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Fixing Climate

The Story of Climate Science – and How to Stop Global Warming

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Extract

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PREFACE

One morning in the spring of 2002, a letter came in with the pile of e-mail that Wally Broecker's assistant prints out for him each day. It was a real paper letter, delivered by the U.S. Postal Service, from someone who, like Broecker, was old enough to consider letters a normal means of communication. The writer's name was Gary Comer, and as Broecker soon learned, he was the founder of Lands' End, the mail-order clothing company. He was also, it seemed, a passionate yachtsman, particularly in Arctic waters, which is how he came to be writing to a climate scientist.

The previous summer, Comer explained, he had been cruising off Greenland on his 152-foot motor yacht, Turmoil. Almost on a lark, he and his shipmates had decided to see if they could navigate the Northwest Passage, along the northern coast of Canada all the way to Alaska. European explorers, Comer knew, had spent four centuries trying to find that seaway through the Arctic ice, before Roald Amundsen finally succeeded in 1906. The most notorious of many failures had occurred in the 1840s, when the two ships of a British expedition commanded by Sir John Franklin were trapped in ice off King William Island for a year and a half; all hands ultimately died, many while trying to walk out, and some were apparently cannibalized by their starving shipmates. Such precedents hadn't worried Comer, because he had his seaplane with him. But he hadn't expected either to steam right through the passage in 19 days, his path barely

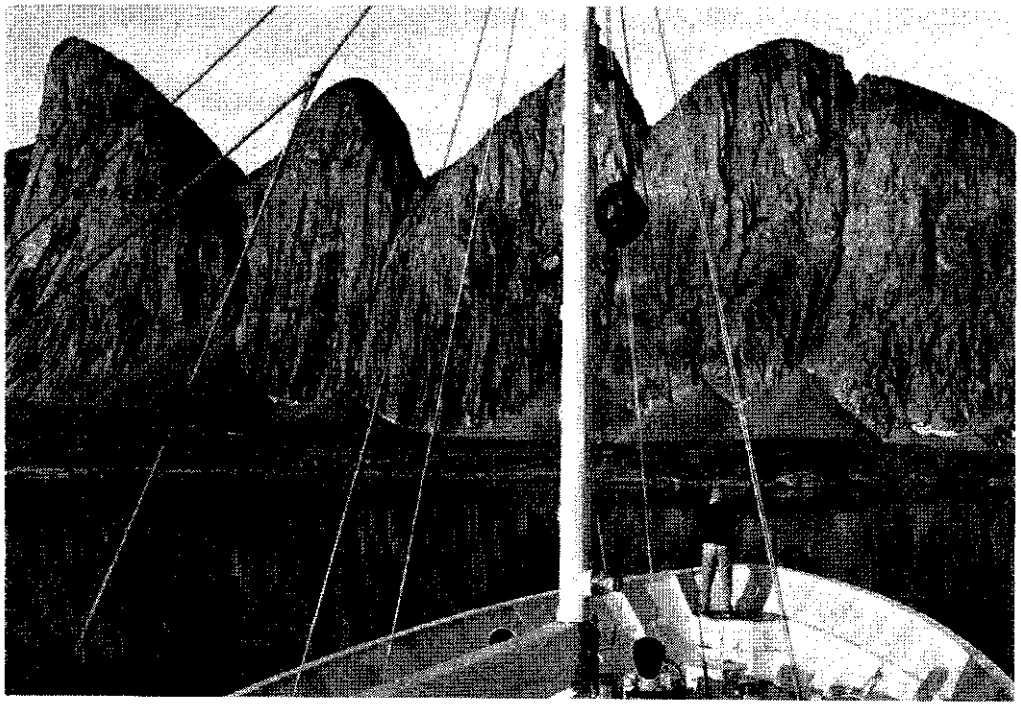
encumbered by ice. That unnerving experience had gotten him concerned about global warming—and, being the sort of man who creates $2 billion companies from scratch, he wanted to take action. As he began to educate himself on the subject, one name he kept hearing was Broecker's, who as long ago as 1975 had been one of the first scientists to warn of the dangers of global warming. Would Broecker like to come out to Chicago for a meeting—soon, please?

As Broecker read this, he was sitting in his office at the Lamont-Doherty Earth Observatory, on the Hudson River about ten miles north of New York City. It was a room and a long wooden table he had sat at for more than 40 years, in a building he had helped build himself in 1954—a rambling, one-story, cinderblock building, frequently added onto since. Morning light was streaming through the long bank of windows on one wall, past the 20-foot long stuffed blue snake that hung above his expansive wooden desk. It was falling in dusty beams onto the bearded lady mannequin and the poster of Dolly Parton reclining on a haystack; onto the dozens of smaller photos of the graduate students and postdocs he had mentored; onto the long line of bound PhD theses that filled his bookshelf, and onto the motley assortment of curios and mementoes that a scavenging mind had collected over four decades. Later, after they had gotten to know each other, Comer would refer to Broecker's beloved Geochemistry Building as the "pigsty," but Broecker was happy there, like a pig in mud. Science is his life—and he had managed to make that office and Lamont into a world center of climate science. Comer had found his way to Broecker because everybody in the business knew him, at least by reputation.

Broecker wrote back that his teaching duties precluded a trip to Chicago for at least two weeks. A few days later he got a phone call: Comer couldn't wait that long, and would come to him. They met for breakfast at the Clinton Inn in Tenafly, New Jersey, not far from Broecker's home, and not far from the airport where Comer's jet had landed. Scientist and billionaire immediately hit it off. Both had been born within a few years of

each other—Comer in 1927, Broecker in 1931—to working-class families in Chicago; Comer had never gone to college. Both men were straight talkers, both were at the top of their fields, and both abhorred red tape. They even liked the same breakfast, eggs sunny-side up.

Since his trip through the Northwest Passage, Comer had sold Lands' End and been diagnosed with advanced prostate cancer. He wanted to do something about climate, and do it fast. Broecker, for his part, had survived his own bouts with cancer and heart disease, and had been thinking of retiring. Comer's enthusiasm rejuvenated him. Over the next four years, Comer would fund a range of climate research projects and he would do it in a uniquely red-tapeless way: by giving money to established scientists to hire graduate or post-doctoral fellows. Broecker would



Comer's yacht Turmoil in Scoresby Sound, Greenland, in 2003.

select many of those mentors and give the program its scientific focus. Somewhere along the way Comer suggested Broecker write a popular book about climate. Broecker decided he needed the help of a popular science writer and invited Kunzig, whose book about oceanography he had liked, to collaborate with him. This book is the result.

Broecker has been studying climate, and in particular the way it has changed in the past, for more than half a century now. His career has coincided precisely with the emergence of man-made global warming as a problem. In the summer of 1955, while Broecker was a graduate student collecting some of the first radiocarbon dates of the end of the Ice Age, Charles David Keeling was making the first reliable measurements of the carbon dioxide content of the atmosphere. Within a few years Keeling would report that the CO_2 concentration was rising—as it has continued to do relentlessly ever since, in direct relation to the use of fossil fuels. In recent years the rise has even accelerated, thanks largely to the coal-fueled economic booms in China and India, but also to the failure of the industrialized countries to restrain their own emissions.

The volume of climate research has followed the same upward trend as the Keeling curve; scientific understanding of climate is incomparably more sophisticated and specialized than when Broecker started out. Since 1990 the Intergovernmental Panel on Climate Change (IPCC), made up of hundreds of scientists from around the world, has tracked the swelling mountain of research in a way that no individual scientist possibly could. In its most recent and most urgent report, released in 2007, the IPCC said the evidence showed unequivocally that Earth is warming. (In December 2007, the UK Met Office released its own analysis indicating that the eleven warmest years since record-keeping began in the 19th century had all happened in the last thirteen years.) The IPCC concluded with more than 90 percent certainty that the warming so far has been caused by greenhouse gas emissions—

and thus that it will continue. Reviewing the forecasts from more than a dozen computer models, the panel gave as its "best estimate" that Earth's average temperature would warm anywhere from 1.8 to 4.0 degrees Celsius (3.2 to 7.2 degrees Fahrenheit) by the year 2100, depending on how much CO_2 we emit between now and then. The "reasons for concern," the IPCC said soberly, had gotten stronger since its last report in 2001.

To anyone paying attention to the news these past few years—of the rapidly shrinking Arctic ice cap, for instance, or of glaciers in Greenland and West Antarctica accelerating into the sea, or of the prolonged severe drought in places like Australia and the American Southwest—the IPCC report seemed sober to the point of understatement. Like most committees, and the IPCC is the mother of all committees (which is one reason Broecker has always steered clear of it), the IPCC is a deeply conservative body. That's why its reports have been so valuable—precisely because they are not alarmist, and if anything tend to stay behind the science rather than get ahead of it. In particular they do not do full justice to one of the biggest "reasons for concern"—what the IPCC calls "risks of large-scale singularities,"- and what Broecker once referred to, more colorfully but no less euphemistically, as "unpleasant surprises in the greenhouse."

That was in an article published in Nature in 1987. He was by then already deeply worried about the future of climate. Computers were not as fast and climate models were not nearly as developed and well-tested as they are now, but simple physics already made clear that temperatures would rise as atmospheric CO_2 did. And what troubled Broecker most was the lesson that he and other researchers were just then beginning to glean, not from computer forecasts of the future, but from cores drilled through the ice on Greenland and the sediments on the Atlantic seafloor—that is, from the hard records of climates past. The lesson has since been confirmed again and again, in studies that Broecker has devoted much of his time to analyzing and catalyzing: Climate is not stable. On the contrary, it is a tetchy beast, subject to large and abrupt mood swings.

In Greenland at the tail end of the last ice age, temperatures rose to their present average—an increase of around 20 degrees Celsius—in just a few decades, then stayed that way for millennia. Similar swings happened repeatedly during the Ice Age itself. Broecker's theory is that they were caused by a sudden jamming or restarting of what he dubbed the conveyor belt, a globe-spanning system of ocean currents that transports heat to the North Atlantic. The events of the Ice Age won't be repeated in the same way in a warming world—the conveyor is not likely to switch off in the next century—but there are likely to be other switches in the climate system that we understand much less.

So far we can only speculate what they are, and what flips them. What will happen to climate as a whole, for instance, when the Arctic ice cap that Comer skirted on Turmoil disappears altogether, as it looks set to do in the coming decades? How stable are the Greenland or West Antarctic ice sheets? If either one melts, sea level will rise between five and seven meters, and many of the world's great cities, including London, New York, and Shanghai, will be partially inundated, to say nothing of Kinshasa, Lagos, and most of Bangladesh. If that process happens over a millennium, as the IPCC still assumes, then the inhabitants will have time to adapt or move. If one of the ice sheets collapses in a century or two, then the "reason for concern" will be much, much stronger.

One of Broecker's biggest contributions to science has been this fundamental idea that climate does not just change smoothly and continuously, but that it also shifts abruptly between discreet states—that it has tipping points, to use the current buzzword. For a time, though he is by nature far from gloomy, that realization made him rather gloomy about the future. The massive emission of greenhouse gases into the atmosphere seemed like a good way of pushing climate toward a series of tipping points—and there seemed no prospect for restraining those emissions. Indeed they are still growing now, in spite of the Kyoto agreement, in spite of all the publicity that global warming has received lately, in spite

of the IPCC having recently shared the Nobel Peace Prize with Al Gore. A quarter century after Broecker first started thinking about abrupt climate change, solar panels and windmills have become much more familiar parts of the landscape in some parts of the world, but they are still a tiny part of the world's energy supply, and nowhere near supplanting fossil fuels. Consumption of fossil fuels is still growing.

That is not in itself a bad thing. Urgent as it is, global warming is not the most urgent problem for most of humanity; human misery is. Fossil fuels have lifted people in the industrialized countries out of misery, allowing the average person to live like a preindustrial king. The correlation between energy use and quality of life, as measured by such indicators as infant mortality, life expectancy, and literacy, breaks down past a certain threshold of development—western Europeans get along as well as Americans on half as much energy—but up to that threshold it is direct and strong. And that tells you right away that global fossil fuel use is going to increase, not decrease, in the decades ahead, no matter what course the industrial countries might take. China now uses around a quarter of the energy per capita that, say, Germany does; India uses around an eighth. Those two countries have well over a third of the world's population. As they reach for the quality of life found in the West, their use of fossil fuels will soar—because fossil fuels will remain, for the foreseeable future, the cheapest and most plentiful source of the energy they need.

Burning fossil fuels is not bad; what is bad is dumping the waste into the atmosphere. There is a direct analogy to eating food, which is also not a bad thing. When we burn food in our bodies, we create waste too, and for centuries we simply dumped it wherever we liked, as we do now with carbon dioxide. But as our numbers increased, and cesspools and privies got too close to wells, cities in America and Europe regularly endured not just foul smells but epidemics of typhoid fever and cholera. Today billions of people in poor countries still drink contaminated water; the World Health Organization estimates that six hundred thou-

sand die of typhoid fever every year. The rich countries, however, have nearly eliminated such diseases, in part by building sewers and sewage treatment plants.

If we are to avoid dangerously warming the planet, we need to figure out how to build the equivalent of a sewage system for carbon dioxide—and what makes Broecker more hopeful than he used to be is that the task now seems doable. In the final chapters of the book we present a vision for a carbon disposal system, a vision that draws heavily on the work of Klaus Lackner, a colleague of Broecker's at Columbia University. The technology for capturing carbon dioxide at the smokestack of a coal-fired power plant, before it even gets into the atmosphere, already exists, though it is still too expensive. The technology for "sequestering" carbon dioxide in deep rock formations is currently being tested at various sites around the world, and the results look promising.

The final and most novel element of Lackner's vision is just now taking shape, in prototype form, in a warehouse in Tucson, Arizona: it's a scrubber for removing carbon dioxide from ambient air. Such a machine is absolutely essential, because so much of our carbon dioxide comes from cars and planes. There is no prospect for a device that would capture that waste at the tailpipe or the jet engine, like the bags that are sometimes strapped to the rear ends of carriage horses; each vehicle produces too much CO_2. On the other hand, since carbon dioxide mixes quickly through the atmosphere, it doesn't matter where we take it out: if we take it out anywhere we benefit everybody. If we can find an economic way to scrub the atmosphere on a large scale—the underlying science is not complicated—then Lackner's idea may present us with a tantalizing possibility. We may one day be able not only to stop the rise of carbon dioxide in the atmosphere but even to return it to the level we want—and in so doing choose the climate we want.

It sounds like a utopian scheme; it sounds like too big a job. But cleaning up sewage is a big job too. A lot of the infrastructure for doing so, which we now take for granted, is more recent than young people might realize. In America, the richest country in

the world, most sewage still flowed raw into rivers and the sea as late as the 1960s. But since the passage of the Clean Water Act in 1972, under President Nixon, the United States has invested more than $200 billion in sewage treatment. More than $100 billion of that came from the Federal Government. A couple of years ago an environmental group put out a report called "Swimming in Sewage," pointing out how far Americans still have to go to get their water clean—but clearly they have come a long way.

In the mid-nineteenth century, when the first municipal sewers were being built in America, there were plenty of sewage skeptics. For a while the science demonstrating the connection between sewage and disease remained uncertain; Pasteur and Koch were just then establishing the microbial theory of infectious disease. Even after the science was settled, however, and even after many thousands of people had died, some people still argued vehemently that the good old cesspools were good enough. As late as 1885, in Harper's magazine, a physician named J.S. Billings was bemoaning the situation:

> But, it may be asked, if the dangers and discomforts which arise from the storage of filth in or near human habitations are so great, why is it...that proposals to do away with these evils meet with stubborn opposition, and sometimes give rise to bitter hostility against the proposers of such improvements? The answer to this is that the danger is in most cases not apparent to the great majority of people.... Moreover, cleanliness is not to be secured without some cost and labor...

Eventually, though, the sewage skeptics all faded away, a few no doubt from cholera and typhoid fever. People in the United States, as in other developed countries, came to accept the notion that they did not have a fundamental right to dump their waste where they pleased, and that they should be willing to pay to have it disposed of properly. The same change in public opinion seems to be happening now with regard to carbon dioxide. The amount

of carbon dioxide the United States emits each year, around 6 billion tons, is only around a tenth the amount of wastewater coursing through the country's sewers. Cleaning it up would be a big job—but not too big if we decide to do it.

Ultimately of course it would be better not to emit carbon dioxide at all. And ultimately solar and wind and fusion energy may make that possible—but we can't count on it happening, and on the fossil-fuel era ending, in this century. Yet the message from the study of past climates is that the time for stopping the increase in atmospheric CO_2 is now. Skeptics often find a strange solace in the knowledge that climate varies naturally, as if that somehow disproves the fact that we are rapidly changing it ourselves, or as if it somehow implies that climate change is inevitably benign. When you have explored the Ice Age for as long as Broecker has, and especially the wild swings that happened within the Ice Age, you don't think natural climate variability is benign.

Most researchers interested in the Ice Age have on their shelves a copy of The Glacial World According to Wally, one of the informal textbooks Broecker occasionally dashes off for his students, publishes himself, and sells at cost to whoever wants one. A few years ago he wrote one that has a cartoon on the cover. It shows a boy with glasses and unruly hair—he resembles Broecker a bit, but he is meant to be Everyman. The boy is poking a stick, labeled CO_2, at a Large-Scale Singularity, which for some reason is represented as a fire-breathing dragon rather than a long blue snake. The book is called Fossil Fuel CO_2 and the Angry Climate Beast.