one causes the other but never mentions whether Weart says which is the cause and which the effect, or whether he gives evidence to support either case. Solid science, though, does support one case.

It is widely known that the largest single repository of CO_2 on Earth is the oceans, and that the solubility of CO_2 in water drops as the water temperature increases. So clearly a mechanism exists whereby increasing ocean water temperatures (which is where most of the solar energy goes) causes increased outgassing of CO_2 into the atmosphere. Furthermore, Arctic permafrost zones revert to marshy peat bogs when the Arctic warms, and then bacterial activity takes hold and converts decaying ancient vegetation into atmospheric CO_2. Both of those processes are happening right now.

The Russian Vostok ice cores going back 420 000 years and the Dome-C ice cores going back 730 000 years show that the Antarctic ice sheet has not melted during that time frame, even in the warmest interglacial periods. The ice cores also show periods of rapid global warming accompanied by rapidly increasing atmospheric CO_2.

Now we know that our sport-utility vehicles did not cause all those CO_2 increases back then, but we do understand how global warming causes them. So perhaps Weart can tell us conclusively which of the two is the cause and which the effect; the ice cores seem to give us the answer.

By the way, when floating sea ice melts, Archimedes would insist that the level does not change; in particular, it does not go up. That takes care of gravitational energy, but the melting of all that sea ice extracts astronomical quantities of latent heat from the surrounding ocean water and lowers the mean ocean temperature; so the level will go down, not up. And I can suggest a very illuminating experiment for anyone who believes that heat to melt sea ice does not come from the surrounding ocean.

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Weart replies: Earth's climate system involves many basic phenomena—science teachers should note how that could be used to spark interest! George Smith's letter shows some ways a temperature rise can cause CO_2 emissions. Such feedbacks are worrisome, because they could accelerate warming once it is initiated.

What initiated the current warming? It took many decades for scientists to agree on the most likely answer.[1] The crucial observation was the recent atmospheric CO_2 increase, whose rate and magnitude are vastly beyond anything in the ice core record. The steep climb neatly matches calculations of the rise expected from the known consumption of fossil fuels. The calculations include estimates of gas exchanges with the oceans, tundra, forests, and so forth: estimates checked through many measurements—for example, of carbon isotopes. The oceans are found to be a net absorber, transporting carbon into their depths. Net biosphere output, although harder to estimate, is certainly dominated at present by emissions due to human activities.[2]

Sea ice will melt provided the greenhouse effect adds enough energy to the planet to warm the seawater even while the ice melts. A temperature increase has been observed, and will bring sea-level rise through thermal expansion.

References

1. Spencer Weart, *The Discovery of Global Warming*, Harvard U. Press, Cambridge, MA (2003). For additional material, see http://www.aip.org/history/climate.
2. Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis,* J. T. Houghton et al., eds., Cambridge U. Press, New York (2001), online at http://www.grida.no/climate/ipcc_tar.

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Even in Translation, Richter's 'Science' Unimpressive

Having read the exchange of letters about the value of Ronald Richter´s nuclear fusion work in Bariloche, Argentina, in the early 1950s (PHYSICS TODAY, August 2003, page 12, and March 2004, page 14), I thought it unfortunate that most challenges to Richter's results are in Spanish. Analyses appear in two reports from the scientific panel that Juan Perón's government appointed to evaluate the project after Richter's erratic behavior became apparent.[1]

The first report, by physicist José A. Balseiro, challenges Richter's physical ideas and shows with order-of-magnitude calculations that the proposed method is unfeasible. Perhaps more to the point regarding the plasma physics involved is the second report, written by electrical engineer Mario Bancora, which describes the apparatus Richter used. I have translated the last paragraphs of Bancora's report:

> The device used by Dr Richter is the singing arc discovered by [William Du Bois] Dudell[2] about 50 years ago. The negative resistance of this arc neutralizes the positive resistance of an oscillating circuit, which is completed by a "control" impedance and two condensers of one microfarad each, connected in parallel, which are close to the reactor. This gives rise to a series of sustained oscillations whose frequency depends on that of the resonant circuit. These oscillations could be at a frequency low enough to be in the audible range (hence the singing arc) or they can be supersonic (which is the origin of the ultrasounds claimed by Dr Richter). By incorporating a magnetic field, and adding gas, hydrogen for example, to cool the arc, it is possible to enhance the frequency considerably, to around 300 000 Hz. With exactly this setup, [Valdemar] Poulsen, in the early days of radio communications, could achieve transmissions over more than 500 km.[3]
>
> These arcs emit light high in the ultraviolet, as well as centimeter-wavelength sound, which together with the intense electromagnetic perturbations produced are particularly effective in activating the Geiger counters. The increase in response obtained when introducing hydrogen is simply due to the increase in frequency produced by this means, according to Poulsen's experiments.
>
> To be absolutely sure, I have repeated this experiment in my own laboratory and have obtained the same results, that is: a) the same type of oscillations in the screen of an oscilloscope connected to an exploration coil and b) detection by a recorder connected to a Geiger counter located 1.5 m from the arc.

The report concludes that "there is therefore no serious scientific content to Dr Richter's assertion that he has achieved a controlled thermonuclear reaction, and I deeply regret having had to reach such a conclusion."

Bancora's description is based on an on-site inspection of the fully operational device demonstrated by Richter himself in 1952. Wolfgang Meckbach's account, mentioned in the previous PHYSICS TODAY letters, may have referred to an already dismantled apparatus seen when Meckbach arrived in 1955. I took his course in experimental physics in Bariloche; he was an ingenious and resourceful experimentalist and an inspiring teacher. I never heard him discuss Richter's work, but I have few doubts that he regarded the subject as closed.

Apparently, then, far from using imaginative new plasma physics, Richter was reproducing well-known technology. The fact that Bancora could obtain similar spectacular results without being misled as to their relevance is significant. According to Mario Mariscotti's account,[4] Richter did not do any follow-up experiments. This implies that he acted under his own delusions and was helped by the fact that no scientist questioned his early results. There were a few competent physicists in Argentina at the time, perhaps the most prominent being Enrique Gaviola, mentioned in Santos Mayo's letter, but the secrecy surrounding the project and the physicists' politically motivated distrust of the government conspired against an early dismissal of Richter's adventure. Now, however, there should be no doubt that it had no sound scientific basis.

References

1. Both reports are available at http://www.ib.edu.ar/historia/historia.htm.
2. See http://www .obsolete.com/120_years/machines/arc/index.html for a brief description and history of this device.
3. For a description of Poulsen's work, see H. Buhl, http://www.acmi.net.au/AIC/POULSEN_BUHL.html.
4. M. A. J. Mariscotti, *El Secreto Atómico de Huemul*, Sudamericana-Planeta, Buenos Aires, Argentina (1985).

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Up on the Roof, Another Green Weapon

Reading the letters about green power in the June 2004 issue of PHYSICS TODAY (page 11), I was reminded of an observation I made some years ago in the Bay Area of San Francisco and in Los Angeles; there appear to be almost no solar water heaters on the roofs of buildings there. Many parts of California enjoy essentially the same sunny weather as southern European countries such as Greece, where individual solar water heaters can be seen on the roofs of almost all buildings. Consisting essentially of a small black water-storage tank, such solar collectors are efficient water heaters that offer a low-cost supplement (not replacement) to more conventional technologies. Why are they not used in the sunnier parts of the US? If they were, the financial savings to each household would be great, and the combined energy savings across the US would be enormous.

Local energy-saving solutions have enormous potential to reduce our dependency on fossil fuels. A full account of the economics of solar water heating is contained in the publication *A Consumer's Guide: Heat Your Water with the Sun*, available from the US Department of Energy (http://www.nrel.gov/docs/fy04osti/34279.pdf). According to that document, for homes with electric water heaters, up to 25% of domestic energy costs go to heating water. The adoption of local energy-saving solutions should be considered wherever practical and built into new homes. The nature of the solutions depends on the location; excellent insulation and good use of sunlight should be high on everybody's list.

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Misattribution and the Matthew Effect

The part of David Mermin's Reference Frame (PHYSICS TODAY, May 2004, page 10) that I enjoyed most was his exposition of the Matthew effect, which was an exquisitely ironic example of what he was writing about.

The term is very unfair to Mark,