bit by bit, week by week, writing in specialized journals, their latest findings accumulate.

Scientists tell us, for example, that temperature measurements taken from satellites show no change in global temperatures in recent years, but bore holes (dug deep into the ground) in Canada and the United States show signs of warming temperatures over the past century. Another study suggests that air pollution might be cooling the Earth, and another examines how ocean currents affect temperatures. So, while it is too early to tell if the greenhouse effect will cause noticeable warming, gradually the pieces of the puzzle are being put together.

Unfortunately, this discovery process is largely neglected in the schools when environmental issues are discussed. Reading a typical textbook would lead you to believe that on most environmental issues the science is settled. But it is not.

- Children learn that one hundred species of plants and animals may be going extinct each day. In fact, no one even knows how may species there are now, and the estimates are guesses, partly based on studies of how many species disappear when the habitats of small islands are destroyed.

- Organic farming is considered safe because it doesn't use pesticides. But the fruits and vegetables we eat have many more *natural* carcinogens than are ever added through pesticides.

- Overpopulation is often pegged as the root of environmental problems. Yet economic studies have failed to show that rapid population growth causes economic problems or leads to depletion of natural resources.

The Scientific Method

To understand where environmental science veers from science, we need to recognize that over the years scientists have developed a process for learning what “is”. This is the scientific method, and it works like this.

Scientists start by being curious about something. To use a simple example, suppose that they want to know the cause of fire. Gradually, they develop a hypothesis, a statement about the physical world that can be tested. For example, a scientist might develop a hypothesis about one piece of the puzzle: The scientist might propose that fire needs oxygen to burn.

To test hypotheses, scientists devise experiments. The scientist studying fire and oxygen might use three closed chambers. In each, the scientist might start a fire and then replace the air in each chamber with a different gas: in the first, carbon dioxide; in the second, nitrogen; and in the third, oxygen.

The scientist then observes the results. The fires in the chambers with carbon dioxide and nitrogen go out, but the fire in the oxygen chamber continues to burn. The experiment supports the hypothesis that fire needs oxygen to burn.

Scientists document their experiments and results precisely and submit their findings to scientific journals. If other scientists (their professional peers) find a paper to be of high caliber, it is published and becomes part of the scientific literature. More scientists can then review the experiments and perhaps repeat them.

If an experiment is repeated many times and produces the same results, scientists have established a scientific fact. The accumulation of many scientific facts leads to the development of a theory. This is a statement about the physical world that is supported by scientific experiments and other forms of verification but does not have sufficient evidence to establish it as a scientific law.

Ultimately, a theory may lead to the recognition of a scientific law. Sir Isaac Newton, the famous seventeenth century British scientist, for example, first stated the theory of gravity. However, only after many experiments did other scientists agree with Newton and consider the theory a scientific law.

The World As Laboratory

Of course, real science is rarely as simple or straightforward as this outline suggests. For one thing, not all scientific questions are testable in carefully controlled laboratory experiments. So scientists have developed techniques to discover facts "in the field." While these techniques are not as good as a controlled experiment, they can, when used rigorously, lead to greater understanding.

Some years ago people began to notice that trees in Western Europe, including England, were dying. Many people thought that the cause was "acid rain" (excessive sulfur dioxide and nitrogen oxides in the atmosphere). When scientists examined the forests more closely, however, they found that acid rain couldn't explain very much of the damage. Forests are affected by many factors—different kinds of pollution, cold weather, poor management, and insects. They concluded that abnormal weather had caused some damage. More important, they found that the diseased trees were exceptions. European forests were, in general, fairly healthy. The amount of wood they produced each year was rising steadily.[2] (We will look more carefully at acid rain in Chapter 15.)

In the mid-1980s, scientists developed a theory that chlorine from CFCs was reducing ozone in the upper atmosphere over the Antarctic. To test this theory, NASA scientists made expeditions into the stratosphere over the Antarctic in specially fitted high-flying airplanes. There they measured the levels of ozone and other chemicals. These expeditions supported the theory that chlorine from CFCs is depleting ozone, but they also supported the view that other factors, such as cold polar temperatures and the winds known as the polar vortex, affect ozone levels, too.[3] (We will look at ozone more closely in Chapter 14.)

Why Science Isn't Easy

Other factors make environmental science difficult—but stimulating.

Cause and Effect or Just Correlation?

Scientists want to understand what causes things to happen. Often it is possible to detect two things happening together, but it is difficult to know if one caused the other. The two events may be "correlated" but not linked by "cause and effect."

Over the past hundred years, the average global temperatures rose about half a degree centigrade. Over the same period, the amount of carbon dioxide in the atmosphere went up about 25 percent. Did the carbon dioxide cause the warming? Did the warming cause the rise in CO_2? Or did the carbon dioxide and temperatures just happen to go up at the same time? Scientists are still grappling with this question, as we shall see in Chapter 13.

Scientists have also looked back at the distant record, hundreds of thousands of years ago, by drilling deep holes in the ice. The ancient ice contains the carbon dioxide that was present in the atmosphere at that time, long before any greenhouse gases were unleashed by humans. Scientists can also estimate past temperatures from this ice. Again, there is a correlation between carbon dioxide levels and temperature. But in many cases the carbon dioxide came *after* the warming![4]

Computers—Shedding Light but Also Confusion

One way to cope with the complexity of the real world is to use computers. Scientists enter vast amounts of data about the real world and use sophisticated mathematical programs to simulate the complexity of weather and climate.

Many global warming predictions are based on models that attempt to simulate the workings of the entire Earth's atmosphere. This is an enormous task, since thousands of factors, from ocean currents to water vapor, influence the Earth's atmospheric and weather conditions. But how? Do clouds cool the Earth or warm it? They can do both. If greenhouse gases lead to an increase in clouds (as they might), the clouds could either warm or cool the Earth. Predictions are thus rather shaky.

Furthermore, simply because the Earth is so large, computer models treat large stretches of the Earth as if they were the same. For example, some computer models can't distinguish between forest and desert.[5] And one prominent scientist, Richard Lindzen, points out that the computer models cannot even successfully calculate the present average global temperature—let alone predict the temperature of the atmosphere 10 or 20 years from now.[6]

Theories in Conflict

For every scientific theory, usually several others exist that conflict with it. Scientists are constantly refining their theories in light of increased knowledge and experience.

For example, physics was full of uncertainty about fundamental theories and laws for more than half a century. When Marie Curie, late in the nineteenth century, observed that a rock containing the element radium (supposedly, inert matter) could create an image on a sealed photographic plate, she realized that matter was more complex than scientists had thought. At the time, physicists believed that matter only reacted at the chemical level, not at the atomic level. But, in fact, alpha particles from the radioactive radium had traveled through the protective cover and exposed the photographic plate.

The existing scientific theories could not explain what had happened, so Curie set out to discover the answer. She and her husband

Pierre proposed a mysterious source of energy within the atoms. Others, however, identified the alpha particle as the nucleus of the helium atom. And in 1905 Albert Einstein explained the source of the apparently enormous energy with his famous equation $E = mc^2$. It took about thirty more years to establish the theory firmly, and it led to the development of the atomic bomb.

Continuing the Search for Truth

When properly conducted, scientists' search for truth is governed by strict rules of conduct and ethics. Scientists make hypotheses, test them, and submit their findings for review and replication by other scientists. These scientific debates, while lively, are conducted free from political interference.

Environmental issues, however, are different. There is political interference. In 1992, U.S. Vice President Al Gore (then Senator) concluded that global warming was a fact. He wrote in his book *Earth in the Balance* that paying too much attention to the doubters "undermines the effort to build a solid base of public support for the difficult actions we must soon take."[7] His message: Agree with him or be quiet. Because of his prominence, American scientists had to listen, and Canadian scientists tended to follow suit.

But neither Al Gore nor any other politician is going to quash the scientific method. Ultimately, science, not politics, will answer the *scientific* questions surrounding global warming, species extinction, and other environmental issues.

Several years ago, Robert Balling of Arizona State University pointed out that knowledge about global warming was accelerating rapidly. Nearly half of all the major scientific articles or books about global warming since 1800 had been published in 1989 and 1990! He also noted that two scientists had concluded that if global warming was actually occurring, even a ten-year delay in reducing greenhouse gases would have a minuscule effect on future temperature (because the effect would occur so slowly). "We are learning more about the greenhouse effect every week, and we are certain to learn a great deal more in the immediate future," he wrote.[8] The sad part is that children aren't likely to obtain much of this knowledge in their classrooms.

Notes

1 Susan V. Bosak, *Science Is* (Co-published: Richmond Hill, ON/ Markham, ON: Scholastic Canada/The Communication Project, 2nd ed., 1991), 388.

2 National Acid Precipitation Assessment Program, *1992 Report to Congress*, Washington, DC, June 1993. Also K. Mellanby, ed., *Air Pollution, Acid Rain and the Environment* (Elsevier Applied Science Publishers for the Watt Committee on Energy).

3 Pamela S. Zurer, "Antarctic Ozone Hole: Complex Picture Emerges," *Chemical Engineering News*, November 2, 1987, 22–26.

4 Andrew Solow, "Is There a Global Warming Problem?" in *Global Warming: Economic Policy Responses*, ed. by Rudiger Dornbusch and James M. Poterba (Cambridge, MA: The MIT Press, 1991), 18.

5 Robert Jastrow, William A. Nierenberg, and Frederick Seitz, "An Overview," *Scientific Perspectives on the Greenhouse Problem* (Ottawa, IL: Jameson Books, Inc., 1990), 11.

6 Richard S. Lindzen, "Global Warming: The Origin and Nature of the Alleged Scientific Consensus," *Regulation*, Spring 1992, 89.

7 Al Gore, *Earth in the Balance: Ecology and the Human Spirit* (Boston: Houghton Mifflin Company, 1992), 39.

8 Robert C. Balling, Jr., *The Heated Debate: Greenhouse Predictions Versus Climate Reality* (San Francisco: Pacific Research Institute), 141–42.