rising budget that prevented NSF expansion from being a zero-sum game, a degree of skill at administrative politics within the agency, and the fact that, in the first decade or so, grantees committed no serious gaffes or egregious offenses to the conventional morality or established values of those who controlled authorization and budget.

I don't think that the explanation put forth by Riecken and Larsen is wrong; rather it is ahistorical and thus needs to be placed in a context of change. Neither American society nor the social sciences stood still during these 50 years. The sweeping changes in American society are well known. Let me cite some of the "outside the Beltway" changes in the social sciences that certainly increased their prospects for legitimization:

1) The wartime experiences of hundreds of social scientists—in everything from assessment of the morale of soldiers and civilians to psychological warfare to price control—sent them to the universities as the best-trained generation of social scientists the country has ever had.

2) The enormous postwar expansion of university social science departments created a strong second generation of social scientists, which now dominates most of the disciplines.

3) The postwar flourishing of university-based social, psychological, and economic research institutes both trained students and made research results useful to a broader audience.

4) The postwar development of quantitative research methods and mathematical modeling greatly improved the scope and specificity of research results.

5) The postwar creation or development of disciplines that study the institutions of science—the history of science, the sociology of science, science policy analysis, ethical issues in science—commanded wide respect and created important bridges to the natural sciences.

6) The concepts and language of the social sciences entered popular discourse during this era. Larsen quotes from a 1986 Congressional Research Service report that lists a number of words and phrases that made this transition, including: *acculturation*, *alienation*, *charisma*, *ethnocentrism*, *fiscal policy*, *GNP*, *identity crisis*, *juvenile delinquency*, *minority group*, *quality of life*, *reference group*, *self-fulfilling prophecy*, *sample*, *socialization*, *stagflation*, *standard of living*, *status*, *stereotype*, *the unconscious*, and *youth culture*.

I cannot say whether or not the attitudes of natural scientists changed during this period. A suggestion that Larsen believes they have not is found in his pronouncement that "it would help if social scientists in the major research universities would take a physicist, chemist, biologist, or mathematician to lunch from time to time."

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## A Vanishingly Small Case

**Cold Fusion.** The Scientific Fiasco of the Century. JOHN R. HUIZENGA. University of Rochester Press, Rochester, NY, 1992. xvi, 259 pp., illus. $45.

"One watt input, four watts output!" was the electrifying claim that precipitated a storm of publicity and started a worldwide scientific race to verify the existence of nuclear fusion in a jar. Members of the scientific community and lay readers interested in the history of the cold fusion episode and its broader implications for the scientific process will find much to consider in John Huizenga's thoughtful account of this astonishing chapter in the history of science. Huizenga, professor of chemistry and physics at the University of Rochester, co-chaired the Department of Energy ERAB (Energy Research Advisory Board) panel appointed to investigate the claims made in the memorable 1989 press conference by the two University of Utah electrochemists Martin Fleischmann and Stanley Pons. The most startling aspect of this report was the claim that nuclear reactions could be induced by loading deuterium atoms into a palladium metal lattice and that these reactions released macroscopic quantities of heat detectable by a simple calorimeter. Present nuclear theory predicts vanishingly small D + D reaction rates ($\sim 10^{-64}$ per second) under the reported experimental conditions, but experiment, not theory, is the final authority in science, and it is argued persuasively in this book that the resolution of the cold fusion story came about through careful analysis of the experimental procedures and data.

Huizenga begins his narrative by tracing the history of cold fusion claims and counterclaims through press conferences, scientific meetings, and journal publications. The level of technical detail provided enables the reader to judge the science for himself or herself, and the chronicle of the subject is liberally documented with journal citations and illuminating techni-

cal commentary. This is followed by a brief summary of the ERAB panel's report and a closely reasoned critique of the experimental evidence for cold fusion. The case against the claimed phenomenon can perhaps best be stated as: No evidence has been found for nuclear reaction products (whether high energy or low) of sufficient quantity to account for the claimed levels of heat production. As the matter was put in the ERAB panel's final report, "the present evidence for the discovery of a new nuclear process termed cold fusion is not persuasive."

I particularly appreciated Huizenga's discussion placing the cold fusion saga in the broader context of the scientific process. How could two respected researchers go forward with a press conference and rush into publication on the basis of fragmentary and inconsistent evidence? An example of such an inconsistency is that the claimed levels of nuclear reaction products accounted for less than $10^{-8}$ of the claimed heat production. Good experimentalists, when confronted with anomalous readings, first suspect their experimental technique. They ask such questions as: Have I investigated all possible sources of systematic errors? Have I done adequate control experiments? Can the effects be replicated? Peer reviewers ask the same questions. In the rush for publication and priority the temptation to skimp on this essential checking naturally arises; Huizenga documents recurrent instances of publication by press conference of isolated, irreproducible, poorly calibrated, poorly controlled experiments.

The history of science documents many cases of "pathological science," which has been defined by Nobel laureate Irving Langmuir as "the science of things that aren't so." Huizenga consigns cold fusion to this category, placing it in the ranks of scientific mistakes such as polywater, N-rays, Lysenkoism, and laetrile. Although cold fusion retains a small group of vocal proponents to this day, the skeptics await a single experiment confirming nuclear reaction products sufficient to produce macroscopic amounts of heat in an electrochemical cell. In the words of Carl Sagan, "extraordinary claims require extraordinary evidence."

The book concludes with a discussion of lessons and cautions to be gleaned from the cold fusion saga. The scientific community is warned against premature publication, press conferences that bypass the peer-review process, secrecy in basic research, lobbying before congressional committees, and funding of large research initiatives of questionable scientific basis. Huizenga concludes that the cold fusion fiasco illustrates once again that the scientific process works by exposing and correcting its own errors.

Scientists are often motivated by visionary dreams: Wouldn't it be wonderful to discover a new nonpolluting energy source having an inexhaustible fuel supply? This contributes to what might be termed the conflict between the romantic and rationalistic in the scientist. Can the beauty of the dream sometimes overpower the rational evaluation of the data?

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## Vignettes: Lines of Credit

If the positive side of [Joseph] Black's failure to publish was a belief that he had made his doctrine public enough, then the negative side was an almost paranoid fear of plagiarism. . . . When [James] Watt tried to get him to publish on heat in the 1780s . . . Black responded by making a comparison with the situation if Watt himself were to write on the steam engine. As an author Watt would be obliged to show a conventional modesty, and to describe his invention "in such a Cold and modest manner that Blockheads would conclude there was nothing in it, and Rogues would afterwards by making trifleing Variations vamp off the greater Part of it as their own and assume the whole merit to themselves."

—*Jan Golinski*, in *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820* (Cambridge University Press)

Peter snorted, "Oh, no, he's not bad, is he? It's just his unfortunate manner, is it? I suppose he can't help stealing the credit for other people's ideas, can he? What about your pet *drosophila sub-obscura*? Who wrote the article about them in the *Journal of Genetics*? You know you did, but your name did not appear at all. It was all a contribution to science by that brilliant young geneticist—Doctor Ian Porter."

Mary smiled and said, "Well, I *was* working under him, wasn't I?"

—From *Unholy Dying*, a 1945 detective novel by R. T. Campbell (Dover paperback)

Leo's most famous books were *In the Beginning* (Routledge & Kegan Paul, 1965) and *Royal Essence* (Weidenfeld & Nicolson, 1971). These were still on the reading lists. They were mentioned and quoted in student essays and dissertations. The extracts quoted were always the same ones. This was because they were copied from other dissertations and textbooks. For over twenty years the authors of books and learned articles in the field had been building on each other's work, and no one now could have identified the lone pedant who originally quarried *In the Beginning and Royal Essence*.

—From *The Grown-Ups*, a 1989 novel by Victoria Glendinning (Knopf; paperback, Ivy Books)

## Biotechnological Progress

**Vaccines**. New Approaches to Immunological Problems. RONALD W. ELLIS, Ed. Butterworth-Heinemann, Stoneham, MA, 1992. xviii, 478 pp., illus. $95. Biotechnology Series, 20.

Microbial pathogens are rapidly yielding their secrets to the tools of modern biotechnology. As a result extraordinary progress has come about in the creation of new vaccines and the improvement of old ones. The development of effective vaccines against even stubborn old scourges such as malaria and virulent new foes like human immunodeficiency virus is held to be an achievable goal, despite the many challenges to be overcome.

The rational development of a vaccine first requires an understanding of the cellular, and frequently the molecular, basis of microbial pathogenesis and the critical interactions of a microorganism with the host's immune system. Advances in biotechnology have vastly accelerated the acquisition of such knowledge. Live attenuated vaccines such as cholera can therefore be custom-designed by specific deletion mutations of known virulence genes. Also, mechanisms for precisely identifying the critical immunogenic components of a