

interesting reading. I strongly recommend it.

Bad Science: The Short Life and Very Hard Times of Cold Fusion

Gary Taubes

Random House, New York,

1993. 473 pp. \$25.00 hc

ISBN 0-394-58456-2

Gary Taubes's *Bad Science* is not the first book to conclude that shoddy scientific research and overblown claims were associated with cold fusion; some others are by Frank Close (Princeton U. P., 1991; see *PHYSICS TODAY*, March 1992, page 68) and John Huizenga (U. Rochester P., 1992; see *PHYSICS TODAY*, January 1993, page 73). All three books describe numerous violations of the scientific method that dominated this field and characterize some of the people involved, but each book has a somewhat different emphasis and style. *Bad Science* comprehensively covers the longest period of time and perhaps best captures the frenzy associated with this episode from the years leading up to the March 1989 announcement through the end of 1991.

Taubes uses extensive quotes from many of the people involved to chronicle the events and give a flavor of the players in this saga. As was characteristic of Taubes's book *Nobel Dreams* (Random House, New York, 1986), many of the quotes and evaluations are very candid; the reader comes away knowing not only the names but also the personalities and reputations of many of those involved, who could be called the "heroes" and the "villains" of cold fusion, as well as some examples of what Taubes terms "bad science."

As Taubes notes, part of what fueled the furor over cold fusion and kept it going was a variant of Pascal's wager; namely, while the probability of its being correct was essentially zero, the cost was low relative to the potentially huge payoff. Of course, there were other reasons why cold fusion got so much publicity, including the hope of many people that the "little guy" was going to overturn established thinking and "big science."

From the beginning, cold fusion was full of contradictions, and Taubes does an excellent job of detailing the problems: heat supposedly caused by a nuclear reaction, but

without the products of the reaction; the results of an experiment claiming tritium production used to justify the results of one with no tritium production; the tendency for more sensitive or careful experiments to observe weaker effects; the amazing phenomenon of an announced major new positive effect disappearing just before a review committee arrived; and the continually changing statements from Stanley Pons and Martin Fleischmann of what they did or did not do. To add to the confusion, the news traveled instantaneously and unfiltered, by way of telephone, electronic mail and fax, and was covered in the national press rather than refereed journals. And, of course, the fact that Pons brought lawyers into the picture very early on put the whole episode on a different footing from normal scientific discourse. Throughout the whole cold fusion saga, faith seemed more important to the proponents than proof. Several of the scientists who were convinced initially by peculiar effects express regret in Taubes's book for not having looked harder for systematic errors before going public.

As a participant in some of the events described in the book, I can identify a few things that might be misconstrued or that could be supplemented. Taubes does not point out that the grounding of the Exxon Valdez occurred at around the time of the Pons-Fleischmann news conference, fueling the wild hope that cold fusion would solve the future energy needs of the world. Taubes's statement that "DOE would cover the expenses" of cold fusion research could be misinterpreted. The national labs were told to use their own resources; there was very little if any new DOE money directed to research on cold fusion. To be sure, other research certainly was delayed, and if one adds the cost of the researchers' time, DOE support of cold fusion research was considerable.

Taubes's description of a controversial Electric Power Research Institute-NSF meeting in Washington, DC, in October 1989 is not exactly as I remember it. That meeting was very useful, at least to this skeptic, because it provided one of the very few opportunities to have one-on-one conversations with the proponents of cold fusion. Some of those interactions actually increased my concerns about the quality of the "science" of cold fusion. At that meeting there were actually two talks by Edward Teller, not one as stated in the book. The first covered what we know about nuclear fusion and concluded

that cold fusion could not be correct. After considerable coaxing as to whether he could imagine some mechanism to make cold fusion possible, Teller gave a talk a day later where he introduced the "meshugganon" (crazy particle). The proceedings of that conference, although promised, were never published. By the end of 1991 the primary funders of the EPRI experiments on the nuclear effects associated with cold fusion were convinced that it was time to wind down funding.

In the early days of cold fusion, Taubes notes, there tended to be a polarization of chemists versus physicists. If there is any positive legacy to the cold fusion story, it is that at many institutions scientists from very different disciplines were brought together to do joint research, and in the process they learned a lot of science and acquired more respect for their colleagues.

Taubes has written a very lively, entertaining book for the nonscientist as well as the scientist. The book reads easily despite the fact that it is quite lengthy, with extensive footnotes, and that a couple of figures are not well integrated into the text. One need not have an interest in cold fusion to enjoy *Bad Science*.

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Catching the Light: The Entwined History of Light and Mind

Arthur Zajonc

Bantam, New York, 1993.

313 pp. \$23.00 hc

ISBN 0-553-08985-4

Consider the four universal forces: strong, electromagnetic, weak and gravitational. So important is each that a theory explaining all of them can be called a theory of everything. Except for gravity, each has its identified field particle, and perhaps the graviton will also be found. Among these connections and similarities, however, there is something special about electromagnetic effects: In the guise of light, they are the only ones to which we humans react in ways other than the physical.

This human reaction to a central physical phenomenon is a main premise of the sweeping survey *Catching the Light*. Arthur Zajonc, a physics professor at Amherst College, relates an enormous variety of information about light: as a spiritual

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force that emerges, it seems, in every mythology and religion throughout human history; as a subject of scientific experimentation and analysis over centuries; as a key element in the revolutionary ideas of relativity and quantum mechanics; and as an inspiration for artists, poets and thinkers.

In this book, therefore, physical understanding is only part of an attempt to integrate different ways of knowing light. The idea of integration is a good one, and Zajonc shows an impressive grasp of disparate fields of knowledge: Nevertheless, *Catching the Light* does not always find the right balance or persuasive connections among its different elements. Some scientists may be put off by the lengthy discussion of light's religious and spiritual history, while nonscientists may be repelled by the scientific detail that sometimes appears, such as the highly numerical analysis of the phenomenon of refraction.

Multidisciplinary books are hard to write. Still, I would have liked to see a more consistent level of presentation and smoother transitions between topics. But Zajonc tells some fascinating stories about light, in words that occasionally become poetry. He explains what each scientist and thinker contributed, from Empedocles to René Descartes, Johann Wolfgang von Goethe to Michael Faraday, Albert Einstein to John Wheeler. He fleshes out historical byways, such as early attempts to model light on sound. He recalls the long dispute between corpuscular and wave theories, and he emphasizes the troublesome issues remaining at the heart of quantum theory. Because of the variety of topics and characters, *Catching the Light* will not do to teach optics or electromagnetic theory to physics majors. But the book could enhance such courses, as well as help to teach nonmajors and remind scientists who deal with light of the richness of their medium.

In fact, one of the author's concerns is that scientific understanding of light and of the world merge with a more encompassing view. Many physicists will reject this approach, although in my opinion physics must indeed rethink its narrow focus to continue as a successful enterprise in society. But even those who prefer clearly delineated intellectual limits, or who find that light's spiritual role diminishes the purity of the physics, can still take away from *Catching the Light* a sharp reminder: Despite our best scientific efforts, light remains enigmatic. This may engender a

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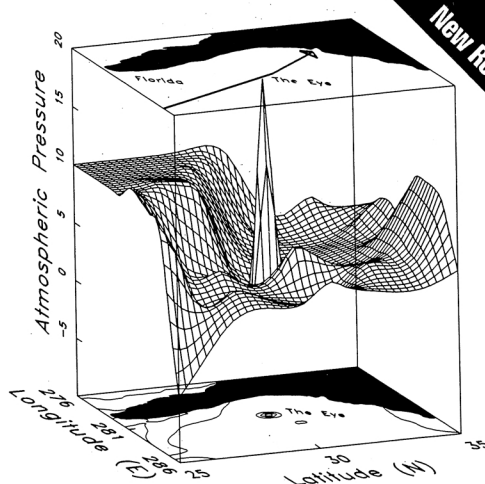
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sense of humility, a spiritual good that also makes for creative science.

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Stopping the Spread of Nuclear Weapons: The Past and the Prospects

D. Fischer

Routledge, New York, 1992.
336 pp. \$79.50 hc
ISBN 0-415-00481-0

David Fischer is one of the elders of the nuclear nonproliferation community and was present at the creation of many of its successes and failures. He helped draft the statutes of the International Atomic Energy Agency and has spent 25 years helping to develop its policies. His book is strongest when he reviews, comments on and puts into perspective these experiences. It is not as strong when he analyzes the prospects for stopping the spread.

Nuclear proliferation and nonproliferation policy have replaced the US-Soviet nuclear arms race as the topic of choice in the nuclear arms field. Commentators fall into two almost distinct categories: those who discuss the supply of nuclear weapons material and the regime needed to curtail that supply, and those who trace the demand for nuclear weapons and the political drives behind this demand.

The former (who include most technical commentators) focus on what inspections have revealed and might reveal in countries of current concern and on steps that are needed to tighten the nuclear supply restrictions. The latter (who include most political scientists in print to date) focus on what the weakening or death of alliances on both sides of the former Iron Curtain might mean for their various participants and which countries perceive themselves as newly isolated—in short, the perceived security incentives (whether justified or not in the eyes of the nuclear “haves”) that might underlie a demand for nuclear weapons.

Fischer is knowledgeable on the supply situation. Starting with President Eisenhower's Atoms for Peace program and its ambiguous impact, he recounts the road to the present regime and its relative success in containing the spread of nuclear weapons. He knows where many of the bodies are buried on that

road and spares no one, certainly not the US, in discussing the inconsistencies and double standards that inevitably attended the policies of the Non Proliferation Treaty signatories regarding the spread of nuclear weapons to particular nations. He gives the perspective of the international establishment on these matters, enlivened with the wit and wisdom of an independent-minded, longtime participant.

The book contains little about demand and the internal debates in many of the countries of interest, such as Argentina, Brazil, India, Taiwan and the two Koreas. The recent reservations of the Japanese government about an indefinite extension of the NPT without progress on disarmament are not foreshadowed, although they echo what Japan, Germany and Italy said when the treaty was negotiated the first time around and the issue of the treaty's duration came up.

The book does not refer to events past 1991. Events these days have a way of dating all perspectives. Understandably, the book does not foreshadow the breakup of the Soviet Union and the consequent nuclear concerns pertaining to Ukraine and others. The book is at its most useful in reminding us of what has gone on in the world following the signing of the Non Proliferation Treaty. With the treaty's 1995 extension conference less than two years away, we need to remember this history, some of which is likely to be repeated in the months to come. The book's critiques of US policy in chapter 3 are especially useful. Fischer gives a good short list of what our government should do between now and then. The 60 plus pages of notes are at least as interesting as the text proper. The book is a useful, well-documented addition to any library on nuclear proliferation.

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Radiation and Cloud Processes in the Atmosphere

K. N. Liou

Oxford U. P., New York, 1992.
487 pp. \$85.00 hc
ISBN 0-19-504910-1

One of the greatest uncertainties in modeling the Earth's climate is how to treat the effects of clouds on the rest of the system. So many interactions are possible that even small

changes in cloud properties are likely to affect the system's response to enhanced greenhouse effects or other perturbations. Kuo-Nan Liou's book on radiation and cloud processes makes a timely contribution to a subject that is central to current physical climate models.

The book covers a wide range of cloud interactions. The microphysical structure of clouds affects both precipitation processes and atmospheric radiation, directly impacting atmospheric thermodynamics and remote sensing. This structure is determined by the interactions of water vapor with atmospheric aerosols; the interactions in turn are governed by the flow of atmospheric dynamics. Cloud water and ice contents also have a complex dependence on temperature. All of this makes for a tantalizing mixture of nonlinear feedback possibilities, most of which have yet to be properly understood.

There are so many components to this problem that a uniformly authoritative treatment may indeed be beyond a single author. Liou nonetheless recognizes the “need to integrate radiative transfer and cloud physics . . . and to bridge the gaps between cloud-radiation and dynamical processes”; there is little he shies away from. This has yielded an admirably broad compendium of information, but with varying levels of insight and discussion. Liou's treatment is extremely thorough when he is on home ground, as in discussing the delta-four stream solution to shortwave radiative transfer or the radiative properties of ice crystals. In other areas—for example, when he discusses a Hadley circulation at the poles with “airflow in the upper level towards the equator,” or when he interprets the statistical correlation between increased high cloud and higher surface temperature at the same locale as an indication of direct cause and effect—the reader is left, at best, in a state of bemusement.

Despite the comprehensive nature of this book, which considers many of the important topics relating clouds and radiation, no mention is made of the radiative or other time constants needed to couple the different components together and determine the relative significance of climate feedback loops. Neither is there any mention of internal cloud inhomogeneity, which is thought by some to have a significant effect on radiative transfer. Several topics that fall exclusively in the domain of radiation or of cloud physics are also included.

The final chapter, on the role of