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The Ozone Parable

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Was it Joan Baez who sang, during the days of nuclear weapons testing in the atmosphere, "What have they done to the rain?" Today we need a new song, "What have we done to the ozone?" It is a song we can all sing because all of us, especially we in the "advanced" countries, made it happen. It must be sung softly, to ourselves, for it is a song of self-reproach rather than protest. "They" did not blow a hole in the ozone, it was us, us taking a million daily thoughtless actions around the globe, us living in air-conditioned, spray-canned, styrofoamed convenience.

A brief history: Chlorofluorocarbons (CFCs) were synthesized in 1930. These wonderfully inert chemicals created the air-conditioning revolution that facilitated America's great shopping cathedrals and summer automobiling Odysseys. CFCs caused little fuss until 1973-4 when academic chemists discovered that free chlorine has a terrific appetite for laboratory ozone, and asked where all these harmless CFCs might be drifting. During the previous forty years of profit-taking, nobody had thought of this question.

The new theory was that CFCs could find their way to the stratosphere where they could destroy the dilute band of ozone that makes life, chemists, and spray cans possible. This created the great spray can debate, a classic stand-off between environmentalists and business that resulted in a classic compromise: In the US, CFC-powered spray cans were taken off the market, but the big problems, coolants and foams, remained. It was the first time that a substance suspected of causing global harm had been regulated before the effects had been fully demonstrated, so it was a victory of sorts for theoretical science.

That was in 1978. Then everybody forgot CFCs for several years.

Fortunately, a few scientists had kept an eye on the Antarctic since 1950, a lonely service unrelated to the CFC wars. They observed a curious trend, beginning in 1977 and strengthening each year until 1985 when they finally reported it. A temporary hole opened in the ozone every spring. A few scientists were sufficiently impressed by these findings that ozone expeditions were mounted beginning in 1986, the ozone hole was confirmed, and the subtle stratospheric chemistry of the Antarctic was sorted out.

And, in one of humankind's most graceful moves, CFCs are being phased out and banished by international treaty. Inspired mainly by a scientific theory and calling nevertheless for actual cuts and then a ban on a popular and profitable industry, the 1987 Ozone Treaty was a real first. The treaty was not influenced greatly by the ozone hole. It was signed mainly because scientists thought that gradual, world-wide, long-term damage to the stratosphere was theoretically probable. Negotiations began in 1982, long before anybody suspected that there was an ozone hole. It is one of history's great success stories, and is recounted well by US negotiator Richard Benedick's in *Ozone Diplomacy* (Harvard University Press, Cambridge, 1991).

But the patient is dying. While we were all enjoying the air conditioning at the mall, CFCs were slipping into the stratosphere. They won't go away anytime soon. Despite the ban, chlorine levels will rise for another five years, level off for ten years, then go into a slow decline that will return it to *present* levels by the year 2020, and to a hopefully "safe" level (the 1975 level) in 2075. To the next century, we have bequeathed a sickness in the stratosphere.

Ozone erosion is now above 4% per decade, and accelerating. We know little of how bad it will get. Erosion is now year-round and world-wide, exposing crops and people in the summer when they are most vulnerable. Ozone is 5% thinner over the Northern Hemisphere than it was a decade ago. In the US, where skin cancer has already doubled since 1980, reduced ozone is expected to cause an extra 12 million skin cancer cases and 200,000 deaths over the next 50 years. The ozone hole hit record levels again in 1991. In Australia, which already has the world's highest skin cancer rate, ozone depletion occasionally pushes ultraviolet levels 20% above normal, and television airs daily UV readings and warnings. F. Sherwood Rowland, one of the chemists who discovered the problem in 1974, says "What's happening is close to the worst fears."

Ozone is a parable for our times. It calls us to attend less to shopping and more to Earth. Will we learn anything from the parable?

In my neighborhood, some people want to build a new jetport. It will be good for business. Yet jet airplanes already strain the fragile chemistry of the stratosphere. Earth will not support a further expansion of jet travel, yet seldom is this factored into future travel plans.

The nation is saddened by layoffs at General Motors, due to foreign competition and a declining economy. And yet few note that this is only the tip of a larger iceberg, that we are at the end of the age of the fossil-fueled automobile because global warming will not support it.

World population growth has been faster than exponential for the past 2000 years, with another inevitable doubling coming soon. Few seem to notice that Earth cannot sustain so many of our species.

This is a small sampling of the lessons of the ozone parable. The lessons are fundamental, going beyond style, convenience, politics, and economics, to nature herself.

And who makes it their business to deal with the fundamental questions of the natural world? Could we physicists have some responsibility in these matters? Did we help mind the store during those 40 years while the downside of CFCs went unnoticed? Did we teach this significant and fascinating scientific topic to the public and to our students once the dangers were discovered? Or did we keep, instead, to our ivory research towers, and to the safe ground of teaching physics as we learned it, with few connections to the world?

To paraphrase Einstein, the unleashed power of science and technology have changed everything save our modes of thinking. Physicists, central to this power, can be instrumental in changing those modes of thinking, but only if we are willing to change our own modes of thinking. We could, for example, devote more of our professional lives to physics-related cultural and social concerns. The APS Forum on Physics and Society is one avenue for such activity. Or we could, for another example, devote real effort to educating the non-scientific majority about the physics that is relevant to their lives and our planet.

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