"What the Earth Knows": An Exchange

In the Summer 2010 issue of the SCHOLAR, *we published as our cover story an article by Robert B. Laughlin, a Nobel laureate physicist at Stanford University, suggesting that a greater understanding of geologic time gives a new perspective on climate change and our future energy needs. The article drew lots of commentary, ranging from a column by George F. Will in* Newsweek *to postings from the far reaches of the blogosphere. Joel E. Cohen of the Laboratory of Populations at Rockefeller and Columbia universities, an occasional contributor to the* SCHOLAR, *submitted the following critique, to which Professor Laughlin responds.*

Dear Professor Laughlin:

Thank you for your efforts to communicate complex scientific information to the general public through "What the Earth Knows." However, I am startled by the arithmetic errors in your article, and even more by errors of fact and logic.

Arithmetic error 1: "This rate appears to the eye of a regular visitor to be about one millimeter per year, perhaps less, for the rock here is relatively hard, so that it would take 100,000 years to erode a kilometer, or about a million years to erode away the shore entirely."

A kilometer is 1,000 meters, and each meter has 1,000 millimeters. At one millimeter per year, it would take 1,000 x 1,000 = a million years to erode a kilometer, not 100,000 years. If the rate of erosion were less than one millimeter per year, it would take more than a million years to erode a kilometer.

Arithmetic error 2: "It's also consistent with estimates of the ice mass required to leave behind such industrial-strength mischief as Long Island, Nantucket, and the Great Lakes—about 50 million cubic kilometers in all, or five million billion tons."

A cubic kilometer contains 10^9 (= 1 billion) cubic meters. A cubic meter of water weighs 1 metric tonne. Therefore 50 million cubic kilometers of water weigh 50 million billion metric tonnes. Ice, at its least dense, weighs about 0.92 grams per milliliter, or about 0.92 metric tonnes per cubic meter, or about 0.92 billion metric tonnes per cubic kilometer. Fifty million cubic kilometers of ice would weigh nearly 50 million billion American tons, or about 10 times more than five million billion tons.

I have not checked the rest of your arithmetic.

Error of fact and logic 1: "... keeping carbon-based fuels in the ground a while longer won't make much difference in mitigating the loss of biodiversity. The real problem is human population pressure generally—overharvesting, habitat destruction, pesticide abuse, species invasion, and so forth. Slowing man-made extinctions in a meaningful way would require drastically reducing the world's human population. That is unlikely to happen."

You ignore the extinction risks of drilling, mining, spills, leaks, toxic dumps, and habitat fragmentation associated with fossil-fuel extraction, transport, and use. Then you make a heroic, and faulty, leap in logic. "Overharvesting, habitat destruction, pesticide abuse, [and] species invasion," which are real causes of species extinctions, are at most weakly coupled to human numbers and spatial distribution, but are strongly coupled to technological, economic, legal, and political factors that can be influenced independently of human demography. These real causes are not inevitable components of some vague "human population pressure generally," which is a concept with no clear operational scientific definition. Overharvesting of fisheries, for example, is driven by multiple factors, including economic demand for fishes high in the food chain from wealthy countries, subsidies for fishing fleets to prevent unemployment among fishers, inadequate opportunities in other sectors of developing economies, changes in technology that led to industrial fish-and-freeze boats, globalization of fishery fleets that move from

exhausted fishing grounds to the next unexploited opportunity, and the lack of effective consensual international regulation of marine fisheries. Each of these important factors is caused, not by "human population pressure generally," but by specific policies, economic interests and incentives, and technological capabilities that can be addressed directly.

Projecting the future relations between population and climate change requires many assumptions. O'Neill et al. (*Proceedings of the National Academy of Sciences*, October 2010) estimated that reducing the global level of fertility by approximately one-half of a child per woman's lifetime from now to 2050 "could provide 16–29% of the emissions reductions suggested to be necessary by 2050 to avoid dangerous climate change." This decrement in fertility could be greatly facilitated by providing contraceptive materials and services to the roughly 215 million women who have expressed an unmet need for contraception. My article "Population and Climate Change" (*Proceedings of the American Philosophical Society*, June 2010) concluded that "the contribution of slowed population growth to stabilizing the atmosphere would be substantial, though not dominant."

Your conclusion—"Slowing man-made extinctions in a meaningful way would require drastically reducing the world's human population. That is unlikely to happen"—misdirects attention from extinction, the causes of which can and should be addressed directly (and are being addressed directly with some limited success by conservation organizations and public policies), to an impossible and largely irrelevant alternative, "drastically reducing the world's human population." This profoundly misleading conclusion is wrong on the facts and unhelpful as a guide to action.

Error of fact and logic 2: "Global warming forecasts have the further difficulty that you can't find much actual global warming in present-day weather observations. In principle, changes in climate should show up in rainfall statistics, hurricane frequency, temperature records, and so forth. As a practical matter they don't, because weather patterns are dominated by large multiyear events in the oceans, such as the El Niño Southern Oscillation and the North Pacific Gyre Oscillation, which have nothing to do with climate change. In order to test the predictions, you'd have to separate these big effects from subtle, inexorable changes on scales of centuries, and nobody knows how to do that yet."

We both have a scientist's understanding of geology and climate. Here we are outside the areas of our primary research and are therefore bound by the norms of scientific argument without being able to rely on direct personal expertise. Those norms obligate us as scientists, first, to recognize the existence of contrary claims when those claims are well-founded in observation and argument and, second, to respond to the specifics of those claims with countervailing facts and arguments if we disagree.

The National Research Council's (NRC) Panel on Advancing the Science of Climate Change issued a report in 2010, *Advancing the Science of Climate Change*. That report reviews critically many previous studies. The free summary of the report offers the following first conclusion and supporting information (page 2), contrary to your claims:

> What We Know About Climate Change
>
> Conclusion 1: Climate change is occurring, is caused largely by human activities, and poses significant risks for—and in many cases is already affecting—a broad range of human and natural systems. . . .

• Earth is warming. Detailed observations of surface temperature . . . show that the planet's average surface temperature was 1.4 °F (0.8 °C) warmer during the first decade of the 21st century than during the first decade of the 20th century, with the most pronounced warming over the past three decades. . . . Independent observations . . . indicate warming in other parts of the Earth system, including the cryosphere (snow and ice covered regions), the lower atmosphere, and the oceans.

• Most of the warming over the last several decades can be attributed to human activities that release carbon ~~dioxid~~ and other heat-trapping greenhouse gases (GHGs) into the atmosphere. The burning of fossil fuels—coal, oil, and natural gas—for energy is the single largest human driver of climate change, but agriculture, forest clearing, and certain industrial activities also make significant contributions.

• Natural climate variability leads to . . . fluctuations in temperature and other climate variables, as well as significant regional differences, but cannot explain or offset the long-term warming trend.

• Global warming is closely associated with . . . increases in the frequency of intense rainfall, decreases in snow cover and sea ice, more frequent and intense heat waves, rising sea levels, and widespread ocean acidification. . . .

• Human-induced climate change and its impacts will continue for many decades, and in some cases for many centuries. The ultimate magnitude of climate change and the severity of its impacts depend strongly on the actions that human societies take to respond to these risks.

This conclusion of the NRC report directly contradicts your concluding sentence:

"The geologic record suggests that climate ought not to concern us too much when we're gazing into the energy future, not because it's unimportant, but because it's beyond our power to control."

Your sweeping dismissal of the contrary conclusions of major studies fails to meet the standards of fact and logic required of sound science for specialized or general audiences.

JOEL E. COHEN

Robert B. Laughlin replies: First of all, thank you for finding those arithmetic errors. I'll be sure to correct them in the final version.

For the record, this piece is a chapter excerpt from a book I've written on the future of energy. The book's provisional title is "When Coal Is Gone." Its premise is that you travel in your mind to a time, about 200 years from now, when nobody burns carbon out of the ground any more, either because they banned the practice or because it's gone, and ask: What happened?

Reading between the lines here, I'm guessing that, like Paul Ehrlich, you're hoping that the energy problem doesn't get solved because cheap energy is what enables humans to abuse the environment so effectively. I'm also guessing that you concur with one of my correspondents who said that the premise of my book was political. If so, we must just agree to disagree. I am reasonably sure that the energy problem will get solved in roughly the same way, regardless of any actions governments take on climate or anything else, and I don't accept that prognosticating about events likely to take place a century from now is political.

Your substantive criticisms are, of course, much more serious than a couple of little math errors, so I need to address them.

The error of fact and logic 1 appears to me, in the final analysis, to be a criticism of (1) my failure to preferentially blame industrialized countries for habitat destruction, biodiversity loss, and environmental degradation generally; (2) my implicit underwriting of current abusive industrial practices, for example overfishing by factory fleets; (3) my assertion that the rollback of human population required to mitigate environmental stress sufficiently is massive; and (4) that this rollback isn't going to happen. I trust I've summarized correctly.

My first observation is that none of this is relevant to the thrust of the paragraph, i.e., that people satisfying their wants, not carbon dioxide per se, are the true source of stress on the biosphere. Nor do I think you even disagree with me on this,

although you didn't say one way or the other, so I can't tell for sure. My second observation is that I am actually innocent on all counts. I did not reach a "profoundly misleading conclusion" that was "wrong on the facts and unhelpful as a guide to action." I reached the conclusion that economic activity, the true source of environmental stress, was not likely to mitigate in the future. This is fully consistent with your remarks about efforts to control population, and it is an excellent guide to action. It implies, among other things, that you must redouble your efforts to protect and preserve Nature because that preservation won't happen by itself. I did not promote rollback of world economy as a way to save the environment, of course, but that's because I'm prognosticating, and I genuinely don't think it will happen. I remind you that Kyoto and Copenhagen have both failed.

The error of fact and logic 2 is that I ignored the scientific facts distilled in the IPCC consensus position on global warming and dismissed IPCC recommendations based on them. First of all, I did no such thing. I avoided the IPCC issues entirely, both in the SCHOLAR piece and in the book itself through the premise that fossil fuel wasn't burned anymore. I did this for a reason. If you search the web or pick up a few newspapers from anywhere in the world, you will find lots of intelligent people violently impugning the IPCC science as quackery and fraud. They are not religious fanatics or paid propagandists of Big Oil (at least for the most part) but thinking men and women that the IPCC did not successfully persuade. One of the reasons it didn't persuade them was exactly what I said. The weather fluctuates wildly, and it's correspondingly difficult for ordinary people to see any global warming directly. Things are likely to change once they can, of course, but this hasn't happened yet. In any event, it is the IPCC's fault, not my fault, that it hasn't been persuasive. In political life, the scientific imprimatur cuts no ice. People don't trust specialists, especially specialists who stand to gain financially if you follow their advice, and they definitely don't want said specialists dictating to them what they should do based on things they can't see and don't understand.

I also plead innocent of unbalanced science and conflict with the NRC report. Such science as I talk about in this piece merely makes the case that the time scales of the Earth are long. I believe I cited the relevant facts in a fair and balanced way. The point probably seems so self-evident to you that it's not even worth mentioning, but most lay readers haven't grasped the concept yet and have corresponding difficulty thinking through energy/climate issues on the right time scales. (The original title of this chapter was "Geologic Time.") This piece also doesn't make climate policy assessments and recommendations, so in this sense it's orthogonal to the NRC report the same way that it's orthogonal to the IPCC reports. Only in political atmospherics does it have any relationship at all. My response there is that atmospherics are atmospherics, and anyway mine pertain to how people will procure and use energy in the future, not to how people will protect the environment or to how warm it will be.

My final remark is that my book is fundamentally about fighting denial over the terrible events about to unfold. I have my methods for doing this and you have yours, but the bottom line is that you're preaching to the converted. I suspect I haven't made things any happier for you here, but it's the best I can do under the circumstances. Thanks for writing.