Session 6

Case study

This study is part of a broader project which involved the training and professional

Development of primary school teachers (Afonso, 2002) and the analysis of the influence of their pedagogic practices on children's scientific and socio-affective development (Pires, 2001). The analysis of the relation between training programs, teachers' professional development and children's learning has been defended by many authors such as Liston and Zeichner (1993), Monk and Dillon (1995), Tuomi (1997) and Wilson and Berne (1999).   To understand what science is, just look around you. What do you see? Perhaps, your hand on the mouse, a computer screen, papers, ballpoint pens, the family cat, the sun shining through the window …. Science is, in one sense, our knowledge of all that — all the stuff that is in the universe: from the tiniest subatomic particles in a single atom of the metal in your computer's circuits, to the nuclear reactions that formed the immense ball of gas that is our sun, to the complex chemical interactions and electrical fluctuations within your own body that allow you to read and understand these words. But just as importantly, science is also a reliable process by which we learn about all that stuff in the universe. However, science is different from many other ways of learning because of the way it is done. Science relies on testing ideas with evidence gathered from the natural world. This website will help you learn more about science as a process of learning about the natural world and access the parts of science that affect your life. Science helps satisfy the natural curiosity with which we are all born: why is the sky blue, how did the leopard get its spots, what is a solar eclipse? With science, we can answer such questions without resorting to magical explanations. And science can lead to technological advances, as well as helping us learn about enormously important and useful topics, such as our health, the environment, and natural hazards. Without science, the modern world would not be modern at all, and we still have much to learn. Millions of scientists all over the world are working to solve different parts of the puzzle of how the universe works, peering into its nooks and crannies, deploying their microscopes, telescopes, and other tools to unravel its secrets.

Cold fusion: A case study for scientific behavior

By the Understanding Science team Stanley Pons and Martin Fleischmann University of Utah chemists Stanley Pons (left) and Martin Fleischmann.

Most people — including scientists and politicians — now recognize that a serious energy crisis looms in our future. Human populations use an enormous amount of energy, and as the population grows and standards of living increase, we will require even more. Unfortunately, the energy sources currently available to us all have major drawbacks in the long term. Oil is efficient, but contributes to climate change and will run out eventually. Coal is plentiful but polluting. Solar energy is appealing but only as dependable as a sunny day — and it's currently expensive to boot! A clean, reliable energy source that won't run out any time soon would solve our energy problems and revolutionize the world. You might think such an energy source is a pipe dream, but in fact, it has already been discovered — in seawater!

Seawater contains an element called deuterium—hydrogen with an extra neutron. When two deuterium atoms are pushed close enough together, they will fuse into a single atom, releasing a lot of energy in the process. Unfortunately, figuring out exactly how to get deuterium atoms close enough together — in a way that doesn't take even more energy than their union generates — has been a challenge.

Hydrogen and deuterium atoms

A hydrogen atom has only a single proton in its nucleus, whereas deuterium, a rarer isotope of hydrogen, has a proton and a neutron.

The process by which two atoms join together, or fuse, into a single heavier atom is called fusion. Fusion is the energy source of stars, like our sun — where it takes place at about 27,000,000° F. In 1989, chemists Stanley Pons and Martin Fleischmann made headlines with claims that they had produced fusion at room temperature — "cold" fusion compared to the high temperatures the process was thought to require. It was the kind of discovery that scientists dream of: a simple experiment with results that could reshape our understanding of physics and change lives the world over. However, this "discovery" was missing one key ingredient: good scientific behavior.

This case study highlights these aspects of the nature of science:

The scientific community is responsible for checking the work of community members. Through the scrutiny of this community, science corrects itself.

Scientists actively seek evidence to test their ideas — even if the test is difficult. They strive to describe and perform the tests that would prove their ideas wrong and/or allow others to do so.

Scientists take into account all the available evidence when deciding whether to accept an idea or not — even if that means giving up a favorite hypothesis.

Science relies on a balance between skepticism and openness to new ideas.

Scientists often verify surprising results by trying to replicate the test.

In science, discoveries and ideas must be verified with multiple lines of evidence.

Data require analysis and interpretation. Different scientists can interpret the same data in different ways.

This entire section is available as a PDF download.

Take a side trip

Throughout this story, we'll emphasize the standards for good scientific behavior. To review these standards, visit our section on scientists' code of conduct.

The ingenious idea

The chemists claiming to have solved the world's energy problems with cold fusion, Stanley Pons and Martin Fleischmann, made a somewhat unlikely pair. Pons was a quiet and modest man from a small town in North Carolina. Fleischmann was an outgoing European who exuded confidence and was almost old enough to be Pons' father. The two had met while Pons was completing his Ph.D. at the University of Southampton in England, where Fleischmann was a professor. Pons admired Fleischmann's intelligence and ingenuity, and Fleischmann soon became his mentor and friend. The two remained close over the years, as Pons moved from a graduate student position into a professorship at the University of Utah. Shortly after Pons took up his post as professor, the two began to collaborate on research projects.

Palladium lattice absorbing a deuterium

The idea behind their cold fusionexperiment was sparked by another one of Fleischmann's studies. In the late 1960s, Fleischmann had been using palladium, a rare metal, as a key ingredient to separate hydrogen from deuterium. In those experiments, he saw firsthand how palladium can absorb unusually large amounts of hydrogen — about 900 times its own volume. That's a bit like using a single kitchen sponge to mop up 30 gallons of spilled milk! This amazing absorption power is due to a chemical reaction on the surface of the palladium that draws hydrogen inside the metal. Because hydrogen and deuterium are so similar (differing by just one neutron), the same reaction occurs with deuterium — it can also be sucked up by palladium in surprisingly large amounts. Fleischmann reasoned that since the deuterium absorbed by palladium undergoes a dramatic reduction in volume (by a factor of about 900), the deuterium atoms must be squished together inside the palladium. He began to wonder if a similar process could be used to force deuterium atoms close enough to fuse and release energy …