

Science & Technology Studies

(formerly 4S Review)

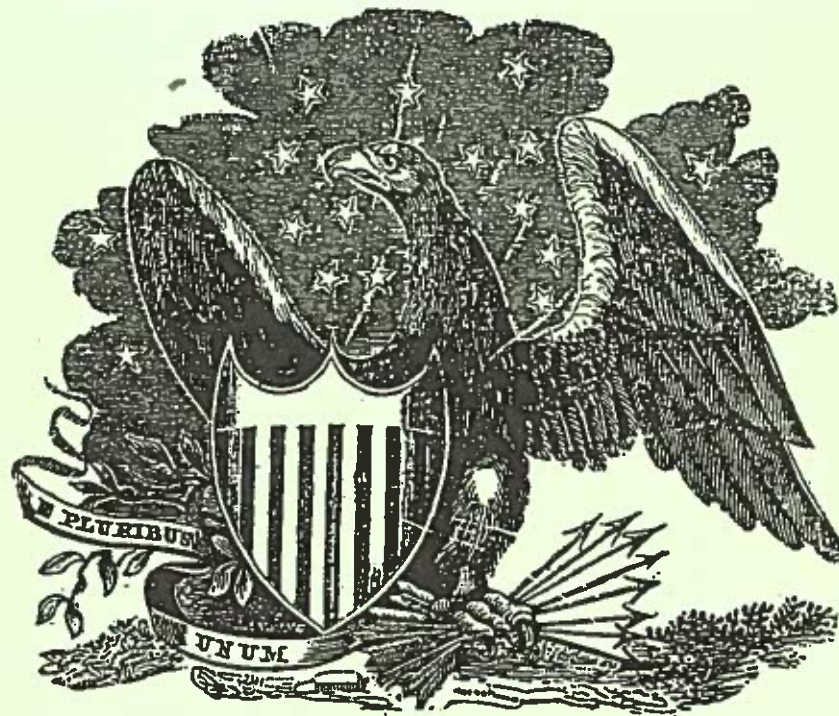
ISSN 0886-3040

Volume 5

Number 1

Spring 1987

Amusement here with
Science is combin'd,



Journal of the Society for Social Studies of Science

Society for Social Studies of Science

President: David O. Edge

President-elect: Arie Rip

Secretary/Treasurer:

Thomas F. Gieryn

Past Presidents:

Robert K. Merton

Warren O. Hagstrom

Dorothy Nelkin

Bernard Barber

Arnold Thackray

Nicholas C. Mullins

Council:

Ruth Schwartz Cowan

Susan E. Cozzens

Mary Frank Fox

Ronald Giere

Ron Johnston

Rachel Laudan

Bruno Latour

Helga Nowotny

Steven Shapin

Publications Committee: Marcel C. LaFollette, *chairwoman*

Randall Albury

Marc De Mey

James L. McCartney

Sal Restivo

David O. Edge, *ex officio*

Thomas F. Gieryn, *ex officio*

Susan E. Cozzens, *ex officio*

Science & Technology Studies

Editor: Susan E. Cozzens

Department of Social Sciences

Illinois Institute of Technology

Chicago, Illinois 60616 USA

(312) 363-4556

Bitnet: SOCCOZZENS@IITVAX

Special Editorial Advisor: Daryl Chubin

Computer Consultant: Juan Jewell

Science & Technology Studies (ISSN 0886-3040), journal of the Society for Social Studies of Science, is published four times a year. Journal subscription includes membership in the Society. Rates are \$40 institutional, \$30 individual, and \$15 student.

To join 4S and receive *Science & Technology Studies*, send a check for the appropriate amount payable to "Society for Social Studies of Science (4S)" to: Academic Services, Inc., Attention: Paul Henderson, 1040 Turnpike Street, Canton, MA 02021 USA. **Subscriptions in European currencies** may be paid through the European Association for the Study of Science and Technology (EASST). For specific rates, contact Arie Rip, Wetenschapsdynamica, University of Amsterdam, Nieuwe Achtergracht 166, 1018 WV Amsterdam, The Netherlands.

Change of address should be sent to: Academic Services, Inc., Attention: Paul Henderson, 1040 Turnpike Street, Canton, MA 02021 USA.

For other information about the Society for Social Studies of Science, contact Thomas F. Gieryn, 4S Secretariat, Department of Sociology, Indiana University, Bloomington, IN 47405 USA.

SCIENCE & TECHNOLOGY STUDIES

Journal of the Society for Social Studies of Science

Volume 5

Number 1

Spring 1987

Table of Contents

ARTICLES

- Science as an Idiom in the Domain of Technology
Mark H. Rose 3
- Science and Coca-Cola
Thomas F. Gieryn 12
- The Use of Scientometric Methods for Evaluating National Research Programs
Loet Leydesdorff and Peter van der Schaar 22

POLICY REPORT

- A Strategic Assessment of the Scientific Performance of Five Countries
Rémi Barré 32

BOOK REVIEW

- Shapin and Schaffer, *Leviathan and the Air Pump: Hobbes, Boyle, and the Experimental Life*
reviewed by *Lawrence Busch* 39

NEWS AND VIEWS

- President's Page 41
- 4S News: Treasurer's report and election results 43
- Letter to the editor 44
- News Clips 44
- Meetings Calendar 48

- About the Authors 2

- Information for Contributors Inside Back Cover

Cover illustration (for Mark Rose article) courtesy of the American Philosophical Association.

About the Authors

Mark H. Rose is a member of the Program in Science, Technology, and Society at Michigan Technological University. He is at work on a book entitled *Cities of Light and Heat*, which explores the social construction of gas and electric systems, 1880-1940. Rose is also co-editor of "Technology and Urban Growth," a monographic series edited by Temple University Press.

Thomas F. Gieryn is Associate Professor in the Department of Sociology at Indiana University. He is working on a history of the social science programs at the National Science Foundation and writing a book, *Boundaries of Science: Theories and Episodes*.

Loet Leydesdorff published a book on Philips and solid state physics, and obtained his doctorate with a thesis on "Employees and Technology Policies." He is co-editor of *The Social Direction of the Public Sciences: Causes and Consequences of Cooperation between Scientists and Non-scientific Groups*, volume 11 of the Sociology of the Sciences Yearbook. *Peter Van der Schaar's* contribution is based on work done in the course of his studies.

Rémi Barré, Ingénieur Civil des Mines, holds a master's degree in City and Regional Planning from the University of North Carolina at Chapel Hill and a Ph.D. in economics from the Ecole des Hautes Etudes en Sciences Sociales in Paris. He has worked from 1982 to 1986 for the French Ministry of Research and Technology. He is currently concentrating his research on S&T policy and management.

Science as an Idiom in the Domain of Technology

Mark H. Rose
Michigan Technological University

And they were sometimes satisfied with superficial investigations as long as they exhibited the general form of the exact sciences.

Lewis Mumford, 1934

The tendency to confuse science and technology has two sources; a misunderstanding of the tasks of each, and the attempt to equalize the social status of the two.

Jerry Gaston, 1980

Those who would codify the meanings of words fight a losing battle, for words, like the ideas and things they are meant to signify, have a history.

Joan W. Scott, 1986

By the 1880s, articulate Americans routinely confused technology with science. Leaders in politics, industry, and the professions celebrated rapid development of the urban technologies such as gas and water systems that were improving the comfort and convenience of members of the middle class. But the label science adhered to these undertakings. Majestic science had captured the rhetorical and ideological highground. As an idiom, science, mostly technology in fact, was part of a process historian Charles E. Rosenberg identified as "an unquestioning faith in the unambiguous virtue of progress."¹

During the period up to at least 1940, literate and articulate Americans continued to describe technological change in terms of science applied to everyday life. Indeed,

science occupied a lofty place in the American imagination. By 1900, argues historian John C. Burnham, Americans assumed that technology and medicine, still known as science, were leading to "miracle[s] comparable with those described in the Bible." By the 1920s, reported the journalist and popular author Frederick Lewis Allen, science had assumed a still broader and perhaps more practical currency among prosperous and educated Americans. "The man in the street and the woman in the kitchen, confronted on every hand with new machines and devices which they owed to the laboratory, were ready to believe that science could accomplish almost anything. . . ." Even during harsh depression days, invocations of majestic science could secure changes in the legal process. "The brute dominance of scientific issues," reports historian Edward W. Constant regarding litigation involving the Texas petroleum industry, led the court to "redefine . . . both 'reasonable' and 'due process.'"²

Scholars trained in the natural and social sciences reinforced the facile blurring of technological and scientific activity. By 1933, for instance, physicist and MIT president Karl T. Compton was promoting a "large program of research in basic science and technology financed under the National Recovery Administration and . . . [a] part of the public works program." In this scheme, "public works" included the "discovery and application of scientific principles" necessary for social and industrial life, such as meteorology, sewage disposal, power transmission, soil mechanics, and geological surveys." During the postwar era, the blending of science and technology remained a staple in publications aimed at collegiate and educated audiences. Particularly popular was the notion that science informed technology in a direct fashion. By 1964, Jacques Ellul was able to observe that, while inaccurate, "everyone has been taught that technique is an application of science." No doubt, the effort to identify one's products and activities with elegant science resulted in part from the recognition that science often had its origins among a group identified as "well-to-do and formally educated. . . ." Indeed, Victorian Americans, especially the well-to-do and formally educated, believed, as historian David A. Hollinger reports, that "science was noble and pure; its practice ennobling and purifying." In a society identified as the Republic of Technology, it was still the case that many could not deny themselves the pleasure of vicarious

Author address: Program in Science, Technology, and Society, Michigan Technological University, Houghton, MI 49931 USA

I wish to acknowledge the following sources of support of research: The Albert J. Beveridge Award Committee of the American Historical Association; the Herbert Hoover Library Association; the Eleanor Roosevelt Institute; and the National Science Foundation, which made two awards. At Michigan Tech, financial support was made available by the Dean of Sciences and Arts; the Office of Research; and the Program in Science, Technology, and Society with funds granted by the Sohio Corporation. In August 1986, an early and abbreviated version of this essay was presented to the 12th meeting of the ICOHTEC (International Cooperation in the History of Technology Committee) in Dresden, DDR, and I want to thank Melvin Kranzberg for making arrangements for the North American delegates and for including me in the group; participants at that meeting offered a number of valuable remarks. I also want to thank W. Bernard Carlson, Josef Konvitz, Lynn Nyhart, and Bruce Seeley as well as an anonymous referee for *Science & Technology Studies* for perceptive and encouraging comments on subsequent drafts. Any opinions, findings, conclusions, and recommendations expressed herein are those of the author and do not necessarily reflect the views of those who supported my research.

Science & Technology Studies 5(1): 3-11, 1987

association with uplifting and fashionable science. Regardless of the reason, after 1900, the proposition that technology was identical with science appeared routinely in the assertions of opinion leaders, evidence of its existence as an artifact of culture among educated Americans.³

After about 1900, then, technology in the guise of science assumed a remarkable cogency in the development of American institutions. At the risk of appearing slightly tendentious, however, I want to advance several ideas that, I hope, will modify our general understanding of science in the domain of technology, and in particular place it more securely in a social context. First, the recent monographic literature suggests that scientists exercised only a modest influence within corporate and political arenas. Curiously, and this is my second point, engineers nonetheless adopted the idiom and even the logic of science for their own purposes. In general, engineers invoked science, *inter alia*, as part of efforts to secure funds, legitimacy, prestige, and markets. Such considerations necessarily direct attention to a concluding point. The resort to science occurred unevenly across the landscape of engineering. Appeals to science, as method and idiom, it appears, had to cohere with the specialized, often volatile markets and politics in which participants worked. In short, and here I want to appropriate the recent and excellent phrasing of philosopher Dudley Shapere, "it is time at last for a piecemeal approach."⁴

I

During the 1880s, North Americans began to participate vicariously in the "theater of science." Popular expositions of science frequently combined elements of magic and mystery. (See cover design, courtesy of the American Philosophical Society.) Early exhibits of electric lighting, arc and incandescent, encouraged the coupling of science and wizardry. For instance, during the summer of 1878, publicists for a traveling circus spoke of an illumination so brilliant that "all scientists gaze in wonder at it." In March 1881, a journalist in Kansas City described an arc system installed in a local store as "the splendid triumph of science."⁵

Subsequent innovations in a number of technological arenas encouraged flamboyant allusions to science. Electricity and electrically-driven machinery were of course particularly susceptible to hyperbolic phrasing. "Electricity entered into everyday life," observes Burnham, "far more eloquent than visions of a republican utopia." Thomas A. Edison was labeled "the Napoleon of Science" during the 1870s. By 1879, according to Wyn Wachhorst, Edison, a man little versed in science, "was seen . . . as equal or superior to any scientist in history. . . ." But the adulation of science extended beyond such obvious improvements in comfort and pleasure as the electric light and phonograph. Scientific management, so-named in 1911 by Frederick W. Taylor, enjoyed widespread interest among factory

managers, publicists, and politicians. Even Taylor's opponents lapsed into the idiom, speaking of a "science of shoveling. . . ." Equally, proponents of domestic science hoped to encourage the application of scientific methods to the tasks of cooking, cleaning, and laundering. Beginning around 1910, then, women as homemakers and the home in general were amenable to the rhetoric of science. A matter so ordinary as siting a new home in order "that the greatest enjoyment of sunshine is afforded and the most interesting views retained" might be advertised as the result of "a scientific study. . . ." Science as a ubiquitous idiom also extended to the personal. An advertisement printed during the late 1920s for Lysol disinfectant thus spoke of "'scientific' bodily care . . ." and still another touted "'scientific' advice on how a woman," by using Lysol as a spermicide, "could avoid 'premature old age and a needlessly unhappy marriage.'"⁶

Engineers and technologists also appropriated rhetorical science. During the nineteenth century, as Edwin T. Layton has found, leaders in American engineering began to describe their work as applied science. Engineering was not science in an exclusive sense, but, according to Layton, a "mirror-image twin." By the twentieth century, leaders of technologically-oriented firms were deploying the idea of science willy-nilly. In many instances, they wished to connect science with its surrounding institutions.⁷

Engineers and technologists (as well as scientists) were particularly fond of making connections to idiomatic science in two steps. In the first, they identified themselves with declining costs of production, increasing wealth, and beneficial social change as a consequence. By 1913, the General Electric Company advertised fans and other small appliances as providing "a luxury once reserved for the rich and now made universal by electricity." Equally, in 1937, following nearly eight years of economic doldrums, the vice president for engineering at General Electric could focus a talk to members of the Edison Electric Institute on innovations in electrical manufacturing since 1920. He paraded higher boiler temperatures, declining energy losses, and even declining weights of equipment as evidence that "the electrical industry has been 'getting more for less' . . ." Iteration of such ordinary and undoubtedly well-known information suggests the powerful imagery for engineers of the notion of industrial growth, based on applied science, as positive social change. Indeed, the talk was entitled, "Engineers Promote Social Progress."⁸

The second step was to connect technological change and social progress with a science sweet and innocent. As early as 1902, a reform-minded educator such as Nicholas Murray Butler of Columbia University could assert that "'scholarship [including scientific scholarship] has shown the world that knowledge is convertible into comfort, prosperity, and success.'" By the 1920s, leaders in American science routinely took credit for economic growth and a rising standard of living. A campaign during the 1920s

among scientists to secure research funds from industrial executives allows a glimpse at the connections often asserted. Physicist Robert A. Millikan appealed for funds to railroad executives with the claim that "the steam engine . . . became possible about the beginning of the nineteenth century . . . because a group of pure scientists, Galileo, Newton, Laplace, and others . . . had worked out the basis of dynamics." In this order, as Millikan had it, "the pure scientist is . . . the scout . . . [and] the army of engineers is to follow. If America calls in her scouts her progress will cease and the demand for any increase in the services of the railroads will disappear." In short, science was good for business, even the railroad business.⁹

Beginning around World War I, scientists, engineers, and industrial executives aimed presentations of idiomatic science at the general public, hoping to alert Americans to their products and services as a whole. In 1914, executives of the chemical industry, a mix of expertise in professional science and engineering as well as complex organizations and marketing savvy, launched a campaign to "make the nation chemically conscious." Books and articles by publicists were part of a campaign in which by 1915, "hundreds of newspapers and periodicals are devoting editorial space to the discussions of the chemists and chemical engineers." Essay contests held annually between 1923 and 1931 offered collegiate scholarships for the best papers on chemistry in farming, medical science, and industrial development, among a number of subjects. Beginning in 1935, the DuPont Company advertised simply, "Better Things for Better Living . . . through Chemistry." Leaders in the chemical industry thus affirmed their own participation in scientific matters and the importance of science (and technology) to the national economy and personal satisfaction.¹⁰

World's Fairs held during the 1920s created another opportunity for technologists to link themselves to science. Both at the Chicago Century of Progress Exposition (1933-1934) and at the New York World's Fair (1939-1940), industrial corporations sponsored many of the exhibits. Naturally, designers stressed the comfort and convenience that technology, especially the corporation's technology, would soon bring near-to-hand. Futurama, which was General Motors' exhibit at the New York fair, featured a gigantic mock-up of America in 1960. In this vision of the future, expressways carried automobiles rapidly through prosperous farming districts and remodeled cities. Corporate sponsors at both fairs also accorded science a position front and center. "The message," according to historian Robert W. Rydell, was "that science was modern man's salvation and that the scientist engineer was priest—if not savior." Authors of the guidebook for the Chicago fair put the matter tersely: "Science Finds—Industry Applies—Man Conforms." The fair in New York delivered a similar package. "The science presented," argues historian Peter J. Kuznick, was not "scientists' science—it was corporate

science, advertiser's science, magician's science, and entertainer's science." Perhaps the important point about the conflation for public purposes of science, technology, and the economy, as historian Bruce E. Seely observes, was that "no one seemed to protest. . . ." Indeed, that so many tentative connections among changes in science, technology, and society went unexamined highlights that crucial role of idiomatic science on the American cultural landscape.¹¹

Curiously, celebrants of a science that was marvelous failed to recognize several of the ambiguities of the scientific enterprise. The place of science in industry appears particularly problematic. Historians George Wise and Leonard Reich have highlighted the remarkable levels of creativity in science and engineering that were encouraged at General Electric and other major research laboratories in industrial settings beginning around 1900. During the early 1930s, for example, physicists at Bell Laboratories, with free time brought about by the on-set of the depression, could turn attention to studying the quantum mechanics of solids. But much of the work undertaken by persons trained in science, even holders of the Ph.D. degree, was routine in nature and oriented toward solving the practical and not particularly scientific problems of their industrial employers. In some firms, moreover, one no longer performed science, but simply knew its contents well enough to administer it. A number of persons working in industrial research laboratories, reports Reich, "had traded the responsibilities of lecturing and directing students for those of keeping records, providing consulting services, and applying for patents." One suspects that John J. Beer's and W. David Lewis' description of science conducted in industry before 1900 as "stultifyingly routine . . ." continued to apply up to at least 1940.¹²

The situation of science in its collegiate setting was equally awkward. On the one hand, collegiate science was institutionalized and prospering, especially at the leading universities. In the area of physics after 1910, for instance, historian Spencer Weart has identified a "research spirit," encouraging faculty to initiate scientific investigation and administrators to finance it. During the 1920s, up to 15 percent of Ph.D. recipients in physics were receiving fellowship awards, allowing a year or two for advanced research. Again in physics, new journals appeared in areas such as rheology to complement the development of flourishing sub-fields, and older journals such as *Physical Review* expanded in size and coverage. After 1930, while not increasing in size, the *Physical Review* was able to publish an increasing number of articles in nuclear physics, a particularly "pure" field. Better news yet, expenditures during the 1930s for research and costly equipment in several academic departments of physics actually increased.¹³

Research protocols elegantly conceived along with original publications comprised only a part of the state of collegiate science. Actually, the content of scientific knowledge

and technique varied markedly across the academic landscape. The "research spirit" identified by Weart, failed, in his telling phrase, to achieve "any very significant diffusion . . . out to the smaller colleges." Indeed, Weart argues that faculty located in twenty departments of physics trained most of the Ph.D.s and authored about three-fourths of the articles in *Physical Review*. Contract research, aimed essentially at solving the pressing problems of manufacturers, also characterized a large component of the on-going work at university research laboratories. Even at colleges emphasizing creative and original work such as Massachusetts Institute of Technology, historian John W. Servos found that "industrial patrons sought answers to narrowly defined questions." As examples, one company wished to reduce leakage in its barrels; another wanted to make its paper greaseproof, and so on. In the science departments located in most colleges and universities, moreover, instrumentation was out-of-date and funds restricted, leaving faculty simply to devote each day to the task of reporting extant knowledge and methods to undergraduates in vast numbers. In a word, scientific knowledge and methods followed ecological lines, flourishing in several, often diverse environments and remaining almost non-existent in others.¹⁴

II

No doubt, participants in enterprises oriented toward science recognized the non-scientific dimensions of their activities. But a strongly ideological dimension accompanied this science, especially as it was purveyed and comprehended at the popular level. The anthropologist Clifford Geertz reminds us that one must not dichotomize science and ideology. Each constitutes a "symbolic strategy for encompassing situations that they respectively represent." One of the goals of an ideology, he continues, is "to motivate action." Thus, participants in science, still mostly technology, might endorse ordinary science, non-science, and the strictly meretricious, all in the idiom of science and all with a view toward a process Geertz labels "objectifying moral sentiment."¹⁵ The secondary literature, recast in this framework, serves as an introduction to an assessment of patterns at the intersection of science (technology), ideology, and social action.

Historians seeking to comprehend science and its external relationships are fond, as Robert K. Merton observes, of adopting "a doctrine of factors. . . ." Often, one factor in particular is cited to explain the remarkable popularity of science (technology) in its idiomatic form. Politics broadly defined to include the allocation of prestige and authority has constituted a popular explanatory scheme. "Through the scientific method," reports Robert W. Rydell, "exposition designers hoped to adjust Americans to a political culture increasingly dominated by corporations." Other scholars have located an urge to professionalize engineering, and connected it with the use of an idiom of science. For instance, Layton argues that the invocation of science

among engineers was part of an effort beginning after 1880 to "mark . . . off the engineer from other groups and of asserting his superiority to them." And still others have linked the invocation of science with an effort by members of the middle and upper classes to achieve a degree of control over the vast social and economic changes taking place in the United States following the Civil War. "Science," reports Charles Rosenberg, "became . . . an increasingly plausible idiom in which to formulate—and in that sense to control emotionally—almost every aspect of an inexorably modernizing world." Finally, historical scholars point to a penchant for modernity in order to account for the persistence of the science idiom. In discussing the immediate popularity of gas, electric, and trolley systems, historians Christopher Armstrong and H.V. Nelles assert that "in North America the anxiety to be up to date, progressive, . . . [was] an appetite as basic as hunger."¹⁶

As a gross generalization, then, historians lodge the popularity of science in its value to nearby institutions and popular ideals. The literature overall suggests that the ideological dimensions of science—its emotional and motivating aspects—served as the couplers to other institutions (even in light of non-science and flimsy science). According to this line of reasoning, so pervasive and satisfying were the ideology, contents, and methods of science that it could be called upon to underwrite a myriad of social activities.

One might allow the matter of science, culture, and social action to repose itself lazily at his point. Science delivered the goods or held out the prospect of making delivery, an ideologically-bounded set of social facts that were congenial personally, professionally, commercially, and so on. But we need to understand these relationships in a more substantial fashion. To borrow once again from Geertz, what we have accomplished is to assemble "supposed facts from the cultural and subcultural levels side by side so as to induce a vague sense that some sort of relationship between them—an obscure sort of 'tailoring'—obtains." In short, we lack social middle terms. I want to probe more diligently for those middle terms in the form of mediating agencies.¹⁷

Road building and electric utility operations offer a beachhead for this probing action. Their American context is the place and the first half of the century the time. Actually, road building and utility operations are only partially commensurable activities. The logic of this comparison lies in the vast investments made in electric and highway systems and their obvious importance for economic development, political action, and social change. Equally important were the frequent references made by leaders in both industries to abstractions regarding the political economy such as individualism and the marketplace and their common invocation of science. The remainder of this section, then, explores in general terms the social organization of highway building, then of electrical utility systems.

This analysis serves as background for comprehending the manner in which idiomatic science was deployed in the ideologies of these two enterprises.

Although highway construction and improvement remained public responsibilities, the level of funding and authority shifted upward from local to state and federal officials. During the period up to 1900, finance and construction rested in the hands of local agencies, including county, borough, township, and city governments. After 1900, state officials assumed part of the responsibility for finance and construction; and in 1921, the federal government agreed to fund up to 50 percent of the expenses of building a national network of connected rural roads, the U.S. highway system. During the 1930s, the federal government also initiated a program of financing construction of urban and farm market roads. Beginning in 1944, moreover, federal officials authorized construction of the Interstate Highway System, no doubt the most innovative system in terms of design and certainly the most costly. Curiously, as late as the mid-1950s, several thousand units of government remained active in the highway construction field. But the net effect of the effort and expense dedicated to highway building overall was creation of a vast and integrated road system under the supervision of a network of trained engineers at the federal, local, and state levels.¹⁸

Road improvements greatly facilitated the flow of automotive and later truck traffic. As late as 1910, according to historian Warren J. Belasco, travel across the nation was limited to "affluent individualists for whom the very lack of an established infrastructure was its major attraction." These early motorists referred to themselves affectionately as "gypsies." Even during the next ten years, completion of a lengthy trip by automobile was evidence of fortitude and stamina. By the mid-1950s, however, road engineers at every level had built and paved more than 2 million miles of roadway. In 1955, the nation's fleet of buses, automobiles, and trucks totalled more than 62 million, and each travelled on average nearly 10 thousand miles a year in a routine fashion. Indeed, Belasco describes the highway system as "the all-too-familiar beaten path."¹⁹

Curiously, this system of roads never appeared adequate or affordable. During the 1920s, road engineers and political leaders in larger cities undertook major programs of extending and widening streets and roads. But traffic increases overwhelmed remodeled roads, especially along routes that proved attractive for the location of roadside businesses. All the while, organized road users such as truck and bus operators along with leaders of the American Automobile Association complained to politicians about the diversion of gasoline tax revenues to non-highway purposes such as schools and the dispersion of remaining revenues toward the construction of low-volume roads in the hinterlands. Following World War II, the traffic problem and its accompanying tangles in political arenas just grew

worse. As late as 1955, in fact, disputes regarding tax levels and allocation formulas left members of the U.S. Congress unable to shape legislation to accelerate construction of the high-volume Interstate Highway System.²⁰

During the first half of this century, then, road engineers operated within an administrative paradox. On the one hand, highway building on a day-by-day basis was embedded within public agencies with fixed responsibilities and prescribed geographic horizons. On the other, road engineers at each level of government were engaged with members of the highway and transport industry in fierce competition for funds, sharp contention regarding routing and design, and consequent political and financial uncertainty.

Initially, electric companies commenced operations in markets that were even more volatile. During the early 1880s, permanent installations of arc (and later incandescent) lamps in department stores and at busy intersections as well as atop towers as high as 250 feet inevitably attracted the attention of journalists and large crowds of curious urbanites. Inevitable also was entry into the electric lighting business in many cities by several competing firms, usually composed of local businessmen possessing enthusiasm for the magic and mystery of this new technology and a conviction that immense profits could be leveraged from excited customers and stock deals. By the 1890s, leaders in many cities boasted of the presence of several electric firms, which now competed with one another along with the gas company for a lighting market proving slow to expand. In Detroit during 1897, for example, four electric companies provided service only to four thousand households out of about 55 thousand. The ensuing rate wars in Detroit and elsewhere led to defaults and bankruptcies. So fierce was competition between firms in several markets that construction workers occasionally destroyed the equipment of rival firms. Competition for the electric lighting business in Milwaukee, reports historian Forrest McDonald, led to "price wars, duplication of investment, poor service, and sabotage. . . ."²¹

After 1900 or so, the popularity of the public utility idea allowed managers such as Samuel Insull in Chicago to consolidate operations. By installing the new, alternating current systems capable of city-wide service, moreover, Insull hoped to achieve economies of scale and enhanced and predictable rates of return on growing investments. By World War I, only one firm provided electric service in most American cities; and by the early 1930s, sixteen holding companies controlled approximately 75 percent of the generating capacity in private hands. In short, utility status at the local, urban level and the flow of vast sums of capital through several holding companies nationally had created a stable environment for electrical utilities, both politically and financially. Finally, executives in charge of engineering and financial operations located at the headquarters of holding companies such as Cities Service directed local af-

fairs. Between 1900 and 1930, the locus of authority within each firm also shifted inexorably upward.²²

Marketing remained a local responsibility. Trade associations and manufacturers such as the National Electric Light Association and General Electric conducted massive advertising campaigns aimed at selling appliances and boosting electric consumption. For instance, promotions conducted during 1915 and 1916 featured the idea of electrically illuminated Christmas ornaments. But these efforts only set the larger scene, perhaps stimulating a wish and a tentative connection with its fulfillment. Local officials still had to write up the business. Managers at each of the local companies enjoyed surprising discretion in shaping these sales campaigns, including the ability to select brands of appliances deemed to hold special appeal in a particular city. Generally, early promotions offered electric irons at modest prices; occasionally, irons and replacement light bulbs were given away. Later campaigns featured fans, refrigerators, and ranges, including samples of fresh pies and cakes baked by women holding degrees in home economics. In turn, each sales campaign engendered fierce competition brought by distributors of cheap and plentiful gas, coal, and oil. The key to a successful campaign—defined in terms of additions to connected load rather than return on appliance sales—was to develop marketing ideas that cohered with the city's income, climate, and industrial mix. Cleanliness and health proved especially popular themes among marketing executives. By the 1920s, preparation of electrical consumption data in conjunction with income estimates in each sales territory permitted an increasingly sophisticated approach to marketing activities.²³

The electrical and highway building industries thus differed in several ways. Structural features varied between the hierarchically-organized utility firms and the fluid relationships among public officials and engineers in the road building arena. Only the marketing units were subjected to the discipline and monthly vicissitudes of the local urban market. The visible hand of management shaped the utility firm; and the equally visible hand of politics shaped the highway agency. The relationships of the two industries to the formal political arena were also different. Utility operations and highway construction represented the public and private traditions of infrastructural development in the United States. No doubt, public agencies approved electric rates and conferred monopoly status in the utility field. Nonetheless, regulation of rates by state utility commissions helped legitimize operations, leaving day-by-day management in private hands. By contrast, road engineers at every level had to return each year (or biannually) to legislative bodies for renewal of funds, perhaps for an increase to handle the crush of traffic. The political hand helped guide the selection of highway department personnel as well as the design of new roads, their routings, and the timing of construction.²⁴

But road engineers and utility executives rarely perceived the structural and extra-local dimensions that shaped operations. Instead, they reflected on their own situations in terms of two analytic categories. First, the language of a commercial civilization pervaded ordinary communications. Individualism was a favorite metaphor for comprehending the economic patterns surrounding their own industries. Persons, one at a time it was said, made choices about commuting patterns or about the quantity of electric current consumed. In this analytic scheme, the market place of individual selection dictated the direction of utility operations and road building, and success was measured by the volume of consumer demand alone. The self was supreme; and politics, which catered to the sordid ends of groups, only distracted from the proper flow of resources into this natural market. The idea of a consumer democracy was probably a congenial one in a market place that occasionally appeared tumultuous. Actually, this ideology of individualism obscured the organized and impersonal factors shaping the local environments in which road and utility engineering took place.²⁵

Alongside the crude but powerful notion of the individual stood a competing and equally compelling set of assumptions regarding expertise in a democratic society. In the highway field, for instance, civil engineers routinely agreed that gasoline tax funds should be dedicated to highway building and that roads ought to serve traffic rather than local economic or urban development. Federal as well as many state engineers contended that the Interstate Highway System, by virtue of its geometry of design and route coordinates, was a superb investment as well as exquisite engineering. Ideology guided design and technique. Even so, these ideological components of civil engineering had appeared in an inchoate form in their introductory courses in college, and had matured through several decades at overburdened highway departments during the course of the first several decades of massive highway building and spending.

The situation was much the same at utility firms. Survivors of the rate wars of the 1890s entered the new era of regulation and monopoly by celebrating the idea of public service—so enamoured were executives of this notion that it appeared in a number of corporate names, as for instance the Public Service Company of Colorado. Service, in this scheme, included not only fewer power failures and progressively lower rates during the next several decades, but instruction to customers in appropriate methods of heating, cooking, and eating as well as interior decoration, including the importance of matching colors for accessories. Salesmen and home economists as well as civil engineers thus perceived themselves as providing expert knowledge, and a tradition emerged as part of their training and experience suggesting that they were entitled to the deference accorded experts. One served the market, but also had the

right to shape it, two ideological rather than empirical realities that provided an explanatory framework for what otherwise was only dimly understood.²⁶

Idiomatic science cohered with and advanced each dimension of these professional ideologies. In a universe composed of autonomous units, irreproachable science offered a rhetorical device for achieving a degree of predictability, even control over events in the disorderly highway field. The logical conflict of these ideas did not emerge, moreover, because control was the due of engineers, particularly in the development of major road projects where scrutiny was intense. Beginning during the 1920s, then, the incessant scramble for political favor and additional funds to serve traffic encouraged road engineers to create elaborate research projects termed scientific and to cite traffic counts termed equally scientific as the bases for project recommendations. In fact, road design remained crudely empirical, and Bruce Seely has shown that early attempts at developing a "scientific research method . . . failed to aid highway designers." Road engineers, argues Seely, had subordinated themselves to a "scientific mystique." Nonetheless, science served as a commons, a valuable meeting point for enhancing leverage in political arenas and for attaining a luster in the marketplace increasingly attributed to "high tech" fields such as utility engineering.²⁷

Science resonated differently in utility circles. Utility executives liked to identify every phase of their business with science. Yet no where was the assertion more strenuously advanced and less well-founded than in marketing, which by 1930 comprised the largest portion of a number of local operations. Among utility executives, science proved a valuable commons between the popular interest in matters scientific and old-fashioned commercialism. Health was one of several popular topics which afforded such common ground. By 1900, germs and disease loomed large among educated Americans. National sales campaigns launched by utility executives were efforts to crystallize the interest in cleanliness into concrete purchases. Employment of female demonstrators—home economists mostly, and possessing the credentials of science for the home—was the last item needed to encourage the individualistic householder to cook scientifically, which meant with electricity and lots of it. In turbulent and industrializing cities, moreover, science might bring a sense of security to anxious householders and a larger and more diverse load to utility operators.²⁸

III

Technology, known popularly as science, was of course a potent factor in American life. Yet much that carried the label of science was only marginal to the modern sciences, including routine research and teaching in corporations and universities. Nonetheless, scientists, engineers, and hucksters routinely celebrated the accomplishments of science as a whole, invoking it in search of improved re-

search methods, natural knowledge, higher sales, legitimization and the valuable prestige associated with the ability to enhance comfort, convenience, and cleanliness. The popularity of science overall rested on powerful components in American and Western life; science was a key to prosperity and a longer life.

But science resonated in particular according to the institutional settings of its defenders and publicists. In a relatively stable and capital intensive field such as electric utility operations, science might serve as a connector to urban residents seeking to improve their health through new methods of cooking, heating, and laundering. So much the happier for new monopolists if idiomatic science could link their enterprises to the traditional virtues of a clean home and good meals. In a more volatile field such as road building, where politicians and traditional politics counted, science might enhance control of spending, perhaps even boost leverage in budget deliberations. And for road engineers who stood in the summer sun with feet deep in mud, one should not doubt the attractiveness of boosting prestige through idiomatic science. Thus, science would function as an ideological middle ground among the notion of individualism, the reality of large organizations, and an urge to secure the deference of others, perhaps to organize their domestic and travel affairs in detail. Technology, still known as science, was thus crucial to the ideological well-being of Americans bent on personal consumption; and it was equally crucial to the ideological development of specialists such as road engineers and utility operators. Science was a valuable idiom for expressing and legitimatizing their own forms of knowledge, their local organizations, and their group identities.

One must also suggest an unexplored dimension of the uses of idiomatic science among specialists. It may well have been the case that the larger contexts of American life were in part not well-suited to the emerging professions. On the one hand, the American political economy was becoming national, pluralistic, and highly-organized. At the same time, the cultural convictions of many continued to celebrate the individual as a social atom. Science as an idiom obscured the paradox. Better yet, these new professionals would not have to face up to the inconsistencies.

Notes

1. Scholars of science and technology have failed to reach agreement regarding the nature, extent, and interpenetration of these enterprises. No advantage would accrue to disciplined knowledge were I to enter that discussion with additional clarifications and illustrations of scientists, applied scientists, or technologists in action. Instead, I would like to recommend for heuristic purposes that we adopt the definitions advanced by sociologist Jerry Gaston and, I suspect, widely endorsed among literate Americans. Science was (and remains) simply natural knowledge and a method of creating it; and technology, advises Gaston, was (and also remains) efforts to develop "innovative processes and products." Endorse-

ment of these definitions does not preclude social analysis of science and technology. Indeed, the matters about which I hope to prove persuasive are grounded in a social construction by actors of those terms. See Jerry Gaston, "Sociology of Science and Technology," in Paul T. Durbin et al., eds., *A Guide to the Culture of Science, Technology, and Medicine* (New York: The Free Press, 1980), p. 467. Finally, I am employing *idiom* and *idiomatic* along the lines sketched by Charles E. Rosenberg. Among Americans of the mid-nineteenth century, he contends, science was "an increasingly plausible idiom in which to formulate . . . almost every aspect of an inexorably modernizing world." But I want to extend the use of idiomatic science to the twentieth century and encompass social and technological phenomena, each of which, I am arguing, were formulated in terms of science with specific social meaning. See Rosenberg, *No Other Gods: On Science and American Social Thought* (Baltimore and London: The Johns Hopkins University Press, 1976), pp. 7, 137.

2. John C. Burnham, "Essay," in John D. Buenker, John C. Burnham, and Robert M. Crunden, eds., *Progressivism* (Cambridge: Schenkman Publ. Co., 1977), p. 19; Frederick Lewis Allen, *Only Yesterday: An Informal History of the Nineteen-Twenties* (New York: Harper and Row, 1931; Perennial Library, 1959), p. 164; Edward W. Constant, II, "State Management of Petroleum Resources: Texas, 1910-1940," in George H. Daniels and Mark H. Rose, eds., *Energy and Transport: Historical Perspectives on Policy Issues* (Beverly Hills: Sage Publications, 1982), p. 174; and also see David M. Kennedy, "In Retrospect: Revisiting Frederick Lewis Allen's *Only Yesterday*," *Reviews in American History* 14 (June 1986), p. 316, for a description of Allen's universe as "restricted sociologically to his eastern urban and suburban subscribers . . .," roughly, then, a geographic stratum of the literate and articulate Americans I am identifying with an enthusiasm for idiomatic science.

3. Compton as cited in Robert Kargon and Elizabeth Hodes, "Karl Compton, Isaiah Bowman, and the Politics of Science in the Great Depression," *Isis* 76 (September 1985), 314; Jacques Ellul, *The Technological Society* (New York: Vintage Books, 1964), p. 7; Howard P. Segal identifies science with the well-to-do and formally educated in his *Technological Utopianism in American Culture* (Chicago and London: University of Chicago Press, 1985), p. 13; David A. Hollinger, "Inquiry and Uplift: Late Nineteenth-Century American Academics and the Moral Efficacy of Scientific Practice," in Thomas L. Haskell, ed., *The Authority of Experts: Studies in History and Theory* (Bloomington: Indiana University Press, 1984), p. 143; Walter A. McDougall, *The Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985), p. 71, recalled my attention to Daniel Boorstin's notion of a Republic of Technology.

4. Dudley Shapere, "External and Internal Factors in the Development of Science," *Science & Technology Studies* 4 (Spring 1986), p. 8.

5. Christopher Armstrong and H. V. Nelles, *Monopoly's Moment: The Organization and Regulation of Canadian Utilities, 1830-1930* (Philadelphia: Temple University Press, 1986), pp. 59-68; reprinted in *Kansas City Star*, June 4, 1950, from Native Sons Archives, Vol. 59, Kansas City Public Library; *Kansas City Evening Star*, March 24, 1881, in clippings file, both in Missouri Valley Room, Kansas City Public Library, Kansas City, Missouri. David Boutris of the Western History Collection at the University of Missouri at Kansas City was extremely helpful in facilitating my use of these materials.

6. Wyn Wachhorst, *Thomas Alva Edison: An American Myth* (Cambridge and London: The MIT Press, 1981), pp. 33, 35-36; Daniel J. Boorstin, *The Americans: The Democratic Experience* (New York, 1973; Vintage Books, 1974), pp. 363-368; *Garden Homes: Planned and Executed by J.C. Nichols* (Kansas City: n.p., c. 1925), unpaginated, in KCPL-MVR; Ruth S. Cowan, "Ellen Swallow Richards: Technology and Women," in Carroll Pursell, ed., *Technology in America: A History of Individuals and Ideas* (Cambridge and London: The MIT Press, 1981), pp. 142-150; Roland Marchand, *Advertising the American Dream: Making Way for Modernity, 1920-1940* (Berkeley: University of California Press, 1985), pp. 344-346.

7. Edwin T. Layton, Jr., "Mirror-Image Twins: The Communities of Science and Technology in 19th-Century America," *Technology and Culture*

12 (October 1971), 562-580; and Layton, "American Ideologies of Science and Engineering," *Technology and Culture* 17 (1968), 688-701.

8. "A Luxury Once Reserved for the Rich Now Made Universal by Electricity," [adv.] *Electrical Merchandising and Selling Electricity* 12 (June 1913), p. 169; R. C. Muir, "Engineers Promote Social Progress: Industrial Research and Evolution Steadily Extract More Benefit Out of Material Resources and Technical Talent," *Electrical World* 107 (June 5, 1937), 82.

9. Nicholas Murray Butler, "Scholarship and Service," *Educational Review* 24 (June 1902), 3 as cited in Daniel J. Kevles, *The Physicists: The History of a Scientific Community in Modern America* (New York: Vintage Books, 1979), p. 71; Peter J. Kuznick, "The Science Popularizers Dilemma: The Battle Over the Presentation of Science at the 1939 New York World's Fair," a paper presented at the Annual Meeting of the Organization of American Historians, Minneapolis, April 1985. Dr. Kuznick was kind enough to share this paper with me. Quotes from Millikan are cited in Ronald C. Tobey, *The American Ideology of National Science, 1919-1930* (Pittsburgh: University of Pittsburgh Press, 1971), pp. 223-224. The assertion of technology's dependence on science is rendered all the more spectacular in light of the development of the steam engine in the absence of any scientific knowledge. In fact, observes Edward Constant, "the rise of the steam engine led directly to the creation of classical thermodynamic theory." See his *The Origins of the Turbojet Revolution* (Baltimore and London: Johns Hopkins University Press, 1980), p. 67.

10. My characterization of the components of the chemical industry is based in part on the analytic categories in Arnold Thackray, Jeffrey L. Sturchio, P. Thomas Carroll, and Robert Bud, *Chemistry in America, 1876-1976: Historical Indicators* (Dordrecht, Boston, Lancaster: D. Reidel Publ. Co., 1985), pp. 98-105. In 1934, the Dupont Company had been labeled a "merchant of death" because of reported profiteering in the manufacture of weapons during World War I, a reputation which might have encouraged the new slogan. That point as well as my overall understanding of public relations in the chemical industry rests on a paper shared with me by the author, David J. Rhees, "Making the Nation Chemically Conscious: The Popularization of Chemistry in America, 1914-1940," which was presented at the Annual Meeting of the History of Science Society, Chicago, December 1985; also see, Bruce Sinclair, "Local History and National Culture: Notions on Engineering Professionalism in America," *Technology and Culture* 27 (October 1986), 686, for an analysis of the social bases of an interest among engineers during the early 1930s in fostering economic development and resolving social tensions.

11. Mark H. Rose, *Interstate: Express Highway Politics, 1941-1956* (Lawrence: University Press of Kansas, 1979), pp. 1-2; Robert W. Rydell, "The Fan Dance of Science: American World's Fairs and the Great Depression," *Isis* 76 (December 1985), 531; Kuznick, "The Science Popularizers' Dilemma"; Bruce E. Seely, *Building the American Highway System: Engineers as Policy Makers* (Philadelphia: Temple University Press, forthcoming); and also see, James Mann, "The Popularization of Science and A Century of Progress International Exposition: Opportunities and Obstacles," a paper presented at the Annual Meeting of the Organization of American Historians, Minneapolis, April 1985. I would like to thank Dr. Mann and Dr. Seely for sharing their work with me. Finally, see, T. J. Jackson Lears, "The Concept of Cultural Hegemony: Problems and Possibilities," *American Historical Review* 90 (June 1985), 573. Because the American cultural scene is characterized by its pluralism, I find the concept of hegemony useful for heuristic purposes in the middle ranges.

12. George Wise, "A New Role for Professional Scientists in Industry: Industrial Research at General Electric, 1900-1916," *Technology and Culture* 21 (July 1980), 408-429; Leonard S. Reich, *The Making of American Industrial Research: Science and Engineering at GE and Bell, 1876-1926* (Cambridge: Cambridge University Press, 1985); and Reich, "Science," in Glenn Porter, ed., *Encyclopedia of American Economic History: Studies of the Principal Movements and Ideas* (New York: Charles Scribner's Sons, 1980), p. 291; Spencer R. Weart, "The Physics Business in America, 1919-1940: A Statistical Reconnaissance," in Nathan Reingold, ed., *The Sciences in the American Context: New Perspectives* (Washington, D.C.:

Smithsonian Institution Press, 1979), p. 317; John J. Beer and W. David Lewis, "Aspects of Professionalization of Science," in Kenneth S. Lynn, ed., *The Professions in America* (Boston, 1965), p. 767. Leaders in industrial research who were scientifically-oriented such as Thomas Midgley, Jr. at General Motors felt obligated, as Stuart W. Leslie reminds us, to apologize for work conducted under corporate sponsorship. See his, "Thomas Midgley and the Politics of Industrial Research," *Business History Review* 54 (Winter 1980), 480-482. For an overview of the state of the art of scholarship in this emerging sub-area, see W. Bernard Carlson, "Industrial Research in America: A Select Guide to Historical Studies," *History of Science in America: News and Views* (November 1984). One suspects that contemporary interest in this topic rests on the emphasis in American universities and state and federal agencies on promoting technological innovation with a view toward enhancing rates of economic growth. Still another factor encouraging research in this area has been the employment of many historians in corporate archives and academic research units focused in particular on the historical dimensions of industrial innovation.

13. Weart, "The Physics Business in America, 1919-1940," pp. 311-313, 321-324; and also see John W. Servos, "The Knowledge Corporation: A. A. Noyes and Chemistry at Cal-Tech, 1915-1930," *Ambix* 23 (November 1976), 175-186, for an assessment of research under a program of selective excellence.

14. Weart, "The Physics Business in America, 1919-1940," pp. 298-299; John W. Servos, "The Industrial Relations of Science: Chemical Engineering at MIT, 1900-1939," *Isis* 71 (December, 1980), 540-541; and also see Stanley Cohen "American Foundations as Patrons of Science: The Commitment to Individual Research," in Reingold, ed., *The Sciences in the American Context*, p. 247, n. 25.

15. Clifford Geertz, *The Interpretation of Cultures* (New York: Basic Books, 1973), pp. 230-231.

16. Robert K. Merton, *The Sociology of Science: Theoretical and Empirical Investigations* (Chicago and London: The University of Chicago Press, 1973), p. 176; Rydell, "The Fan Dance of Science," p. 541; Edwin T. Layton, Jr., *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession* (Baltimore and London: The Johns Hopkins University Press, 1971, 1986), p. 58; Rosenberg, *No Other Gods*, p. 7; and Armstrong and Nelles, *Monopoly's Moment*, p. 64. The literature of science and politics is neatly assessed in Margaret Rossiter, "Science and Public Policy Since World War II," *Osiris* 1 (1985), 273-294; Thomas F. Gieryn, George M. Bevens, and Stephen C. Zehr, "Professionalization of American Scientists: Public Science in the Creation/Evolution Trials," *American Sociological Review* 50 (June 1985), 392-409, present a case study of the professional urge to expand cognitive authority; and in the area of professionalism and the appeal of science, also see Burton J. Bledstein, *The Culture of Professionalism: The Middle Class and the Development of Education in America* (New York: W.W. Norton, 1976), p. 326; and finally see, Marchand, *Advertising the American Dream*, p. 273, who locates a "servent adulation of the works of technological progress."

17. Geertz, *The Interpretation of Cultures*, p. 42.

18. U.S. Department of Transportation, Federal Highway Administration, *America's Highways 1776-1976: A History of the Federal-Aid Program* (Washington, D.C.: GPO, 1976), pp. 113-174; Seely, *Building the American Highway System*; Rose, *Interstate*, pp. 2-54.

19. Warren J. Belasco, *Americans on the Road: From Autocamp to Motel, 1910-1945* (Cambridge and London: MIT Press, 1979), pp. 7-8, 11, 173; U.S. Department of Commerce, Bureau of Public Roads, *Highway Statistics: Summary to 1955* (Washington, D.C.: GPO, 1957), pp. 40, 78.

20. Rose, *Interstate*, pp. 69-84; *Toll Roads and Free Roads*, H. Doc. 272, 76th Cong., 1st Sess., pp. 105-108.

21. Raymond C. Miller, *Kilowatts at Work: A History of the Detroit Edison Company* (Detroit: Wayne State University Press, 1957), pp. 10, 32-49; Mark H. Rose and John G. Clark, "Light, Heat, and Power: Energy Choices in Denver, Wichita, and Kansas City, 1900-1935," *Journal of Urban History* 5 (May 1979), 344; Bill Beck, *Northern Light: An Illustrated History of Minnesota Power* (Duluth: Minnesota Power, 1986), pp. 1-17;

Forest McDonald, *Let There Be Light: The Electric Utility Industry in Wisconsin, 1881-1955* (Madison: The American History Research Center, 1957), pp. 50-51.

22. Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore and London: The Johns Hopkins University Press, 1983), pp. 125-127, 206-226, 392; impressions gained from review of the reports of the Public Service Company of Colorado, Denver.

23. Rose and Clark, "Light, Heat, and Power," pp. 346-360; and Mark H. Rose, "Urban Environments and Technological Innovation: Energy Choices in Denver and Kansas City, 1900-1940," *Technology and Culture* 25 (July 1984), 503-539; and Rose, "Cities of Light and Heat: The Urbanization of Electric and Gas Systems, 1880-1930," *Urban Resources* 3 (Fall 1985), 47-53; and David B. Sicilia, "Selling Power: Marketing and Monopoly at Boston Edison, 1886-1926," a paper presented at the Annual Meeting of the Organization of American Historians, New York, April 1986, which the author kindly shared with me.

24. Alfred D. Chandler, Jr., *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, Mass.: Harvard University Press, 1977); Seely, *Building the American Highway System*. Also see, Armstrong and Nelles, *Monopoly's Moment*, which highlights the development of political legitimacy for technological systems within a Canadian context.

25. Details of the rhetoric of leaders in the road building and electric utility industries are drawn from my book, *Interstate*, and from Rose, "Urban Environments and Technological Innovation." The logic of my analysis is informed by Seely, *Building the American Highway System*; and by John C. Burnham, "The New Psychology: From Narcissism to Social Control," in John Braeman, et al., eds., *Change and Continuity in Twentieth-Century America: The 1920's* (Columbus: Ohio State University Press, 1968), pp. 351-359, which explores the development of "self-centered attitudes . . . [and] self-indulgent behavior . . ." in an increasingly collective age. In addition, my analysis of the patterned relationships between individuals and large organizations continues to be influenced by several community and organizational studies conducted by sociologists and historians. Arthur J. Vidich and Joseph Bensman, *Small Town in Mass Society: Class, Power and Religion in a Rural Community* (Princeton: Princeton University Press, 1968), contends that residents of Springdale, New York often failed to recognize the disjunctures between personal values and strivings and the allocation of prestige and resources by large-scale agencies, public and private. Finally, James Borchert, *Alley Life in Washington: Family, Community, Religion, and Folklife in the City, 1850-1970* (Urbana: University of Illinois Press, 1980), argues that residents of Washington's alley communities, the district's poorest and least influential residents, maintained traditional habits in the face of local and extra-local institutions, thereby reducing the gap between the individual and the larger society.

26. For the development of professional sub-cultures at the local level, I am drawing inferences from Sinclair's insightful essay, "Local History and National Culture," esp. p. 693. Sinclair's argument is that a desire for "insulation both from corporate cupidity and the condescension of aesthetes" helped shape the local culture of mechanical engineers, but I suspect that such a scheme applies with less force to electrical and highway engineers, who emerged in the era of the large corporation rather than during the period of an ascendant shop culture. The conceptual range of an authority of experts is thoughtfully explored in the essays included in Haskell, ed., *The Authority of Experts*. Finally, see Clifford Geertz, *Local Knowledge: Further Essays in Interpretive Anthropology* (New York: Basic Books, 1983), p. 167, for the observation that "crafts of place" are shaped in "the light of local knowledge."

27. Bruce Seely, "The Scientific Mystique in Engineering: Highway Research at the Bureau of Public Roads, 1918-1940," *Technology and Culture* 25 (October 1984), 798-831; Rose, *Interstate*, p. 43.

28. Ruth S. Cowan, Mark H. Rose, and Marsha S. Rose, "Clean Homes and Large Utility Bills," *Marriage and Family Review* 9 (Fall 1985), 58-63; Sicilia, "Selling Power."

Science and Coca-Cola

Thomas F. Gieryn
Indiana University

Science and Coke? You must be joking. What logical set could possibly include as members the epitome of knowledge and the epitome of soft drink? Here is that set: each is a commodity, a commercial product bought and sold in a competitive market, and dependent for sales upon advertising. Ads for science? With no Pepsi to challenge for market-share, why does science need to be advertised? And how could science—if we distinguish it from technological applications—be considered commercial? Who are buyers and sellers of science? And without anticipation of profits that drive the manufacture of Coca-Cola, what drives the manufacture of science?

This paper has a simple theme, with anything-but-simple implications for a social theory of the “rise of science.” The manufacture of Coke and of science depend on the availability of money: liquid assets of the Coca-Cola Corporation are about \$1.2 billion; scientists preparing to do research with a new accelerator under construction near Geneva by CERN will have assets of about \$200 million for their initial round of experiments. To get this money, Coca-Cola sells beverage-products and scientists sell knowledge-products: last year, thirsty people bought \$9.3 billion of Coke world-wide and the United States government bought about \$60 billion of scientific research and development. Sales of all soft drink products went up 40% from 1976 to 1986, but American scientists did even better: a 176% increase in federal funding for R&D over the last decade. The Coca-Cola Corporation annually spends over \$180 million for advertisements to convince people to buy Coke; scientists themselves spend almost nothing on advertising but “science-ads” still appear everywhere to convince people (states or corporations or venture capitalists) to buy science. If Coke-ads succeed in eliciting sales, the Coca-Cola Corporation stays in business; if science-ads succeed in eliciting sales, scientists stay in business.

Advertising campaigns for science and Coke have much in common, as my illustrations will suggest: science-ads and Coke-ads define unique features of the two products, show how they are better than the competition, describe the variety of Coke-products and science-products for different needs and for different market-segments, and lure consumers with the promise of tantalizing side benefits.

Author address: Department of Sociology, Indiana University, Bloomington, IN 47405 USA

Science & Technology Studies 5(1): 12-21, 1987

But one difference is crucial: science-ads—through various “de-advertising mechanisms” identified below—create science as something *other than* a commodity commercially bought and sold in a competitive market, and as something not in need of advertising. Paradoxically, science-ads tell audiences that “this is not a science-ad” because science is simply *not* like Coke at all and does not need to advertise. Scientists thrive (materially) because science is seen as a kind of public good rather than as a product whose sales “profit” its manufacturers, even though the perceived non-commercial character of science is accomplished in part with the same vehicle used to sell Coke or any other commercial good: advertising.

My curiosity about self-denying science-ads has been piqued by developments in four corners of the sociology of science. From Paris, Latour describes how Pasteur pioneered Madison Avenue techniques by convincing French officials that *their* wants were best satisfied through the purchase of *his* laboratory.¹ Just as Coke carried the day in 1952 with an advertising slogan that translated our interests into their product (“What you want is a Coke”), Pasteur told French society “What you want is science.” Coke-ads enlist Coke-drinkers as allies who satisfy their thirst while bringing needed revenue to the Corporation; science-ads enlist science-buyers as allies who satisfy their thirst for knowledge while bringing needed revenue to scientists. From York, Mulkay and friends describe the interpretative flexibility found in scientists’ diverse accounts of science,² the same discursive flexibility that may be the essence of successful advertising. No ad can be “definitive,” and characteristics of products are selectively revealed or hidden: a Coke-ad from 1942 that featured the slogan “Coca-Cola has that extra something” did not tell readers that the “something” might be sufficient acidity to dissolve a tooth.

From the Science Studies Unit at Edinburgh, the work of Barry Barnes, Donald MacKenzie and Steven Shapin suggests that although scientists may have divergent political or ideological interests that separate them, they are united by a common interest in maximizing collective or “professional” resources and opportunities made available (in unequal amounts) to practitioners.³ Just as Coke and Pepsi share an interest in government laws protecting their trade-marks, American scientists have a common stake in lobbying to enlarge the total budget of the National Science Foundation (though disputes about how that pie is cut into disciplines can be every bit as nasty as the cola

wars). From the Tremont Institute in San Francisco, a cluster including Elihu Gerson, Leigh Star, Adele Clarke, and Joan Fujimura pursue Chicago-school sociology of science by drawing attention to the idea that the "social world" of science goes far beyond laboratory walls.⁴ The "science-world" must include not only Einstein's theories but a recent ad for Discovery Toys showing young Albert and his mother at play, with a message that if you buy your kids the right toys they too might grow up to discover relativity. Science goes on in odd places like consumer-product ads in *Time* or *Newsweek*, though these science-ads at the same time remind us that science really has no business amidst such crass commercialism.

Functions of Advertising

What do ads do? Much can be learned from Michael Schudson's *Advertising: The Uneasy Persuasion*, although its focus on national consumer goods advertising would seem to tell us more about Coke-ads than Science-ads. The social significance of commercial advertising is not to persuade a rather inattentive audience to buy a *specific* brand but to instill in us a "consumer culture" or a "framework for thought and feeling" that "extols acquisition and consumption at the expense of other values."⁵ The barrage of ads create an interpretative context in which the endless and even unnecessary purchase of goods has *prima facie* legitimacy: one does not have to justify "shopping."

But this is the distanced view of a sociologist; advertising firms and their clients must believe (even if they cannot prove) that advertisements help to sell the specifically-mentioned product. That belief has led some advertisers to use "science" as a way to persuade consumers to prefer *their* brand. The claim "Scientists at a leading research university have discovered . . ." is an advertising cliché constantly testing our credibility. Why is it so common? An insightful discussion of science in consumer products advertisements comes not from the mountain of advertising textbooks but from a countertext designed to reveal the deceptive ploys that have become Madison Avenue stock-in-trade. The book is written by Hugh Rank and titled *How to Analyze Ads: The Pitch: A Simple 1-2-3-4-5 Way to Understand the Basic Pattern of Persuasion in Advertising*. The following, long passage from Rank, which explains *why* advertisers use white lab coats and fancy statistics to sell products, is best read while remembering the different image of science that has emerged from our sociological studies of what goes on in laboratory life:

'Science' is used here as a category of some human need or desire, a 'good thing' already wanted or desired by people; ads often simply associate their product or service with 'science' words or images, thus suggesting or implying an 'added value' to the buyer. . . . the common human desire for certitude (for support, reassurance, guidance, direction, approval) is related to this category of 'science.'

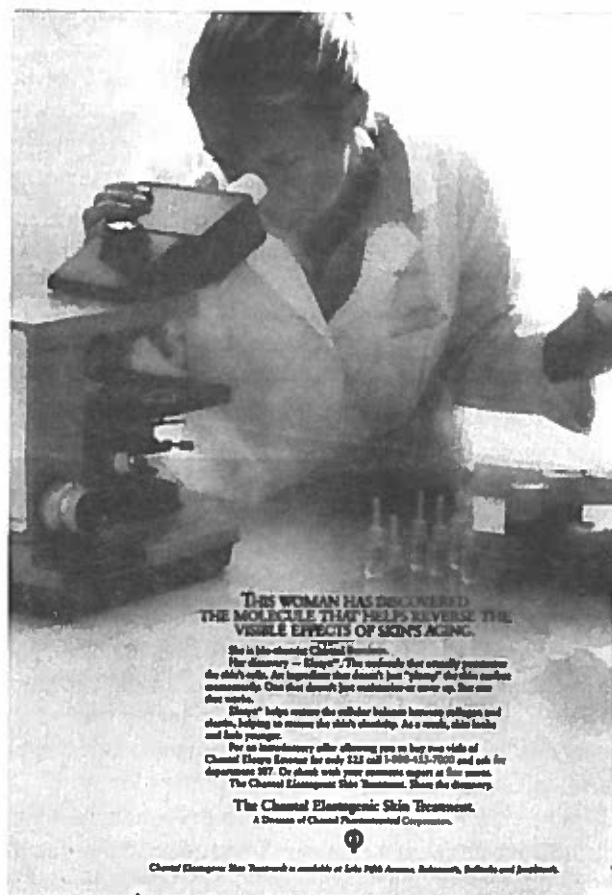
In a modern society, some say that science has replaced religion in the sense that some people have an almost worshipful attitude toward scientific authority and technological progress which seems to promise cures, solutions and a better life. Associating things with science and technology can also create the sense (or the illusion) of accuracy, certitude and truth. Non-verbal images suggesting scientific authority are very common (labs, microscopes, white-coated doctors, complex machinery, computers, print-outs, synthesizer music, etc.) as is the use of jargon and shop talk from many scientific and technical areas . . . There is widespread use of science to lend prestige to many products and services.

SCARE AND SELL: 'attack words' intensify the opposite, undesirable aspects: the lack of scientific values; superstition, ignorant, unskilled, illogical, unsubstantiated, inaccurate, etc."⁶

The contrast between the science sociologists find in laboratory life (where "accuracy, certitude and truth" dissolve into political interests or contextually-contingent beliefs or empiricist repertoires) and the science taken-for-granted by advertisers and their audiences is sustained in part by science-ads themselves.

To return to Schudson, ads which present scientists as authoritative arbiters of useful truth reproduce another part of "culture"—not the consumer culture—but a kind of "folk epistemology" or a widely shared and simple theory of knowledge that demarcates scientific knowledge from other brands and (importantly) puts the purchase of science beyond reasonable question. Science-ads depict a science long ago banished from our sociology of it: science is assumed to be truthful, reliable knowledge, produced by disinterested experts, serving the good of us all. Such "misrepresentations" of science are characteristic of consumer product advertising, Schudson says, which "simplifies and typifies," [and] "does not claim to picture reality as it is but reality as it should be . . ."⁷

But even the belief that science *should be* the fount of useful and truthful knowledge capable of reliable cures and solutions is sufficient to legitimate its purchase. Who would protest an investment in scientific research that discovers "the molecule that helps reverse visible effects of skin's aging, as the bio-chemist Chantal Burnison claims for her Elastogenic Skin Treatment? That science-ad is not only selling "Elasyn" but the research from Burnison's laboratory that confirmed "an ingredient that doesn't just 'plump' the skin surface momentarily . . . but one that works." In a word: science-ads reproduce a cultural environment in which purchases of science from scientists, not immediately by you and me but by our fiduciaries in industry and government, are made plausible, justifiable, legitimate, obvious. Few voters and fewer politicians argue these days that government should buy no science at all, although controversy continues over *which* science we



CHANTAL (1986)

want to buy: Star Wars or a cure for AIDS.

How do science-ads market science? The question is not that different from asking how Coke-ads market Coca-Cola.

Coke-ads and Science-ads

Here are some pictures of advertisements for Coca-Cola and for a variety of other goods and services; the originals appeared in mass market magazines and newspapers. My analysis of them is not systematic: I am interested in the pitch that they make for a product, and (in a subset) how "science" is made part of that pitch. Because space allows me to reproduce only a few ads, I have selected polysemic ones (i.e., those rich enough to allow me to make several sociological points). The ads were originally scattered throughout the last eighty years, but I have little to say about historical changes in the form and content of advertising or in their changing use of science. And I am not looking to reveal deep symbolism or hidden meanings or subliminal persuaders: what interests me is on the surface, the intended and obvious messages about Coke and about science.

The complete Coke-ad tells readers *what* Coca-Cola is, *who* it is for, *where* we can get it, *when* we should have it,



THE BUSINESSMAN (1907)

why we need it, and why *only* Coke will do; a good example is "The Businessman."⁸ The heading at the top, and pictures of bottles and drinking glasses, leave little doubt that Coca-Cola is a beverage-product. But what makes this drink different from all other drinks? Only Coke contains a unique combination of coca leaf and cola nut that not only quenches thirst but wakes up brain and body. A weary businessman should take a Coke to invigorate and sustain himself for the next round of work. All this for only five cents, at drugstores everywhere (we infer this from the soda jerk serving up the drink). The tiny print above the logo reads "Guaranteed under the Pure Food and Drug Act, June 30th, 1906, Serial No. 3321," presumably an assurance that Coca-Cola safely delivers its promised "vim and go" as no other soda can.

But Coca-Cola is not only for busy businessmen. "The Arrow" expands the target audience to include "everybody, everywhere," in "every walk of life." The *universal* love of Coke is a theme that persists through the 1970s jingle "I'd like to teach the world to sing/In perfect harmony/I'd like to buy the world a Coke/And keep it company." No one, nowhere is excluded from Coke. "The Arrow" also confronts the problem of distinguishing the original Coca-Cola from a myriad of like-sounding impostors: "Be sure to get the genuine. Ask for it by its full name to avoid imita-



THE ARROW (1907)

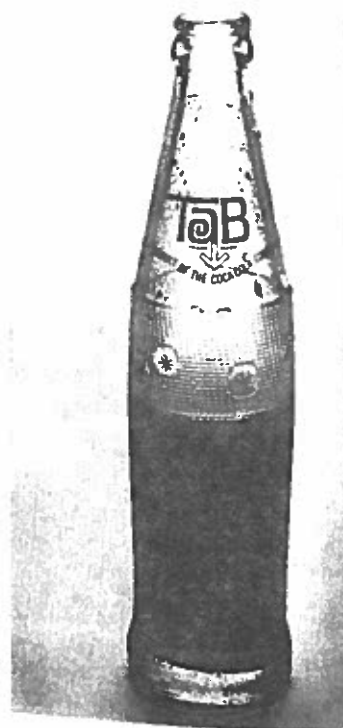
tions and substitution." For many of us, it is *only* the name that distinguishes Coke from Pepsi (although cola addicts swear the two are like night and day), and that is one reason why Coke resisted for a long time the proliferation of products bearing its brand name. At risk of confusing consumers about what really *is* the real thing, we now have New Coke, Coca-Cola Classic, Cherry Coke, Diet Coke, Caffeine-Free Coke . . . The simplicity of one product for all people had obvious marketing appeal, especially for something sold in innumerable countries and languages. The diet craze forced Coke to produce a cola drink that was targeted only for *some* people: the thinning crowd. But "Tab" covers all bases by selling it as "just one calorie" to the slimming Mrs. Jackie Olmstead and by selling it as just "good taste" to her naturally slim children. This effort at market segmentation—simultaneously denied by reminding consumers that anyone can enjoy any Coke product—is continued in the current jingle "Just for the taste of it . . . Diet Coke."

So *when* should we reach for a Coke? "Cuba" tells us: "the moment of fun." The ad illustrates a long-running pitch linking Coke to the good times and the right people; the product has subtly evolved from something we need to something less utilitarian but still desirable. Compare "Cuba" from the 1950s to "The Bridge Player" from the

How can just 1 calorie taste so good?



Mrs. Jackie Olmstead likes Tab to help keep herself and her husband slimmer. Trimmer. Looking more in shape than ever. Her children just like Tab, period. (They couldn't care less about calories. All they care about is taste.) The Olmsteads aren't alone, either. Lots of people are—hanging everywhere. Living trimmer, more active. And Tab is a part of it. How can just 1 calorie taste so good? Easy. The Coca-Cola Company created the new Tab.



TAB (1965)

1930s. In "Cuba," we associate Coca-Cola with pleasant moments lying around on the beach, and with the lucky people who can afford such leisure (if Coke is also for the poor—as claimed in "The Arrow"—we never see them in their ads). Water might do for that dull everyday thirst, but the fun thirst you get with your tan is made for Coke. In "The Bridge Player," Coke is something without which we are not "normal." Its restorative power is *needed* to prevent that fatal gaffe: yawning when you are supposed to be having too good a time to be tired or (worse) bored. So: we need Coke to stay awake, but we should want it even when we do not need it: are those beachcombers in "Tab" and "Cuba" trying to stay alert? Coke can be an upper or a downer, it seems, and since those are the only two ways to go, it is right *anytime*.

"The Bridge Player" begins our move from Coke-ads to science-ads. If you do not believe Coke's claims for its products, then take it on the authority of "foremost scientists" who say that it *really* works "in restoring you to your normal self." The epitome of a Coke-and-science-ad is "The Testimonies." Unfortunately, I do not know where this "text" was first published (the tearsheet I examined had no identifying reference); it is not *obviously* an ad for anything. So let me invent a scenario that may be like the one in 1905 that produced this text. The setting, say, is the office of a



SIGN OF GOOD TASTE...EVERYWHERE



Shot of famous Varadero Beach... Coca-Cola sold in the corner of the

COLORFUL CUBA, TOO, ENJOYS... "THE FAVORITE OF THE WORLD"

Apparently there is something universally right about the special appeal of Coca-Cola to human taste buds. In more than 100 countries today, the taste of Coke is as well liked, the good taste of Coke as well recognized, that over 80 million times each day someone, somewhere, enjoys Coca-Cola. Have a Coke... no good in taste, in such good taste.

Photo of a woman on beach, holding a Coca-Cola bottle.

CUBA (1958)

Methodist publishing house in Atlanta; present are the magazine editor and a company official from Coca-Cola.

EDITOR: We've got a problem. I don't think we'll be able to run any more of your ads in our magazine. Some of our subscribers have been, well, talking about what might be in Coca-Cola. You know how we Methodists are about alcohol and those sorts of things. A few believe that there might be cocaine or some other drug...

COKE: Now wait just a minute. Don't tell me that you believe that rumor?

EDITOR: Well, your ads do mention coca leaves, and anyway—how are we supposed to know what is or isn't in the stuff?

COKE: Take my word for it: there's no cocaine in Coca-Cola. I swear.

EDITOR: That won't work. Nobody would believe you or anyone else at your Company.

COKE: Why not? We know what goes into the syrup, and I'm telling you there is nothing in it that a Methodist could not drink.

EDITOR: Now don't get upset. I'm not accusing you of anything. I mean, really: the magazine badly needs

LARRY HOME JOURNAL

Don't Trump your Partner's Ace

A shrewd young man has bluffed many a social career. At play as at work, you need to be alert. Snap back to normal with a sparkling, invigorating Coca-Cola, and be yourself. It's more than just a drink. It's a very particular kind of drink—combining those pleasant, wholesome substances which ~~scientists~~ ~~say~~ do most in restoring you to your normal self. Really delicious, it leaves a pleasant, ~~the~~ ~~game~~ that refreshes.

Refresh yourself and be alert...
Snap back to normal

THE BRIDGE PLAYER (1933)

your ads. You pay for about half our costs for each issue. But you guys are also in business, and there are too many Doubting Thomases in our Church who think you'd tell us anything so long as we kept drinking Coca-Cola.

COKE: I have a plan. If you guys won't take my word for it, let's find someone who you *can* trust.

EDITOR: Any ideas?

COKE: I just happen to have these two letters with me, one is from the State Chemist and the other from a scientist up in New York who manufactures cocaine and other alkaloids.

EDITOR: What's an alkaloid?

COKE: Don't ask me. Seems they have done some experiments on Coca-Cola and found no traces of cocaine or any other illicit substances. Maybe you could run these letters as testimonials to our purity.

EDITOR: Scientists? Do they believe in the Bible or that evolution hogwash? Besides, why should I trust them? You might be in cahoots with these guys.

COKE: This guy is a *chemist*; he has no financial stake in the outcome. He gets paid by the State. He is supposed to protect us, right? Are you accusing me of bribing a public official? Look, it says he bought our syrup

As is customary with the advent of any article in the advertising columns of the religious press, we have submitted the popular temperance beverage, "Coca-Cola," to a most thorough and impartial chemical analysis, in order to assure our readers that the advertisement, as well as the reading columns of this publication, carry neither a kind nor a word worthy of their consideration.

As to its fascinating qualities, perhaps this is best illustrated by the fact that two words are and always have been so constantly used in its praise as to have become almost of national description—the words "delicious" and "refreshing."

In the matter of its chemical properties and their effects upon health, the declarations of eminent chemists better express the matter than could be done by a layman:

**STATE OF GEORGIA, Department of Agriculture,
Division of Chemistry.**

Atlanta, February 6, 1905.

The Coca-Cola Co.,
Atlanta, Ga.

Gentlemen: Referring to your recent inquiry as to a copy of an analysis I may have made of Coca-Cola, I beg to furnish you with the following copy of a letter written to Professor Kilgore, State Chemist of North Carolina, who inquired particularly concerning any analysis of Coca-Cola which I might have made.

In the matter of Coca-Cola, there was a bill introduced at the last Legislature imposing a tax upon all the soda water syrups, and I believe it was intended to put a still higher tax upon Coca-Cola than upon other syrups because of its supposed insatiable character. I analyzed a sample of Coca-Cola, which I bought in the open market, and tested carefully for cocaine, and also for phosphate, neither of which were present. I found 1.87 grains of caffeine per fluid ounce of the Coca-Cola syrup, and calculated that this amount was considerably less than would be found in a cup of coffee, according to the analysis given in Allen's Commercial Organic Analysis. I also found that Coca-Cola contained .2472 grams of Phosphoric Acid. I did not undertake to estimate or determine any of the various flavoring ingredients which are used in Coca-Cola. My final judgment about the matter was that there was nothing more injurious in Coca-Cola than would be found in tea and coffee. I have seen no other analyses which have been made of this syrup. The specific gravity of the sample which I analyzed was about 1.24. Practically all of the solid matter shown by this specific gravity was due to sugar.

Very truly yours,
JAMES M. McANDERSON, State Chemist.

Quite as conclusive as the reports of State Commissioners is that of Dr. Louis Schaefer, President of the Schaefer Alkaloid Works, Newark, N. J., large manufacturers of cocaine, caffeine, strychnine and other alkaloids. At the request of the Coca-Cola Company, this gentleman bought a sample of Coca-Cola liquid in the open market, for the purpose of analyzing the same to ascertain whether the syrup contained cocaine or other alkaloids. His report is as follows:

"On March 11th, 1901, I went to the drug store of J. Milburn Kane, 187 West 1st St., New York, N. Y., and ordered a half-ounce of original Coca-Cola. I received a bottle which, the druggist asserted, was taken from the original can. I made, during the 11th, 12th and 13th of March, a thorough analysis of the obtained syrup, using the best knowledge of my long experience in the analysis of alkaloids. To locate the alkaloids of the sample, I found that the sample contained a small percentage of caffeine, which is the alkaloid of the kola nut, and which also exists in large quantities in tea leaves and coffee berries. Outside of caffeine, I could not locate any other alkaloids. I especially directed my efforts to the detection of cocaine. For this purpose I made repeated fractional extractions of the total alkaloid obtained from the syrup. I narrowed the fraction which should contain all the cocaine of the sample, if there were any, to a very small quantity of the sample. This small quantity of the sample, when tested with the usual reagents, could be detected.

The above experiments prove to me conclusively that the Coca-Cola syrup, as sold by the Coca-Cola Company, does not contain a trace of cocaine."

(Signed) DR. L. S. SCHAEFER
"Acknowledged before me this eleventh day of March, 1901. Albert
Frenkel, Notary Public, No. 65, Kings Co., N. Y."

THE TESTIMONIES (1905?)

on the open market. We didn't slip him anything special. This is all above board.

EDITOR: How do I know he really did any experimenting on the syrup?

COKE: Where else do you think he got these numbers like 1.37 grains of this and .2472 grains of that. You don't get that kind of accuracy unless you're doing real scientific research.

EDITOR: Maybe these chemists wouldn't know cocaine if it bit them on the nose.

COKE: Well, look at this other letter. The man has long experience in the chemistry of alkaloids. I mean, he is an expert. And he says that the cocaine would have "pronounced characteristics." He couldn't miss it. Besides, he *repeated* those fractional whatever and kept finding the same nothing. I tell you, there really is nothing funny in Coca-Cola. And he even went to the trouble to get the letter notarized.

EDITOR: If this scientist is so trustworthy, why do I need the assurance of a notary public?

COKE: Be reasonable. We've got two testimonials from two experts who have never met. Isn't that enough to make you confident that they've got it right?

EDITOR: OK, let's print them both and see what happens. Cup of coffee for you?

CHESTERFIELD (1951)

This scenario (in compact form) is rehearsed when any ad-writer and client decide to involve "science" in an advertisement. The sociological beauty of "The Testimonies" is that, unlike later ads that typically rely on synecdoche (as in "Chesterfield," where microscope and white coat hint at science *tout court*), the case for trusting scientists is *elaborate*. Readers are told that scientists are disinterested, that they have no material stake in the outcome. The titles "Professor" and "Doctor" establish credentials and, presumably, certify their training. The experiments measure nature, converting "sweet" into a specific gravity of 1.28 due to sugar. That precision, and the use of technical terms like "alkaloid," establish scientific knowledge as more than common sense. It is the kind of knowledge only specialized experts can provide: years of experience in alkaloid chemistry were needed. Conclusions in science are based on independent but reproducible results of experiments with nature.

This is all spelled out in "The Testimonies"; but these same assumptions form a widely-shared folk epistemology evoked by the mere whisper of "science." No better evidence can be found than "Chesterfield," in which the jumbled images and assertions create a parody of the science-ad. The "science" is presumably the testing done with a "taste panel" as reported by a "well-known research

Of cigarettes and science.

This is the way science is supposed to work.

A scientist observes a certain set of facts. To explain these facts, the scientist comes up with a theory.

Then, to check the validity of the theory, the scientist performs an experiment. If the experiment yields positive results, and is duplicated by other scientists, then the theory is supported. If the experiment produces negative results, the theory is re-examined, modified or discarded.

But, to a scientist, both positive and negative results should be important. Because both produce valuable learning.

Now let's talk about cigarettes. You probably know about research that links smoking to certain diseases. Coronary heart disease is one of them.

Much of this evidence consists of studies that show a statistical association between smoking and the disease.

But statistics themselves cannot explain why smoking and heart disease are associated. Thus, scientists have developed a theory: that heart disease is caused by smoking. Then they performed various experiments to check this theory.

We would like to tell you about one of the most important of these experiments.

A little-known study

It was called the Multiple Risk Factor Intervention Trial (MRFIT).

In the words of the *Wall Street Journal*, it was "one of the largest medical experiments ever attempted." Funded by the Federal government, it cost \$125,000,000 and took 10 years, ending in 1982.

The subjects were over 12,000 men who were thought to have a high risk of heart disease because of three risk factors

that are statistically associated with this disease: smoking, high blood pressure and high cholesterol levels.

Half of the men received no special medical intervention. The other half received medical treatment that consistently reduced all three risk factors, compared with the first group.

It was assumed that the group with lower risk factors would, over time, suffer significantly fewer deaths from heart disease than the higher risk factor group.

But that is not the way it turned out.

After 10 years, there was no statistically significant difference between the two groups in the number of heart disease deaths.

The theory persists

We at R.J. Reynolds do not claim this study proves that smoking doesn't cause heart disease. But we do wish to make a point.

Despite the results of MRFIT and other experiments like it, many scientists have not abandoned or modified their original theory or re-examined its assumptions.

They continue to believe these factors cause heart disease. That it is important to label their beliefs accurately. It is important. A label that not was made.

We believe in science. That is why we continue to provide funding for independent research into smoking and health.

But we do not believe there should be one set of scientific principles for the whole world, and a different set for experiments involving cigarettes. Science is science. Proof is proof. That is why the controversy over smoking and health remains an open one.

R.J. Reynolds Tobacco Company

R. J. REYNOLDS (1985)

organization." But how does one use a microscope to detect taste? And if ash from that cigarette were to fall on the slide, it would look like a dinosaur! No matter. Take it from science: Chesterfield really does taste better.

"R.J. Reynolds" does a more effective job in reminding us of what we all know about science. It carefully reviews the logic of scientific method, and may well do a better job of selling science than cigarettes. Here we read an explication of why scientific knowledge is more reliable than non-scientific brands: the credibility of its conclusions can be traced back to the unique methods of its production. The ad suggests that "scientists" who violate these methods by retaining a theory in the face of non-corroborative findings (or by converting bivariate correlation into causation) have left science for the realm of "opinion." Science is factual "proof," not "judgment" (as we are reminded in the current General Motors slogan "Science not Fiction"). Notice how the ad deftly avoids the problem of maintaining scientific credibility when scientists offer different truth: those other scientists who tell you that smoking causes coronary heart disease are simply not being scientific—they violate the method.

Science enters consumer-product advertisements not only to establish credibility of claims, but to establish novelty and utility of technological miracles. Science is tied to

Important Milestones in Modern Medicine: 1776—Jenner's discovery of smallpox vaccine. 1874—Florence Nightingale's discovery of nursing. 1928—Fleming's discovery of penicillin. 1944—Morgan's demonstration of chromosomes. 1953—Watson and Crick's discovery of DNA. 1956—Procter & Gamble proudly announces...

TRIUMPH OVER TOOTH DECAY

Crest Toothpaste with Fluoristan strengthens teeth themselves. You brush Crest on... it actually goes in... and locks decay out

Fluoristan is Procter & Gamble's exclusive fluoride toothpaste formula... the greatest development in tooth hygiene.



Illustration of the Young Without Teeth. When, for years, children growing up to become the nation's future leaders had no teeth, their parents looked on with dismay. Then Crest came along, and the nation's children began to smile.



Science Long Tried to Capture Fluoride—only Crest's exclusive Fluoristan formula was able to do so. Crest's Fluoristan is the only toothpaste that actually goes in and locks decay out.



Fluoristan Makes Possible Crest. Without Fluoristan, you cannot get such close protection against tooth decay with a toothpaste. You brush Crest on... it actually goes in... and locks decay out, the adults and the children, it will win.



Illustration That Crest is the best. It adds 5000 parts. The surface of all decay-free teeth or decay-prone teeth is covered by Crest's Fluoristan. This Crest is the best... it actually goes in and locks decay out.

IMPORTANT

I just with Fluoristan is the only toothpaste ever developed that makes possible a major contribution to tooth decay prevention. Crest's Fluoristan is the only toothpaste that actually goes in and locks decay out. Crest's Fluoristan is the only toothpaste that actually goes in and locks decay out.

You brush Crest on... it actually goes in... and locks decay out. Each time you brush Crest on your teeth, Fluoristan builds new resistance to decay into teeth. In this way, Crest actually builds and strengthens teeth to lock out cavities—the only toothpaste proved to do so. With Crest, your family approaches the long dream of day of healthy, decay-free teeth.



NO OTHER TOOTH PASTE PREVENTS DECAY AND CAVITIES

CREST (1956)

the future, to a better world, to progress, to new solutions of old human ills. "Crest" links its "Fluoristan" to the history of scientific medicine's triumph over disease: Jenner's inoculation to Fleming's penicillin to Crest's toothpaste. Science did what common-sense could not: those happy Western parents with cavity-free kids had no idea why they were so lucky. Scientists converted common sense into a discovery and then into a uniquely effective new technology that marks a "turning point in man's age-old struggle against this almost universal disease." Crest is obviously trying to sell toothpaste, but Procter and Gamble's ad effectively promotes science as a "public good" benefiting us all. Who could deny the desirability of "the long-dreamed of day of healthy decay-free teeth?" As advertisements for Dupont used to say: "Better living through chemistry."

In "Champion," science again becomes an unassailable public good and a fount of the better world: genetic engineering, for example, will be "a boon to children with stunted growth." But what is being sold here? It is almost incidental that gene splicing will allow Champion to grow a more profitable tree. In 1980 as now, genetic engineering invites discussion of government regulation to protect escape of dangerous new beasts and to allow public control over morally questionable creations. Such government

The future is coming. And with it will come great benefits for mankind. And a whole new set of problems. Because we are a forest products company, and plant seeds that take up to 50 years to become mature trees, Champion International has to think a lot about the future. We'd like to share some of the things we've learned with you—so help you make intelligent choices in the years to come. Here is something you might want to think about.

In the future, a new science called gene splicing could produce miracles—like the regeneration of limbs, a cure for cancer, even the flowering of a "better" human being.

But who is going to decide what makes a "better" human being?

Some years ago, a child was checked into a hospital; the tip of one finger had been sliced away. The wound was dressed, but the patient neglected. Days later, the dressing was removed. The finger tip was growing back.

At the time, regeneration was a baffling and spooky phenomenon.

Today, we are beginning to learn more about it through the science of genetic engineering. Genetic engineering has the potential to alter the make-up of mankind as no other science ever has or possibly ever will. Gene splicing, one aspect of this new science, is the transference of genetic material from one living thing to another. With this technique, a gene can be isolated and, when planted in a bacterium, start a whole new process of organic reproduction.

The realizable benefits of genetic engineering are both stunning and myriid.

Splice a gene that produces human insulin into a replicating microorganism, and diabetics have ready access to a purer, yet less expensive insulin. Researchers have already synthesized the hormone responsible for human growth, an immediate boon to children with stunted growth. It's increasingly likely that gene splicing will be able to mass-produce interferon, the anti-viral wonder drug that may put the brakes on flu,

hepatitis, and certain kinds of cancer.

Eventually bacteria may become assembly lines for the creation of whole new life forms, including "better" human beings.

In the long reach after his own betterment, man has covered incalculable ground: from primitive man domesticating wild wheat to his use, to modern man on the threshold of making a better organic self out of his existing self.

The promise for our future is almost beyond comprehension.

Which means questions have to be asked (and answered) right now.

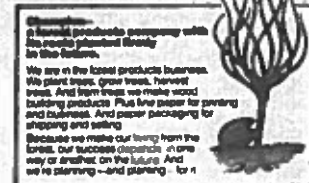
Most critical: who is qualified to decide what makes a "better" human being? Who among us has the capacity, much less the right, to choose?

Also: what safeguards will there be against bacteria containing patented genes escaping from the laboratory and contaminating the very life we're trying to improve? Can patents be awarded to private industry for what is essentially life itself? If so, can science retain its necessary purity and freedom in a commercial situation?

These are questions that desperately concern us all because we are the subject matter.

If you're concerned with the immediate future, and would like a bibliography for further reading, send for our free brochure. Write: Champion International Corporation, Dept. 2007, P.O. Box 10343, Stamford, Connecticut 06921.

Write us today. The future is tomorrow.



Champion
Champion International Corporation
Planting seeds for the future

CHAMPION (1980)

regulation could impede Champion's quest for the most profitable tree, so in effect, the ad is trying to sell us on the idea of unbridled genetic engineering, and that case is more easily made by talking about cures for hepatitis, flu and cancer (public good) than by talking about profitable trees (private gain). Obviously, scientists engaged in genetic engineering (both in private and public sectors) can only champion Champion's efforts: they, too, "profit." But the ad cautions—in its litany of troubling questions raised by genetic engineering—that science will continue to move us into the better world only if it can "retain its necessary purity and freedom in a commercial situation." The miracles of science are polluted by the world of money.

De-Advertising Science

Science-ads present a paradoxical problem for advertisers who use science to sell consumer products, and potentially an even greater problem for scientists. As Rank observed, science sells Coke or skin care products because we assume its findings are reliably truthful and because we suspect that they emanate from disinterested and objective experts working in value- and interest-free research contexts shielded from compromising pressures found in commercial or ideological marketplaces. This is the pitch for science—but in order to work for advertisers of con-



**HIS NECK
Might Save
YOUR
HEART**

High blood pressure can cause stroke and contribute to heart attack. If the giraffe, with sky-high pressure pushing blood up 10 feet of neck, escapes those threats. Research scientists have been searching for more. Their findings might help guard you against high blood pressure, too. Nearly 100 million Heart Fund dollars have been spent since 1965 on many vital research studies. Thousands of lives have been saved. But the cardiovascular diseases remain your Number 1 foe. Scientists need more dollars now to expand their search. Is them to help you.

**Give... so more will live
HEART FUND**



GIRAFFE (1965)

sumer goods, it cannot be read as a pitch. No matter how hard Coke tries to assure us of its purity or its effectiveness, few consumers fail to recognize such claims as ploys to sell a product made by a manufacturer whose coffers expand if we believe them. We recognize Coke as a commodity being sold to us. Science too is a commodity, but sales of scientists' products depend in part on them not being recognized as commodities. Science *could* become perceived as a commodity if science-ads are seen and read as Coke-ads: "buy this knowledge so that scientists can stay in the research business." Compensating mechanisms are needed to preclude the idea that science is just another business.

I call these compensations "de-advertising mechanisms," and both scientists and advertisers who use science have a stake in their effectiveness. Advertisers can continue to use science as a ploy to assure consumers of the truth of their claims only if the folk epistemology defining science as the epitome of reliably truthful accounts of nature remains more or less intact. Scientists benefit in two ways: if science is perceived as reliably truthful knowledge, its purchase by public fiduciaries (i.e., the state) is taken-for-granted as legitimate because it is seen as a common public good rather than as a commodity whose purchase benefits sectarian interests (of scientists, for

example). Also, if advertisers continue to use science in their ads, scientists benefit from the broadcasted reproduction of this folk epistemology without paying for it. The danger is for science to become too much like Coke: as something we buy that directly benefits producers or purveyors whose interest in maximizing sales could jeopardize the accuracy of proffered descriptions of nature.

The paradox: Scientists rely on science-ads to reproduce a folk epistemology that defines their accomplishments as the epitome of reliably truthful and useful knowledge, and that presents an unquestionable *prima facie* case for their purchase. But if science-ads are seen merely as ads their message is lost: can we believe claims to reliability and accuracy (or even utility) if scientists are—like Coke—dependent on sales driven by these advertisements?

De-advertising mechanisms allow science-ads to sell science without our recognition that this is what is happening, and here are some examples. Science-ads tell us why we should want more science, but they do not tell us what we need to know in order to *buy* some of it. In effect, science-ads break almost every rule in advertising textbooks, in that they fail to identify the product in an easily recognizable way, to tell us the point-of-sale and the price, and to make us see ourselves as realistic buyers. In the early ads for Coke (before everyone came to know everything about it), readers were told that *you* should buy this bubbly beverage for only five cents at the corner soda fountain. All the information is there to achieve the advertisements' goal: to convert a magazine reader into a Coke-buyer. By contrast, science-buyers are left in the dark. The easily-grasped bottle of Coke becomes the enigmatic "knowledge" or "trust" or "expertise"; dollars and cents are rarely mentioned; we are never told where science is bought and sold. Readers of science-ads cannot see themselves as buyers of science from scientists, even though they *are* buyers of science when they purchase consumer goods produced (or marketed) with the aid of scientists or when they pay taxes to finance federal "patronage" of research.

All of the clues to seeing science as involved in commercial transactions are missing, *not* because it is not bought and sold like Coke but because its sales depend on its not being *seen* like Coke. This might explain why, in "Crest," the discoverers of inoculation, ether, and penicillin are mentioned by name but Harry G. Day and his colleagues at Indiana University who discovered stannous fluoride become the generic white-coated scientist holding a test tube. (Proctor and Gamble did indeed support Day's research, and Indiana University has since benefitted materially from the sale of Crest toothpaste.) The authoritative disinterestedness of science is enhanced by its depersonalization: to mention Day by name raises questions about *his* financial relationship to the Corporation that profited so much from the discovery. That disinterestedness is enhanced again by the correct assumption that scientists are not the *sponsors* of science-ads: science becomes a free-

rider in a pitch to buy toothpaste or skin treatments. R. J. Reynolds bought that page in *Family Circle* magazine in order to sell its cigarettes. How could science be a commodity if ads for it are bought not by scientists (the indirect beneficiaries) but by those who are using science to sell cigarettes or forest products or Coke?⁹

There are exceptions of course, but some only prove the rule. The most explicit exhortation for ad-readers to buy science (that I have found) is not in a consumer-product ad but in a "public service message" for the Heart Fund (labeled "Giraffe").¹⁰ The ad explicitly recognizes that scientists need dollars, but the altruistic goal of this research disconnects the plea from a commercial context. Science is established as a public good available and benefitting us all, rather than a market exchange that enables scientists to stay employed. This idea is reinforced by the absence of advertisements for competitors of science urging consumers to prefer *their* brand of knowledge or expertise. The competitive and commercial nature of Coke is obvious in a Pepsi-Cola ad showing a 21st-century archaeologist digging up a Coke bottle that he cannot identify, as the camera pans to scenes of a future littered with the logo for Pepsi. I have not seen an ad extolling the virtues of "ignorance" (one alternative to science), and generally ads for scientists' competition come not from commercial products but from alternative belief systems (as in an ad for religion that recommends the Bible over evolution). The near-absence of ads for competitors sustains the image that science is unique (in a category of its own) and an undeniable *good* (only the irrational could prefer the alternative).

My restricted focus on science *in* consumer-product advertising must be relaxed if one further kind of de-advertising is to be identified. Advertisers call "marketing mix" the *variety* of ways producers get their products in front of consumers. Coke has not limited itself to print mass media: we have been subjected to video ads, billboards and other outdoor signs, promotional trays and toys and calendars, cents-off coupons, displays at the points of sale, visible sponsorship of artistic or sporting events and (now) trendy and expensive clothing with the irrepressible logo. Science, too, is marketed in a variety of ways that further obscure its identification as a commodity bought and sold (in part) for the financial support of scientists. Where do we *meet* science? I remember: childhood "field trips" to a natural history museum, "Mr. Wizard" on TV, my first chemistry set ("You, too, can turn water into wine!"), dusty shelves of *National Geographic*, an adolescent "science project" ill-titled *The Science of Plant-Growth* and the scientific dismemberment of a frog in biology class. Things have not changed much: my sons at ages six and seven know that paleontologists are those scientists lucky enough in their view to spend their lives studying dinosaurs (what could be less commercial?).

The point: none of the settings where we form our early and enduring images of science are businesslike. In choos-

ing to look at science-ads in magazines and newspapers, I have chosen perhaps the "toughest case," for the link between science and business could easily be inferred here (as in the Rockwell International slogan "... where science gets down to business"), and *would* be inferred if not for de-advertising. Science-ads are not recognized as ads because all of our *other* contacts with science have little obvious commercial relevance. By the time we are able to read consumer-product advertisements that mention science, we bring to them assumptions about science that picture it as completely unlike Coca-Cola. This does not reduce the importance of science-ads in reproducing those long-ago learned assumptions that science *is* the epitome of reliably useful knowledge about the world. Schudson says that *reproduction* is the goal of most consumer product advertising, which talks to "the already converted" hoping "to affect people who are already committed to a general product category."¹¹

De-advertising mechanisms preserve the distinctive selling-points of science: its status as a public good of universal aid, its promise of a new and better world resulting from useful and truthful discoveries about nature by disinterested expert specialists not concerned about the bottom line. The de-advertising mechanisms found in science-ads and elsewhere *demarcate* science from business, and minimize the skepticism readers bring to ads for Coca-Cola.

A Concluding Agenda

Such a paper as this can have no conclusion, for it is but a slim beginning to possibly fruitful lines of inquiry. The extended parallel of science and Coca-Cola is designed to provoke a reconceptualization of sociological theories about the historical "rise of science." That should really be "rise of *scientists*," for the central message is that the growth of scientific knowledge is dependent upon *scientists'* acquisition of the material and symbolic resources needed to do research and to broadcast results. A "social theory of science" must be able to explain three centuries of improvements (with only an occasional slide) in these working conditions of scientists: the prestige of their occupation, the money they receive for services rendered (in the forms of wages, grants, facilities), their authority over questions of fact, and the autonomy to pursue their own curiosities. The comparison to Coke suggests a kind of explanation that is *not* effective: the spectacular financial success of the Coca-Cola Corporation cannot be explained by the immanent qualities of Coke (it really is a sweet fizzy liquid, but so is Pepsi) nor by the innate thirstiness of humans (let them drink water). So: the spectacular financial success of scientists cannot be explained by immanent qualities of the procedures or products of scientific research nor by an innate human "need to know." Both Coke and science thrive because of their successful marketing: potential buyers must be told (repeatedly) how Coke and

science can distinctively satisfy their needs; indeed, the advertising even tells us what we *need*. No history of Coca-Cola is complete without several chapters on its advertising and marketing; that is also the case for a history of science. Claims by scientists to the Truth or Utility of their knowledge are not viewed (from this theoretical angle) as definitive descriptions of what science yields but as a pitch for its purchase, not unlike the 1947 slogan "The quality of Coca-Cola is a friendly quality you can always trust."

We lack systematic studies of ubiquitous efforts by scientists and allies to sell their expertise and accomplishments in a competitive knowledge-market. Those studies would identify the occasions in which science is advertised (from primary school science-textbooks to appeals by scientists before Congressional committees reviewing budgets for the National Science Foundation), the contextually-contingent content of the "sales pitch," the different characteristics of buyers at various "points of sale." The research would focus on how scientists meet the competition: what arguments are used to convince potential buyers that extant knowledge is insufficient ("more research is needed"); that scientific knowledge is superior to non-scientific kinds marketed by other knowledge-producers such as religionists, ideologues, politicians, lawyers, soothsayers or you and me¹²; and that one kind of science is preferable to another (disciplines sometimes compete among themselves selling distinctive brands of scientific expertise and authority). All this should add up to a better understanding of folk epistemologies—diverse and often implicit assumptions about types of knowledge and their relations and utilities—that sustain a cultural context in which purchases of science only rarely face successful challenge. To better understand the culture that typically defines science as the epitome of reliably useful knowledge requires studies of how science gets done *outside* laboratories and journals—in advertisements for consumer-products, as one small example—though the findings there will tell us much about why and how laboratories and journals acquire the wherewithal to exist.

In 1986, both Coca-Cola in Atlanta and the Pasteur Institute in Paris celebrated their centennial as two of the most successful marketing campaigns in the history of . . . business? "Things go better with science!"

Notes

1. Bruno Latour, "Give me a Laboratory and I will Raise the World," in *Science Observed*, Karin D. Knorr-Cetina and Michael Mulkay, eds. (London: Sage, 1983), 141-70.

2. For example, Michael Mulkay, *The Word and the World* (London: George Allen and Unwin, 1985) and G. Nigel Gilbert and Michael Mulkay, *Opening Pandora's Box: A Sociological Analysis of Scientists' Discourse* (Cambridge: Cambridge University Press, 1984).

3. Among the many works of the Edinburgh School are: Donald A. Mackenzie, *Statistics in Britain 1865-1930* (Edinburgh: Edinburgh University Press, 1981); Barry Barnes, *Interests and the Growth of Knowledge* (London: Routledge and Kegan Paul, 1977); Steven Shapin, "Homo Phrenologicus: Anthropological Perspectives on an Historical Problem," in *Natural Order*, Barry Barnes and Steven Shapin, eds. (London: Sage, 1979), 41-71.

Notes continued on page 31.

The Use of Scientometric Methods for Evaluating National Research Programs

Loet Leydesdorff and Peter van der Schaar
University of Amsterdam

Abstract

National science policy efforts can be understood, from an information science point of view, as deliberate attempts to change the relationship of research groups to the international literature over time. These relationships can be either active (publishing and citing) or passive (being cited, co-cited, etc.). This study examines the development of two highly comparable Dutch national research programs (one on "wind energy" and one on "solar energy") in terms of factors which can be associated with such relationships. The different outcomes of the two programs are analyzed in terms of the emergence of new journals in both areas. The key findings are: (1) An international core literature emerges between 1974 and 1984 in the solar but not in the wind energy literature. (2) The Dutch solar energy researchers, both in their journal articles and in their reports, link themselves to this literature. (3) The contributions of the solar researchers are in turn recognized in the international literature. (4) The wind energy researchers have less opportunity to participate with a clearly defined external professional community.

It has been argued that relationships among journals, individuals, references, and citations can be analyzed in terms of their structural properties, but the question remains whether one such analysis can be used as a baseline to calibrate our understanding of another.¹ This question becomes particularly relevant when we want to measure the effectiveness of national science policies: science policies as a rule aim to change cognitive levels of scientific development by steering, through institutional factors such as funding.² However, there is always also an "endogenous" cognitive development in the sciences—i.e., one independent of external efforts to direct its development. Hence, we have to find ways to distinguish among (i) institutional effects of science policies; (ii) cognitive developments in scientific fields which take place independently of the specific national science policy; and (iii) changes in the quality of the national output which have been brought about, at least in part, by science policy efforts.³

Author address: Science Dynamics, Nieuwe Achtergracht 166, 1018 WV Amsterdam, The Netherlands

We want to thank Rob Zeeman, Nero Matthias, and Gert Timmerman for their help in developing the necessary software for this study. We also want to thank Susan Cozzens for her comments.

Science & Technology Studies 5(1): 22-31, 1987.

Elsewhere⁴, we have argued that the relations among journals as measured through the factorial structure of their aggregated mutual citations can be used as a baseline for changes taking place at other levels of analysis.⁵ The structure at this level can thus—at least in the natural sciences⁶—be accounted for in terms of the differentiation between the fields and subfields as the most important element. In journal to journal citations, we find a structure which can be readily understood, easily plotted, and followed over the years on the basis of the data in the *Journal Citation Reports* (JCR) of the *Science Citation Index* (SCI). We have previously expressed the hope that this baseline of journal-journal citations may help to solve the calibration problem in the measurement of change in science, and hence of the relative success of using policy to promote the various forms of change which we have distinguished above.⁷

In this article we attempt to use these techniques to assess the relative success of two national Dutch research programs in energy research over the period 1974-1984: one on solar energy and one on wind energy. We selected these two programs because they have been very similar, both in management structure and in financial input. In fact, the one (on solar energy) is a deliberate copy of the other (on wind energy). Both programs were set up by the Dutch government in response to the oil crisis of 1973, and

received over the relevant period an extra stimulus equivalent to about \$20 million each. More important for the comparison, however, was the creation of an almost identical strong management structure for the national research efforts in both fields.

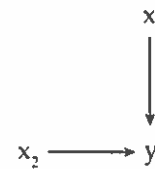
The results of these programs have included the production of 366 scientific reports from the National Research Program on Wind Energy in the period 1974-1982, and 120 reports from the National Research Program on Solar Energy since 1976. The programs actually took off on a larger scale in 1977 and in 1978, respectively. Therefore, at first glance, the Wind Energy program seems to have been more productive in quantitative terms.

However, Holland was not the only country which stimulated wind and solar energy research from 1974 onwards. In fact, both fields were internationally recognized as possible alternative sources for energy in the long term, and since energy is a matter of state concern in many societies, both were made priorities of state science policies in many advanced countries. Hence, the subject matter was also an object of international competition, from a scientific and technological point of view as well as from a business point of view.

In this study we limit our attention to the science policy effects of the two programs, leaving the technological and industrial outputs and implications as a matter for separate analysis. Our primary questions are: What can such input from the political arena mean for the scientific enterprise at the national level? How do the relevant researchers react in terms of their publications and their participation in the development of the relevant sciences? Did the policy initiative indeed stimulate the researchers involved to shift their attention and reorient their research towards new research goals? If so, was this achieved up-hill against the established matrix of the scientific disciplines, or was it facilitated by cognitive developments at the level of internationally organized fields? Did the political incentive change the position of the Dutch researchers in these fields as net consumers or producers of international knowledge in these areas? Or to ask the question more cynically: can an advanced industrial country—like the Netherlands—establish a leading edge in a new field by stimulating its scientists in certain directions, or is such a national science policy merely an epiphenomenon of international scientific development, at best paving the way for scientists to follow paths which are being traced by the international community anyhow?

The answer to this question is likely to be that effectiveness in science policy is dependent on some synergism between the local and the cosmopolitan dimensions. On the one hand, resources must be available, and on the other, publication and career opportunities for scientists within the scientific community have to be favorable. Analytically, however, the local and cosmopolitan dimensions can

be distinguished easily, leading to the following general scheme:



In this scheme x_1 stands for the international environment—later in this article to be operationalized as the journal-journal structures—and x_2 for the policy effort. The dependent variable y represents the research strategies and hence the choices made by the scientists involved.

Further elaboration of the model

This very general scheme of a local and cosmopolitan dimension in the scientific enterprise⁸ indicates classes of variables which have to be elaborated for every specific case. In this study, x_2 is held constant: we selected the two policy programs because of their similarity. Both programs are supposed to induce changes in the choices (y) made by the relevant actors with respect to the international environment (x_1).

However, we should be aware that this distinction cannot be identified with the distinction between the social and the cognitive. Both cognitive and social elements play a role at both levels. We may conjecture that at the cosmopolitan level in the natural sciences, the social elements (such as reputational structure, reward structure, etc.) are largely derived from the scientific substance of the contributions of the authors, while at the local level politico-cognitive vocabularies function within what are primarily social relations.

As a first operationalization for the international environment, the journal-journal citation structure may be a useful indicator. In line with the argument in the former section, the selections which researchers and research communities make in these environments can be specified as: (i) the journals in which they publish, and (ii) the journals from which they cite. The journals in which they are cited, although not an active selection by the authors, also indicate a relationship between their articles and the international literature.

However, researchers who participate in programs like these produce both articles and reports. Therefore, one way for them to deal with the local and cosmopolitan dimensions of science may be to keep the two audiences apart—to use citations from and publications in the international literature as sources of legitimation for their (local)

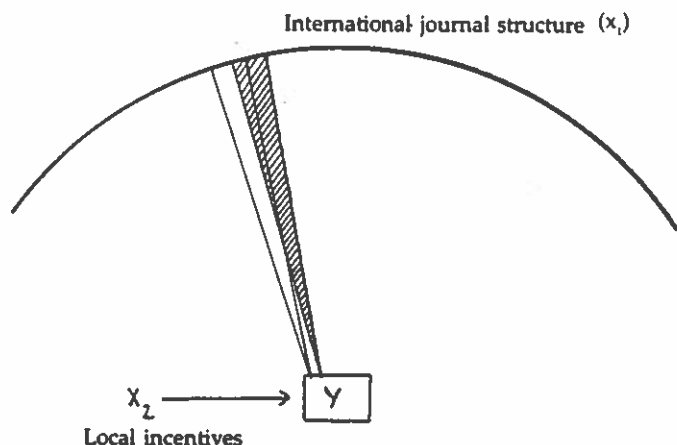


Figure 1. Summary of the relevant selections. 1. Research groups publish in international journals. 2. Research groups quote from international journals. 3. Research groups are quoted in international journals. 4. Research groups use references in their local reports (transfer function).

reports, while they address a different (scientific and international) audience in their articles and books.⁹ Such behavior might be stimulated by the language difference between the (mainly Dutch) reports and the (mainly English) articles.¹⁰ Taking this into account, we specify as a fourth measure of relationship with the international environment the references in their reports, as distinguished from the references in their (international) articles. The four indicators are summarized in Figure 1.

In sum, we maintain that from an information science point of view, science policy efforts amount to attempts to change the selections made by the relevant national (or at least institutionally defined) research communities with respect to the international literature.¹¹ Only with a full text analysis could one determine precisely what is being channeled through these selections, but in the context of this article we limit ourselves to the formal relations between developments in the international literature and changes in the selections which the relevant research groups make from them, since these can be measured with available scientometric techniques.

Methods

Because both solar and wind energy programs were strongly managed from a central office, a complete list could be obtained of all the reports produced between 1974 and 1982. A list of all the authors of these reports served as input for a publication search in the *Science Citation Index* from 1974 onwards. For these publications references in them and citations to them are further analyzed. Because it is common practice for authors to write articles about their research only after having finished their contracts, and because publications and citations each have

their specific delays, the publication and citation analyses were extended to the end of 1984.

To generate the relevant journal set to form a baseline, we conducted short interviews by telephone with leading researchers in the groups involved. These interviews identified a consensus about eight important journals in the case of solar energy; they were used as entry points for later analysis. But in the case of wind energy no agreement about important journals could be reached in this way. Therefore, in the latter case, those journals were taken as entry points which contained more than one publication by authors from the original list, with at least two different institutional addresses. This procedure resulted in five journal titles, of which one was not included in the SCI. Hence, four journals were taken as entries. (See Table 1 for both lists.)

For 1974, 1978, 1982, and 1984, the two journals which cited each of these entry journals most heavily, and the two journals which were most heavily cited by each journal were located in the *Journal Citation Reports* of the SCI. This procedure was reiterated for the two new batches of journals in the Cited and the Citing Journal Packages of the *Journal Citation Reports* until the lists converged, or until we moved more than two citations links from any entry journal. The journals in the set at this point were treated as the "core" of the international literature for the areas. A full journal-journal citation matrix containing the exact citation rates was generated for the core journals for each year. (Rates of less than five were not included since they are not listed in the JCR). The full matrices were analyzed further as described in our earlier article, using factor analysis and multidimensional scaling.¹²

Table 1:
Entry journals for solar and wind energy:

<i>Solar Energy</i>
1. Solar Cells
2. Solar Energy
3. Solar Energy Materials
4. Applied Energy
5. Energy Conversion (and Management)
6. International Journal of Energy Research
7. Journal of Applied Physics
8. Journal of the Electrochemical Society
<i>Wind Energy</i>
1. Transactions of the American Nuclear Society
2. Journal of Aircraft*
3. Applied Scientific Research
4. Journal of (Wind Engineering and) Industrial Aerodynamics

* The *Journal of Aircraft* is included in the Citing Journal Package of the *Science Citation Index* only.

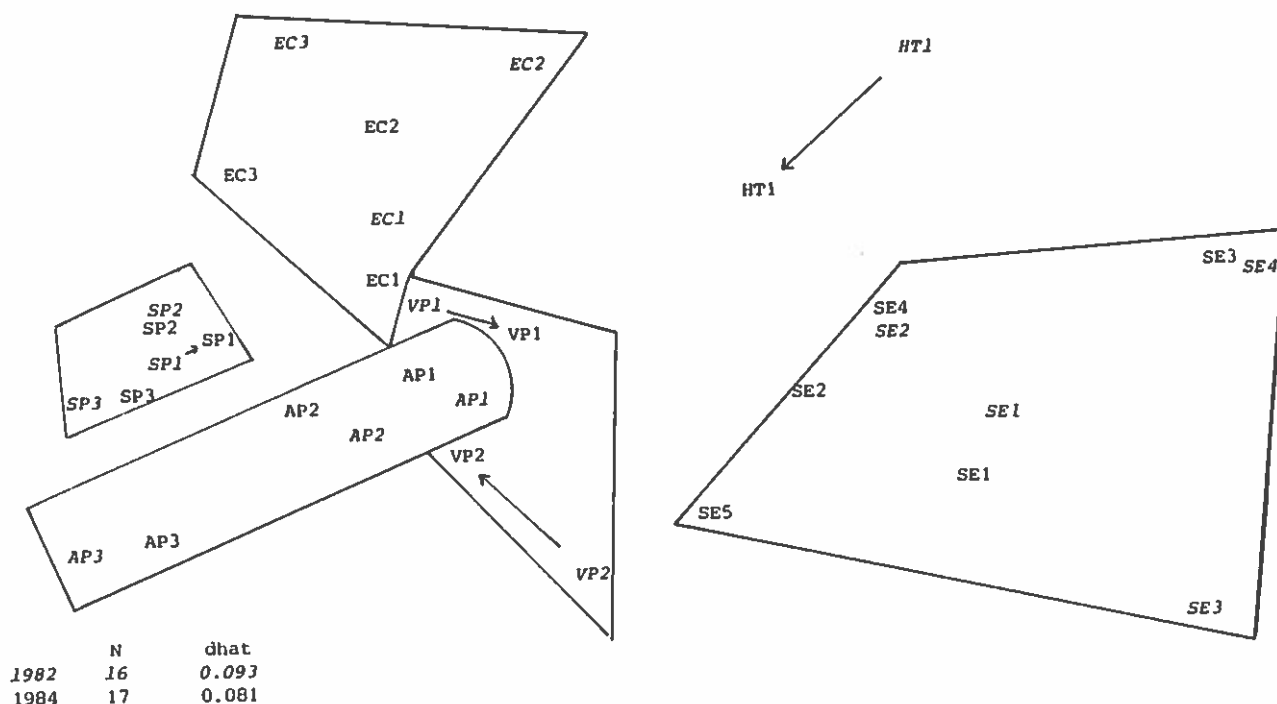


Figure 2. Stabilization of solar energy journals in 1982 and 1984. The figure represents the juxtaposition of MD-SCAL solutions for 1982 and 1984. The journals are labelled as follows: *Solar Energy* (SE1) *Energy Conversion* (SE2) *Solar Energy* (SE3) *International Journal of Energy Research* (SE4) *Applied Energy* (SE5) *Journal of Solar Energy-Transactions of the ASME*; *Various physics* (VP1) *Solar Energy Materials* (VP2) *Solar Cells*; *Applied Physics* (AP1) *Journal of Applied Physics* (AP2) *Applied Physics Letters* (AP3) *IEEE Journal of Quantum Electronics*; *Solid State Physics* (SP1) *Physical Review B—Condensed Matter* (SP2) *Solid State Communications* (SP3) *Physical Review Letters*; *Electrochemistry* (EC1) *Journal of the Electrochemical Society* (EC2) *Electrochimica Acta* (EC3) *Journal of Electronanalytical Chemistry and Interfacial Electrochemistry*; *Heat Transfer* (HT1) *International Journal of Heat and Mass Transfer*

The lists for the four years of journals for solar and wind energy respectively were then combined and matched against lists of publications from the two research programs to divide them into “core” and “non-core” solar- or wind-energy publications. Citations were down-loaded for all publications; the “core” publications only were further analyzed in terms of their citing patterns as well.¹³ For each set of reports—solar and wind energy—the references to journals were also divided into core and non-core groups.

It should be noted that two different on-line versions of the SCI were used, one available through DIALOG Information Services and one through the German DIMDI installation since the citing references are included only in the latter one. Although there are slight differences in coverage between the two, these were not found to affect the analysis.

In the following section we first present the results of the analysis. The results are examined along following dimensions in turn:

1. journals and the dynamic development of their relations;
2. publications in international journals and local reports (output variables);
3. citations;

4. citing references in the articles; and
5. references in reports.

Within each dimension we focus first on the solar energy case and then on the wind energy case. In the last section, we then return to the central questions of the article to draw conclusions with respect to the effectiveness of these science policy-induced research programs.

Results

The development of journal structures

Solar energy journals. The journal analysis for solar energy, which started with the eight central journals of Table 1, led to clear results. (These results are also used later in this article to explain some of the data on publications and citations.)

In 1974, 21 journals constituted the environment of the only solar energy journal of that time, *Energy Conversion*. In that year, this journal exhibited a strong relation in its citation pattern to two electrochemical journals, the *Journal of the Electrochemical Society* and *Electrochimica Acta*. In 1978 the structure of the matrix, now composed of 32 journals, became much more complex, indicating that the field was going through transition. Two new solar energy journals, *Solar Energy* and the *International Journal of En-*

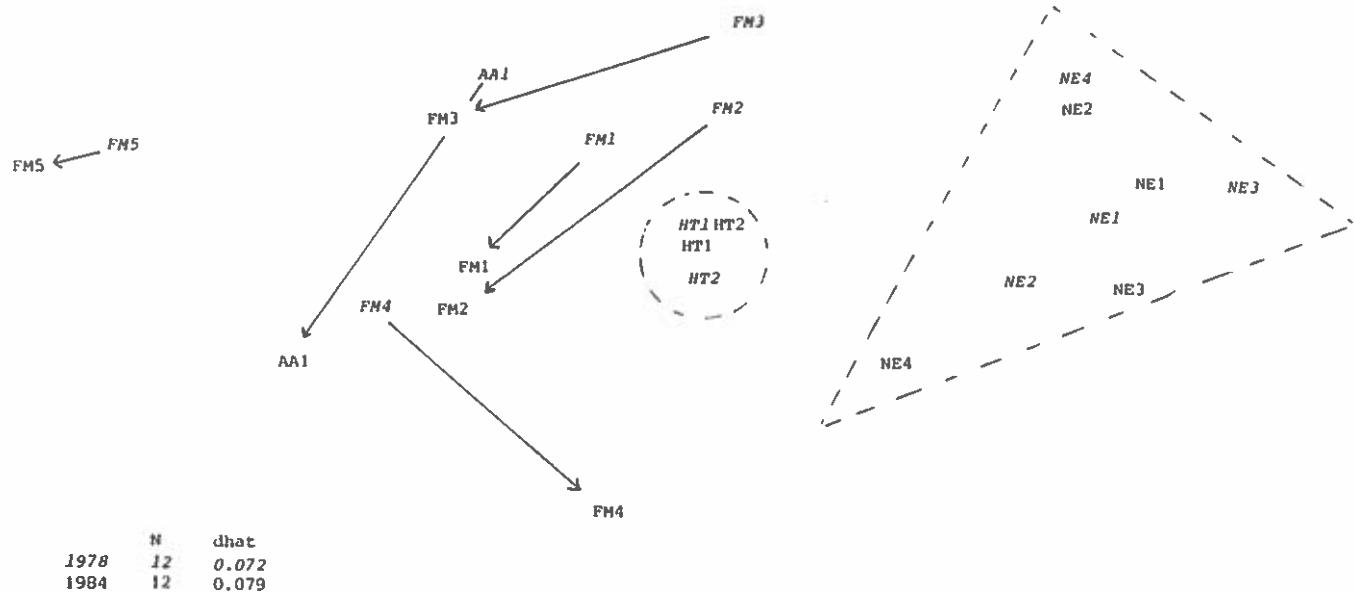


Figure 3. Development of Wind Energy Journals between 1978 and 1984. Wind energy journals are labelled as follows: *Heat Transfer* (HT1) *International Journal of Heat and Mass Transfer* (HT2) *Journal of Heat Transfer-Transactions of the ASME*; *Nuclear Energy* (NE1) *Transactions of the American Nuclear Society* (NE2) *Nuclear Science and Engineering* (NE3) *Nuclear Technology* (NE4) *Journal of Nuclear Materials*; *Fluid Mechanics* (FM1) *Journal of Fluid Mechanics* (FM2) *Physics of Fluids* (FM3) *Proceedings of the Royal Society of London* (FM4) *Applied Scientific Research* (FM5) *Journal of Wind Engineering and Industrial Aerodynamics*; *Aeronautics and Acoustics* (AA1) *AIAA Journal*.

ergy Research, load together but only on a twelfth factor explaining 4.1% of the common variance. In 1982, four solar energy journals, now also including *Energy Conversion*, load on a second factor which account for 17.7% of the common variance of a matrix of 27 journals. Other new journals such as *Solar Cells*, *Solar Energy Materials* and *Thin Solid Films* are included in the list by 1982, but load diffusely on various factors which can be associated with the different specialties of physics (such as solid state physics). By 1984, however, these "loose" solar journals also form a clear structure linked to "applied physics," and this factor (the first) explains 18.9% of the common variance. A second factor, "solar energy," now consisting of five journals, explains 15.1% of the common variance. The nucleus of 5 solar energy journals and 5 applied physics journals, of which two explicitly use the adjective "solar" in their titles, has become stable.

In Figure 2 the stability of this cluster in later years is illustrated by superimposing the multidimensional scaling solutions for the intersection of the 1982-journal list and the 1984-list for both years.

Wind energy journals. Several features of the wind energy analysis indicate that no clear focus on basic wind energy research ever emerged in the international literature. First, in contrast with the solar energy journals the wind energy journals show rapid turnover between the years. Starting with four entries, our analysis located 72 related journals, of which only 20 play a role in more than one year

of the analysis. With solar energy, half or the journals (30 out of 60) appeared in multiple years.

In the wind core, ten journals form a stable background for development over the period 1974-1984. Among these, two journals emerge in 1978 as particularly relevant for our subject in the later years, the *AIAA Journal* and the *Journal of Wind Engineering and Industrial Aerodynamics*. In 1982, four more journals appear which carry over to 1984. By their subject matter, these four are more connected with applied problems about "wind" in general (such as the construction of windmill facilities) than with wind energy research in a narrow sense.¹⁴

Second, factor analysis of the journal-journal citation-matrices also fails to show the emergence of a separate cluster of journals with "wind energy" as a topic. This can best be illustrated with the juxtaposition of the multidimensional scaling solutions for the 12 journals which were present both in 1978 and in 1984 (Figure 3). Among these journals are three of the four entry journals for the analysis: the *Transactions of the American Nuclear Society*, *Applied Scientific Research*, and the *Journal of Wind Engineering and Industrial Aerodynamics*.¹⁵ The picture clearly shows the stability of the "nuclear energy" and the "heat transfer" journals, while the "fluid mechanics" journals move away from "nuclear energy" during this period. Two journals which were already eccentric to the "fluid mechanics" group in 1978 move further away from it in the subsequent period: *Applied Scientific Research* turns somewhat back to

nuclear energy, but specifically to its "electronics" component (approaching much closer to the *Journal of Nuclear Materials*), while the *Journal of Wind Engineering and Industrial Aerodynamics* moves still further away from the "nuclear energy" part of the picture.

In summary, the pattern is dominated by movement and turnover of journals with low impact factors, particularly among those with special interest to our subject. The most relevant journals which carry over move away from "nuclear energy" toward new fields with an emphasis on application and engineering. In 1984, not only "water research" and "civil engineering," but also other fields of engineering such as "agricultural engineering" start to play a role in the journal matrix. The set is also becoming more diffuse: no fewer than 41 journals (reduced to only 16 factors through factor analysis) are relevant in 1984.

From these results we may generate the hypothesis that the research phase for wind energy never really gained momentum as a separate specialty. Before this could happen, problems of implementation and diffusion took over. This hypothesis is consistent with background knowledge about wind energy research.

Publications in international journals and local reports

As noted above, the starting point for the analysis of Dutch publications was the set of authors of local reports, archived in the managing office of the two programs. The publications of these authors in the international literature were retrieved from the *Science Citation Index*. Some publications may have been missed by using the SCI. The in-between category of publications in less visible journals (such as engineering journals and trade journals in Dutch, for instance), could not be retrieved, nor is there a simple alternative procedure for finding them. In addition, particularly in fields such as these, with high policy relevance and emerging journal structures, major publications may also have been published in journals which had not (yet) been included in the *Science Citation Index*.

However, from the perspective of our original question, a database restricted to journals which are included in the SCI is sufficient. We are primarily interested here in the relation between reports, which are oriented toward funding agencies, and the scientific contributions of the researchers to their relevant professional communities. This relationship can be dealt with adequately using the set of publications which pass the selection criteria of the *Science Citation Index*.¹⁶

Solar Energy. In the National Research Program on Solar Energy, 120 reports were written by 57 authors, for an average of 2.1 reports per author. These 57 authors published 63 articles in 32 journals which are included in the on-line installation of the SCI on DIALOG.¹⁷ Of these 32 journals 14 belong to the core journal set for solar energy.

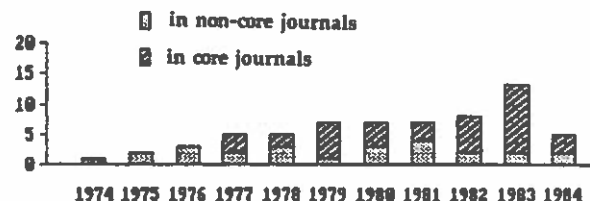


Figure 4. Number of Publications for Dutch Solar Energy Authors in Solar Energy and Non-Core Journals. In non-core journals, N = 24; in core journals, N = 39; total, N = 63.

Thirty-nine of the 63 publications were published in the 14 core journals. Hence, we can speak of a focus on these journals in the publications.

Over the years, the number of publications also grew steadily from 1 in 1974 to 13 in 1983.¹⁸ (See Figure 4.) The share of the publications in core solar journals increased even more rapidly, as is also evident from this figure.

Wind Energy. In the Dutch National Research Program on Wind Energy, 156 authors produced 366 reports (an average of 2.4 per author). These 156 authors also produced 61 SCI publications, which appeared in 44 journals. Only 14 of these journals belong to the wind energy core. The full set of data for wind energy, in comparison with solar energy, is given in Table 2.

In Table 2, we note that although the group of wind energy authors is nearly three times as large as the solar energy group (156 versus 57) and published also about three times as many reports (366 versus 120), both groups pub-

Table 2
Comparison of Output data for
Solar and Wind Energy Programs

	SOLAR ENERGY			WIND ENERGY		
No. of reports	120			366		
Actually archived:	144			348		
No. of authors	57			156		
No. of SCI-publications	63			61		
	Solar energy journals			Wind energy journals		
	core	non-core	total	core	non-core	total
Journals	14	18	32	14	30	44
Publications	39	24	63	24	37	61
Citations	83	40	123	36	76	112
(- self-cites)	28	9	37	9	18	27)
citations per pub.	2.1	1.7	2.0	1.5	2.1	1.8
References	138	336	474	42	183	225
Refs. in reports	99	80*)	179	44	183*)	227

* All other international journals

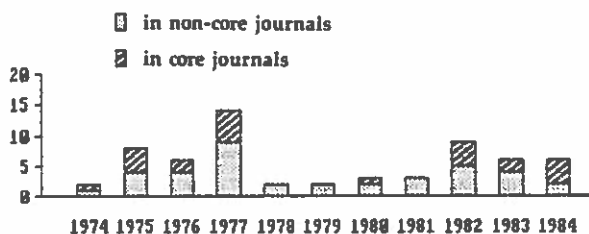


Figure 5. Number of Publications for Dutch Wind Energy Authors in Wind Energy and Non-Core Journals. In non-core journals, N = 37; in core journals, N = 24; total, N = 61.

lished roughly the same number of publications in international journals (61 versus 63). Moreover, the wind energy authors published in a much more scattered set of journals than their solar energy colleagues (44 versus 32) and they focussed less on core journals (only 24 publications in core journals for wind energy as against 39 for solar energy). Clearly, the solar group has a more structured relationship to the international literature.

The absolute number of publications over the years in wind energy also follows a pattern which is different from that of the solar energy case. Although moderately productive in the earlier years (14 publications in 1977), in the 1978-1981 period, this group of authors produced only 2 or 3 publications per year, with none in the core set of journals in 1978, 1979 or 1981. (See Figure 5.)

If we look at the journals in which these authors published in the different years, we see a connection between subject matter and production of international papers. Before 1978 the wind energy authors were active in the nuclear energy field. Only from 1982 onwards do we find publications which we can identify as having typical wind energy issues as their subject matter. However, even in these later years we find more publications of this group in the "nuclear energy" journals than in the journals with the word wind in their title. One problem here, to which we will return in dealing with the citing patterns, is that perhaps more than in the case of solar energy, the new wind energy journals may have remained under the threshold of inclusion in the *Science Citation Index* (such as, for example, is the case for *Wind Engineering*).¹⁹

Citations to "solar" and "wind" energy publications

The full set of 63 articles in international journals from solar energy authors received 160 citations. Thirty-seven of these were self-citations, which we removed from the analysis, leaving 123 citations. The set of 39 articles, which were published in "core" journals for solar energy, received 83 non-self citations. They were thus more frequently cited than the non-core publications, although on the average

they are younger and appear in relatively newer journals. In the wind energy case the full set of 61 received about the same number of non-self citations, 112; but the 24 core wind energy documents received only 36 citations, a lower average number (c/p) than the publications in non-core journals. (See Table 2.)

The development of the being cited patterns over the years is also different for solar and wind energy publications. (See Figure 6.) However, in both cases a substantial percentage of the citations to publications in core journals come from core journals: 42% and 44% for solar and wind energy respectively.

Development of citing patterns

What publications are cited in the articles published by Dutch authors in these two fields in the core of their international literature? For reasons of cost-effectiveness, we confined our analysis to the document set which had been published in core solar energy journals and wind energy journals. A longitudinal analysis of "being cited" and "citing" patterns for these core solar and wide energy publications was compared with citing patterns in the reports of the two programs.

For this analysis we had to use the DIMDI-installation of the SCI since only on that edition the references in the source articles are included as well. However, in this installation we could find only 38 of the 39 solar energy articles which we found in the DIALOG installation. These 38 solar energy articles contain 474 references while 24 wind energy publications contain 225. Hence, the average number of references in a core wind energy publication is somewhat lower than in a core solar energy publication (9.4 versus 12.5). The percent of references to core journals varies considerably over the years. (Figure 7 gives these percentages for 38 solar energy core publications and 24 wind energy core publications distributed according to their

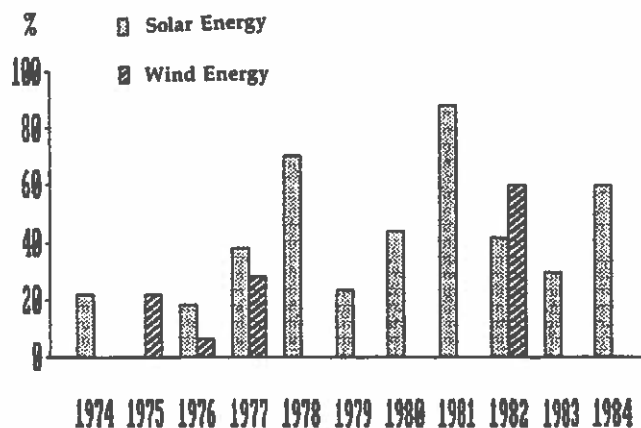


Figure 6. Percentage of Citation in Core Journals for Solar and Wind Energy Respectively, 1974-1984. Self Citations are included. Hence there are 63 publications and 160 citations in solar energy, and 61 publications and 143 citations in wind energy, for a total of 124 publications and 303 citations.

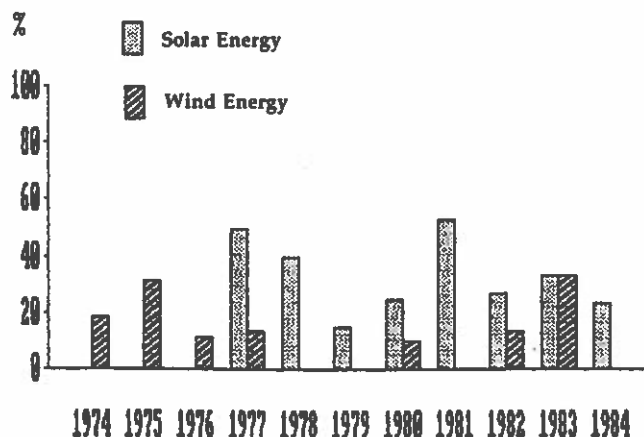


Figure 7. Percentage of References in Articles from Core Journals for Solar and Wind Energy Respectively, 1974-1984. Self Citations are included. Hence there are 38 publications and 474 references in solar energy, and 24 publications and 225 references in wind energy, for a total of 62 publications and 699 references.

publication years.²⁰) However, in the case of solar energy this percentage is on the whole 10% higher than in the case of wind energy. Again, this indicates a stronger relation to the international literature in the solar energy case than in the wind energy case.

References in the reports

Finally, as has been noted above in both programs a substantial number of reports were produced as well. The official records of the National Research Program on Solar Energy lists 120 reports by 57 authors, and those of the National Research Program on Wind Energy 366 reports by 156 authors. In the archives of these programs we found 144 reports on solar energy (that is, 24 more than were registered) and 348 reports on wind energy (which is 18 fewer than were registered); hence what we located were approximately the full sets. We compared the citing patterns in these reports with the citing patterns in the articles produced by the two groups of authors.

The wind energy reports contain 7.4 references per report as against 6.2 for the solar energy reports. In the solar energy reports 20.1% of these references are to publications in international (non-Dutch) journals, while this figure is only 8.8% in wind energy. Of the international references in the solar case, 55.3% (79) are to publications in core solar energy journals, as against 19.4% (44) in the wind energy case.

Also notable in the wind data is the growth of references to English and German journals which are not included in the SCI but which have the word wind in their titles. From 1978 onwards, 46 such references occur in the reports, amounting to another 20% of the international references. (Some references to these journals also appear in the international publications of this group.)

Therefore, we see the wind energy researchers here in

need of an international literature to which they can refer, while the solar energy researchers can refer to this international literature in their reports—and do so to a much larger extent than in their international publications. In terms of the scheme we introduced earlier in this paper, we conclude that in the solar energy case, when an international journal set emerges, scientists support their local resource relations by referring to an international context. In the case of wind energy, resource relations cannot be nourished with such legitimation, and we may expect other mechanisms in these relations to be more important.

Conclusions

1. The solar energy document set reflects the emergence of a solar energy journal set, while the wind energy document set shows some differentiation from what is essentially a nuclear energy document set. After a period in which the latter group of authors seems not to have published or only in journals which are not included in the Science Citation Index, in the more recent years some publications in journals devoted to wind energy issues can be found.
2. Authors publishing in core solar energy journals make more references to other authors publishing in these journals than do their wind energy counterparts. However, both groups have to gain a substantial part of their rewards in terms of "being cited" in non-core journals.
3. In the case of wind energy, publications in non-core journals gained more credit, as measured in citations of these publications, than publications in the core journals. The opposite situation occurs in the case of solar energy.
4. In general, although both document sets cite, and are being cited in, more publications in non-core journals than publications in core journals, the solar energy core set of publications (i) refer less to the non-core set journals, and (ii) are being cited in the non-core journals is to about the same extent, but (iii) have a much higher part of the total of relevant citations within the cluster. This confirms the points made in earlier sections on journal-journal citations and their developments in the two areas: in solar energy research, we are witnessing the growth of a much more stable structure both in terms of journals and in terms of authors referring to each others' work.
5. The relevant Dutch scientific communities which have served as our entries to the analysis seem to follow these international developments with a modest contribution. At the national level, we can witness the emergence of a specialty and its participation in the specific international literature in the case of solar energy from 1978 onwards. In wind energy the development of relevant journals occurs later (1982) and is weaker in its struc-

ture, and the relevant Dutch community, which consists of authors who left the nuclear energy field, did not find publication outlets in the intervening years in journals that are internationally visible. In later years they either returned to the nuclear energy journals or to a small extent they started to publish in the "wind energy" core journals. This smaller extent corresponds to the weaker position of these journals.

Hence, our results suggest that in these fields the international publication (citing and being cited) patterns of the local communities are highly dependent on the development of international developments as measured by journal-journal relations. If any, the effects of science policy efforts at this level are probably to enhance such participation.

6. Lacking international publication outlets, Dutch wind energy research seems to have remained a more local activity than solar energy research. Solar energy researchers back up their reports with references to specific international literature, while wind energy researchers work much more in a local network whose members cannot easily refer to a specific set of international journals.

Discussion

It has not been our purpose in this article to draw conclusions about whether the one program has been more successful than the other. This is a question for policy analysts, and one which deals precisely with a variable which we have held constant in the present study. Our topic here—the changing relationship with the international literature by the relevant research communities in response to policy initiatives—strongly suggests only that there is a straightforward dependence of the publication and citation behavior of these communities on the development of structure among international journals.

On the one hand, the solar energy group, which started from about the same level as the wind energy group, found its way to an emerging set of journals, from which in turn it could profit in terms of legitimation. Although it clearly failed to meet the original objectives of the National Research Program—producing relatively few reports, with hardly any commercial value²¹—the research community managed to gain autonomy over the years to such an extent that when in 1982 the Ministry of Economic Affairs had to decide on the prolongation of the program, it chose to support "more fundamental research".²² Since then, part of the funding for this research has been channeled through a division of the National Research Organization for Fundamental Research.²³ This suggests that not only were the selections made by the research community guided by international scientific developments, but that in this case the development was strong enough to force the polity to adapt.

On the other hand, wind energy never gained theoretic

cal focus as a research field during the later 1970s and the early 1980s. Although some theoretical questions arose in the beginning of the program (such as those concerning "tipvanes"), engineering problems definitively took over during the 1980s. The focus of the later program and its continuation lie in the commercial development of windmills. Hence, the central problems have shifted from basic research questions to problems of industrial application. At the level of substance, we can understand this if we realize that aerodynamics is of major concern to the aircraft and space industries, and that major theoretical problems may have been solved in that context. But this is an *ex post* interpretation. In the beginning, there were no major differences between the two situations. In the early 1970s, the major problems of both wind energy and solar energy belonged to sciences with high industrial relevance: in the one case aerodynamics and in the other case solid state physics and electrochemistry. In terms of the methodology applied here, we can say at the very least that if there were any differences in substance they were not visible at that time yet. Over the years it seems that the balance between research and industrial application has developed in the wind energy case completely differently from the former case: the researchers involved have produced reports in response to the demand. We speculate that as researchers they followed a strategy of publishing in non-wind energy journals in order to maintain their academic standing. However, only a percentage of them manage to do so, sometimes because they are still linked in their research efforts with the more prestigious field of "nuclear energy" from which they were originally recruited.

The efforts made in this study to look at the "citing" patterns as well have been less rewarding, given the amount of software development which was required for the purpose. The major point which could be made is that the solar energy researchers indeed used two types of referencing patterns for their two relevant audiences. (Even in the "wind energy" case we can detect some, although much weaker, attempts to do this.) On the one hand, when they publish in scientific journals, they link their publications up to the international literature in more general journals, even if they publish in the narrowly focused journals of their specialty. However, in their reports they draw from their specialty journals, probably because that legitimizes the status of their specialty.

Let us conclude by returning to the social and cognitive dimensions which we discussed in the introductory section. During the research, a shift has been made from the original "group of authors" as unit of analysis to the different "document sets" they produced.²⁴ On the one hand, if we want to stick to the traditional science policy questions involved—where to spend money and why?—we are inclined to see the proper unit of analysis as institutions, and hence, in terms of scientometric methods, as groups of authors. On the other hand, the results of this study suggest

a strong linkage between the outcomes of science policies and the development of the international scientific literature. The base for this linkage is not "authors" but articles, or to put it more technically: document sets. The crucial question becomes: what makes a scientific article a significant contribution? From this perspective, science policy issues inevitably assume a more cognitive aspect.

Notes and References

1. K. E. Studer, D. E. Chubin, *The Cancer Mission. Social Contexts of Biomedical Research* (Beverly Hills/London: Sage, 1980), 269.
2. G. Küppers, P. Lundgreen, P. Weingart, "Umweltprogramm und Umweltforschung", in *Geplante Forschung*, ed. W. v. d. Daele, W. Krohn, P. Weingart (Frankfurt a.M.: Suhrkamp, 1979), 239-286. On funding, see S. E. Cozzens (ed), "Funding and Knowledge Growth", theme section of *Social Studies of Science*, 16 (1986), 9-150.
3. Cf. I. Spiegel-Rösing, *Wissenschaftsentwicklung und Wissenschaftssteuerung*, (Frankfurt a.M.: Athenäum Verlag, 1973), 106-131.
4. L. Leydesdorff, "The Development of Frames of Reference," *Scientometrics* 9 (1986), 103-125.
5. In most cases the variables load on a second factor only in the second decimal, and hence the split is almost complete. The factorial complexity of citing or being-cited patterns can in such cases be used as an indicator of the "interdisciplinarity" of a journal.
6. In the social sciences, there is more evidence that particularistic criteria may be influential even at this level. See also: W. C. Yoels, "The Structure of Scientific Fields and the Allocation of Editorships of Scientific Journals: Some Observations on the Politics of Knowledge," *The Sociological Quarterly* 15 (1974), 264.
7. L. Leydesdorff, "Various Methods for the Mapping of Science," *Scientometrics* 11 (1987) 291-320. See also Leydesdorff, "Frames," 122.
8. A. W. Gouldner, "Cosmopolitans and Locals: Toward an analysis of latent social roles," *Administrative Science Quarterly* 1 (1957), 281-306, and *Administrative Science Quarterly* 2 (1958), 444-480.
9. R. D. Whitley, *The Intellectual and Social Organization of the Sciences* (Oxford: Oxford University Press, 1984).
10. P. Groenewegen, "Attracting Audiences and the Emergence of Toxicology as a Practical Science," in *The Social Direction of the Public Sciences: Causes and Consequences of Co-operation between Scientists and Non-Scientific Groups*, *Sociology of the Sciences Yearbook*, vol. XI, eds. S. Blume, J. Bunders, L. Leydesdorff, R. Whitley (Dordrecht/Boston: Reidel, 1987).
11. Of course, in addition to this substantive purpose science policy may also strive to improve the institutional management of research.

Notes continued from page 21.

4. Exemplary studies from the Tremont group include: Elihu Gerson, "Scientific Work and Social Worlds," *Knowledge* 4 (1983): 357-77; S. Leigh Star, "Simplification in Scientific Work: An Example from Neuroscience Research," *Social Studies of Science* 13 (1983): 208-26; Adele E. Clarke, "Research Materials and Reproductive Science in the United States, 1910-1940," in *Physiology in the American Context, 1850-1940*, Gerald Geison, ed. (Bethesda: American Physiological Society, 1987), 323-50; Joan H. Fujimura, "Constructing 'Do-able' Problems in Cancer Research: Articulation Alignment," *Social Studies of Science* 17 (1987), forthcoming.
5. Michael Schudson, *Advertising. The Uneasy Persuasion* (New York: Basic Books, 1984), quotations at 43 and 210. I have found the literature on advertising—much of it written by economists—dull and rarely pertinent to the arguments here, with one notable exception: Roland Marchand's *Advertising the American Dream* (Berkeley: University of California Press, 1985) is a beautiful sociological study of the role of advertising in cultural reproduction.
6. Hugh Rank, *How to Analyze Ads: The Pitch: . . .* (Park Forest, Illinois: The Counter-Propaganda Press, 1982), 98.
7. Schudson, *Advertising*, 215.
8. I am grateful to Mr. William Schmidt of the Coca-Cola Museum in Elizabethtown, Kentucky, for the opportunity to photograph from his fine collection of Coca-Cola advertisements. For a history of Coca-Cola, cf. Pat Watters, *Coca-Cola: An Illustrated History* (Garden City, N.Y.: Doubleday,

12. See for a detailed description of the methods L. Leydesdorff, "Frames." Additionally, in this study factors have been extracted obliquely to test whether they were related among each other.

13. This limitation is introduced because of cost-effectiveness: searching citing-patterns in publications without access to the ISI-tapes requires considerable connect time with the host.

14. These journals are: the *Journal of the Structural Division ASCE*, the *Journal of the Water Pollution Control Federation*, *Water Research* and the *Journal of Geophysical Research*.

15. The fourth entry journal, the *Journal of Aircraft*, has not been included in the quantitative analysis because it is included only in the Cited Journal Package of the JCR.

16. About inclusion in the Science Citation Index, see S. Maric, "Scientific Journals: Selection Criteria for Information Services," *45-Letters* 5 (1980/1), 6-8; E. Garfield, *Current Contents*, November 5, 1979. (Also in *Essays of an Information Scientist*, vol. IV, 309-312 (Philadelphia: ISI-Press, 1981).

17. In the printed edition four additional book titles could be found, but 10 article titles were not found! These differences seem to us a relevant argument in the discussion about the use of the printed or the on-line edition of the SCI for scientometric research. See, for example: J. Irvine, B. R. Martin, "Basic Research in the East and West: A Comparison of the Scientific Performance of High-Energy Physics Accelerators," *Social Studies of Science* 15 (1985), 309; H. F. Moed, A. F. J. van Raan, "Critical Remarks on Irvine and Martin's Methodology for Evaluating Scientific Performance," *Social Studies of Science* 15 (1985), 545.

18. The reason for the low values in 1984 is that the analysis was conducted until December 31, 1984 as the date of entry, while some of the 1984 publications were not published and registered until 1985.

19. See note 15.

20. One should keep in mind that the "wind energy" set is empty for 1978, 1979 and 1981, and hence does not contain any references.

21. A. Rip, P. v. d. Schaar, "Het Nationaal Onderzoeksprogramma Windenergie," in *Implementatie van Prioriteiten in het Wetenschappelijk Onderzoek bestudeerd aan de hand van enkele casestudies*, eds. A. Rip, R. Hagendijk, H. Dits (s-Gravenhage: Staatsuitgeverij, 1986); M. Jochem, "Waarom Wind-en Zonne-energie de markt nog niet hebben veroverd?" *Wetenschap & Samenleving* 8 (1986), 20-25.

22. *Zonne-energie in Nederland. Programma voor de tweede fase van het Nationaal Onderzoeksprogramma Zonne-energie (1982-1985)*, Bureau Energie Onderzoek Projecten (BEOP)-15, (Petten: Energieonderzoek Centrum Nederland, 1982).

23. *Energieaspecten* 1984, no. 4, 260; *Energieaspecten* 1985, no. 5/6, 14.

24. On the choice of the unit of analysis in cognitive or social terms, see also: H. M. Collins, "The Possibilities of Science Policy," *Social Studies of Science* 15 (1985) 554-558; B. Martin, J. Irvine, "Evaluating the Evaluators: A Reply to Our Critics," *Social Studies of Science* 15 (1985): 559.

1978) or Oliver Thomas, *The Real Coke, The Real Story* (New York: Random House, 1986). I also wish to thank Carl Briggs for photographic assistance.

9. Scientists are of two minds on the use of science in advertising and, more generally, on its presentation in mass media. The ambivalence is noted in Dorothy Nelkin's brand new book *Selling Science: How the Press Covers Science and Technology* (New York: W. H. Freeman, 1987 at page 169): "Scientists today see improved press coverage as a means of fulfilling their obligation to bring science to the public and attracting support from legislators, corporate leaders, and foundation executives. But they have also carried over values from a time when science was less accountable and more isolated from public affairs. . . . [Scientists] worry about the corruptive influence on science of self-promotion and the encouragement of scientists more skilled in public relations than in research."

10. I thank Anne Figert for this example.

11. Schudson, *Advertising*, 27.

12. The boundary between science and non-science has been the object of earlier work: Thomas F. Gieryn, "Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists," *American Sociological Review* 48 (1983): 781-95. This endnote is an advertisement for my forthcoming book, *Boundaries of Science: Theory and Episodes*.

Endorsing Referee:
Michael Mulkay

A Strategic Assessment of the Scientific Performance of Five Countries

Rémi Barré

Conservatoire National Des Arts-et-Métiers

Abstract

This report compares the concentration of effort among subfields of science across five industrialized nations, as shown in numbers of publications. The analysis is based on the PASCAL database maintained by the French Centre National de la Recherche Scientifique (CNRS) for the years 1980 to 1983. Japan and Germany show strong concentrations in areas of strategic basic research such as new materials, biotechnology, and communications technology. The United States effort is concentrated in environmental and space sciences as well as health sciences and technologies. France and the United Kingdom concentrate on the health sciences.

Editor's Note: Policy Reports in S&TS are an experimental form of communication between the worlds of science studies and science policy. They call the attention of S&TS readers to results of studies commissioned with direct policy applications in mind. Volunteers or nominations for contributors to this series are invited, and comments on its usefulness are welcome.

Analysis of national scientific performance is part of the strategic assessment of science policy which is, explicitly or implicitly, performed by all governments. Such an assessment is needed because ever more difficult decisions about resource allocation among scientific fields have to be made. Furthermore, those decisions can obviously have farreaching consequences for industrial and economic performance. Part of basic research is sometimes labelled "strategic," as opposed to "curiosity-oriented," in that it can relate directly to innovations in the scientifically-driven "core technologies," which in turn can affect a broad spectrum of activities.¹

Such allocation decisions determine a flow of resources which is aimed at changing the scientific level or strength of the nation (which is a stock), as compared to other nations. Year after year, the allocation decisions, whether explicit or implicit, centralized or decentralized, determine the relative level of the country, in each field and sub-field of science: it determines its scientific profile, which can be seen as the "sedimentation" of all past resource allocations. For these science policy decisions, a knowledge of the national scientific profile is clearly needed both to ground the

allocation decisions and to assess their results in terms of modified scientific strength over a period of time.²

The indicators published by the United States National Science Foundation (NSF) provide very useful information in this respect, especially the bibliometric indicators based on the Science Citation Index or CHI-NSF database.³ Nevertheless, they do not solve the problem because the results are reported in a rigid classification of fields and subfields, unchanged for a decade, which may—or may not—be suitable to perform strategic assessment.

Because of the lack of alternative data, M. R. Chabbal from the French Ministry of Science and Technology commissioned the bibliometric study reported here⁴ to identify the scientific profile of various countries according to subfields considered meaningful for a strategic assessment of science in those countries. Such an enterprise was all the more needed because a law passed in 1985 made it compulsory for the Ministry of Science and Technology "to present a yearly assessment to the Parliament of the 'strategic choices' of national science and technology policy, presenting the position of France in international competition in comparison with major foreign countries."⁵

Methodology

The PASCAL database

Two points set our study apart from the Science Indicators data. First, we chose to work with the PASCAL data base for the study. This multidisciplinary data base, which is produced by the Centre National de la Recherche Scientifique (CNRS), is drawn from about 9,000 scientific and technical journals which are chosen to represent the core of the world's scientific activity, even though, like the SCI (and therefore the CHI-NSF), it underrepresents sci-

Author address: Author address: Conservatoire National des Arts-et-Métiers, 292, Rue Saint-Martin, 75141 Paris Cedex 03, France

Science & Technology Studies 5(1): 32-38, 1987.

ence published in non-Roman alphabets. A disadvantage of PASCAL is that it does not include citations; this is why we did only publication counts and could not perform any impact analysis.

An advantage of PASCAL, on the other hand, is that it includes keywords with each article. This feature enabled us to define subfields which were meaningful in terms of science policymaking and strategic assessment. This is the second distinctive feature of this study.

Definition of the subfields

In order to be meaningful in terms of strategic assessment of science policy, yet manageable for the PASCAL database, the subfields of interest were determined through a discussion among policymakers, their scientific advisors, and PASCAL data base specialists. This led to the identification of 145 subfields. For various reasons, mathematics, particle physics, clinical medicine, and the social sciences were excluded. Each subfield is accessible without ambiguity or overlap through the classification scheme or the PASCAL keywords, and all subfields taken together cover about 85% of PASCAL.

Constitution and validation of the data base

The number of articles contained in PASCAL for each one of the 145 subfields was then computed for France, the United States, the Federal Republic of Germany (FRG), the United Kingdom (U.K.), and Japan⁶; in order to increase

the reliability of the results, the numbers were computed as a total over 4 years (1980 to 1983). This being done, we retained subfields for analysis if they met all of the following criteria:

—The world total of articles had to be greater than 200 per year, in order to avoid subfields which were too narrowly defined.

—The proportion of articles without country affiliation had to be less than 30%. We assumed that articles without country affiliations were randomly distributed among countries. The 30% criterion gave us some assurance that even if this assumption were false, the impact would not be significant.

Then we computed the number of articles for each subfield which appeared in another data base, chosen case by case according to the subfield (e.g., *Chemical Abstracts* for chemistry). At this stage we added a third criterion: similarity in relative importance of the different countries when computed with PASCAL and the other data base.

In the end, selection by these criteria left us with 103 subfields out of the 145 initially defined. Most of the subfields we had to drop were applied sciences and technology. We still have very good coverage of basic research and fair coverage of the applied sciences, but poor coverage for technology. To simplify matters, these 103 subfields will be referred to as "science" in what follows.

Table 1:
Scientific Profiles of the Countries (on the macro-profile fields)

	Field	F	FRG	UK	USA	JPN
I	Theoretical physics and chemistry	93	110	97	100	119
II	Life sciences, basic research	98	101	107	147	143
III	Semiconductors; analytic and electro-chemistry; catalysis; condensed matter	94	95	81	68	166
IV	Materials science plus applied and organic chemistry	57	127	80	59	126
V	Physics and technology of electronic components, integrated circuits, "Group III-V" semiconductors, photomemistry	74	91	86	116	255
VI	Computer science and imaging technology	78	102	101	106	84
VII	Technology for pollution treatment, energy storage, civil engineering, plus machine tool research	71	136	74	72	59
VIII	Earth sciences	98	62	83	77	52
IX	Environmental sciences and space sciences	68	84	88	114	55
X	Renewable resources	129	78	97	83	45
XI	Agronomy, food production, biotechnology for agriculture	98	69	97	90	67
XII	Life sciences: health and drugs	155	114	130	121	69
XIII	Other applied life sciences	109	99	142	143	70
	Mean	100	100	100	100	100

Each number is the mean for each field of the value of the relative specialization index of its sub-fields; each number therefore represents a macro-specialization index. Details on the subfields included in each field are available from the author.

Our PASCAL-profiles data base thus comprises a matrix of 103 lines (subfields) and 6 columns (5 countries plus rest of the world). The total number of articles recorded in the 103 subfields (for 4 years, world total, including nonaffiliated articles) is 1,452,500, the number of articles and world share per country being the following:⁷

France	107,001	(6.1%)
United Kingdom	118,603	(6.8%)
Germany	106,632	(6.1%)
USA	511,764	(29.4%)
Japan	105,916	(6.1%)

The mean number of articles for the 4 years, per subfield is 14,000, with a minimum of 800 and a maximum of 9,500.

Scientific and geographic profiles

Each country was given an overall "scientific weight": its share of world scientific articles. Each country also has a weight relative to each subfield, which is simply its share

of the world articles in that subfield. For a country, the ratio of its weight in a subfield to its overall scientific weight measures the relative specialization of the country in that subfield.

The "scientific profile of a country" is the set of measures of its relative specialization for each subfield—a vector of 103 elements. If A_{ij} is the number of articles of a country i in subfield j , then the relative specialization of i in j is: $A_{ij}/A_{i..}$. The scientific profile of country i is the vector $V_i = (K_{i1}, K_{i2}, \dots, K_{ij}, \dots, K_{i103})$.

In exactly the same way, each subfield has a profile of countries, which we call the "geographic profile of a subfield." It is made up of the relative concentration in each country, the concentration being the ratio of the weight of subfield j in country i to the overall weight of subfield j in world science ($A_{ij}/A_{i..} : A_{.j}/A_{..} = K_{ij}$). Therefore the geographic profile of subfield j is the vector $V_j = (K_{1j}, K_{2j}, \dots, K_{ij}, \dots, K_{6j})$.

Definition of the macro-profile fields

Comparing the scientific profiles of the countries (that is, vectors made up of 103 numbers) is no easy task; some sort of aggregation of the subfields into a dozen or so major fields has to be done if we want to be able to interpret the figures. A common way to aggregate such vectors is to put together the subfields considered to belong to the same area of science in terms of the disciplinary categories (chemistry, physics, biology...); but each one of those fields would contain about 10 subfields which have no reason to have the same profile. Therefore the profile of the field, being an average of the profiles of the subfields, would mask the diversity of the sub-profiles. In other words we would lose all the information gathered at subfield level and end up at a high level of generality. As an alternative, we clustered the subfields which had a similar geographic profile. Those sets of subfields, called the "macro-profile fields" or simply "fields" enable us to simplify the interpretation of the scientific profiles while minimizing the amount of information loss in the process.

In practice, to determine the macro-profile fields we clustered the subfields from the PASCAL-profiles matrix, which gave us nine algorithmically-defined clusters. If at this point our macro-profile fields had consisted of unrelated subfields in terms of scientific disciplines, characterization of the macro-profiles would have been difficult. In fact, it appeared that with only minor modifications of the initial nine clusters to ease interpretation, we got 13 well-characterized macro-profile fields.

The ease of interpreting these groups suggests that subfields having the same geographic profile are also related in terms of scientific discipline. Thus, to the extent that discipline concentrations are shaped by a nation's economic system, national or macro patterns of scientific specialization can be interpreted in terms of science policy and

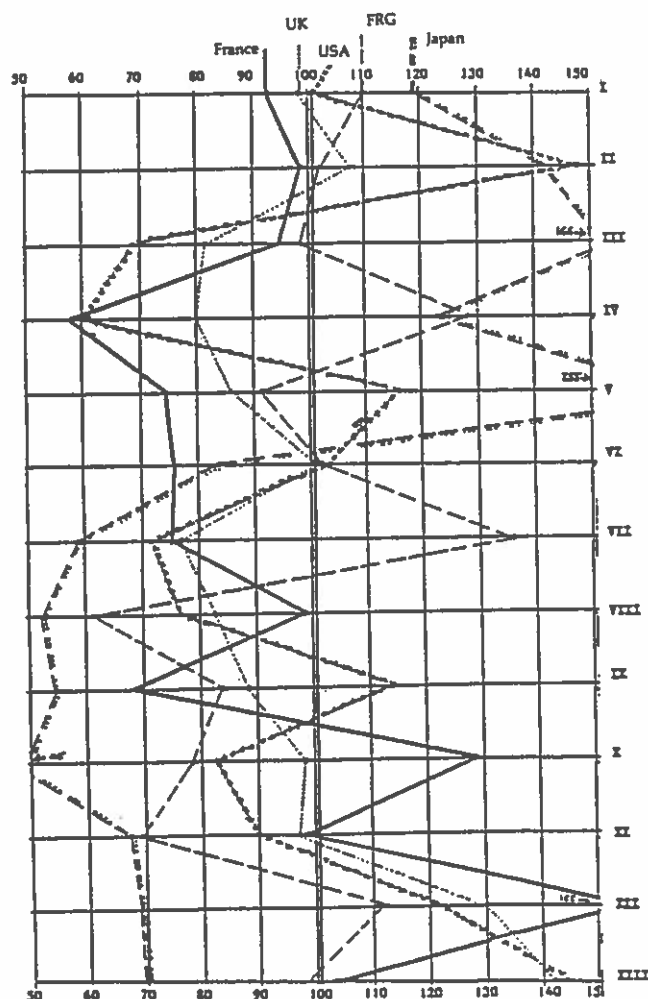


Figure 1. Scientific profiles of the five countries on the 13 macro-profile fields. The mean weight of each country is 100. For each field, the relative specialization index is shown.

the socio-economic objectives which underlie them. This leads us to the interpretation of each field:

—**Field I** is theoretical physics and chemistry, including controlled fusion.

—**Field II** is basic research in the life sciences (molecular biochemistry and genetics, molecular and cell basis of pharmacology, biotechnology).

—**Fields III to VI** are basic and applied research in areas such as new materials, solid-state physics, electronics, chemistry, computer and communication.

***Field III** is physics of semi-conductors and components, analytic and electro-chemistry, catalysis, and the science of condensed matter.

***Field IV** is materials science plus applied and organic chemistry.

***Field V** is physics and technology of electronic components, integrated circuits, "group III-V" semiconductors and photochemistry.

***Field VI** is computer science plus imaging technology.

—**Field VII** is research on technology and devices for applications such as water and pollution treatment, energy storage, civil engineering, and new materials, plus research on machine tools and their automation.

—**Field VIII** is earth sciences.

—**Field IX** is environmental sciences and space sciences.

—**Field X** is research on renewable resources: forestry, wood and wood pulp, biomass for nutrition and energy,

fisheries, ecology and marine ecology.

—**Field XI** is agronomy in a broad sense, including food production and biotechnology applied to agriculture

—**Fields XII and XIII** are health sciences from pharmaceutical products to medical technologies;

In summary, Field I is theoretical physics and chemistry; fields II to VI are the areas of strategic basic research, that is, fields with a clear potential, on a long time scale, for wide-ranging applications (communication technology, new materials and biotechnology); Field VII is about techniques and machines; Fields VIII and IX are earth, environmental and space sciences; and Fields X to XIII are linked to various sectors of economic activity dealing with living matter, respectively renewable resources, agriculture and health.

Results

The results of the study—that is, the scientific profiles for the five countries in the 13 fields—are given in numerical and graphical form in Table 1 and Figure 1).

Overall comparison of the profiles

It is possible to define the distance between two profiles as the sum of the squares of the differences of their relative specialization indices over the 13 fields. Given such distances for all pairs of countries, it is possible to visualize their relative similarity with a "hierarchical tree" which embodies as well as possible all the distances among countries. (See Figure 2.) Clearly, the scientific profiles of Japan

Table 2
Fields of relative strength and weakness for the countries

	Important relative weakness	Relative weakness	Around the mean of the country	Relative strength	Important relative strength
France		I, II, IV, V, IX XI	III, VI, VII, XIII	VIII, X	XII
FRG	XI	II, VIII, X, XIII	I, III, V, IX, XII		IV, VI, VII
UK		I, III	II, IV, V, VII, VIII, IX, X, XI	VI, XII, XIII	
USA		I, III, IV, VIII, X, XI	XII	V, VII, XIII	II, VI, IX
Japan	VIII, IX, X, XI, XII, XIII	VII	I, VI	II	III, IV, V

The numbers from I to XIII refer to the 13 macro-profile fields.

If A is the value of the macro-specialization index of a country on a field, then we have the following scheme:

$A \leq 70$: field of important relative weakness

$70 < A \leq 90$: field of relative weakness

$90 < A \leq 110$: field of around the mean position of the country

$110 < A \leq 130$: field of relative strength

$A \leq 130$: field of important relative strength

and Germany are relatively similar, and very different from the three other countries; those three countries (U.S., U.K., and France), in turn, have very similar profiles, France and the U.K. being closest.

Let us now describe those similarities and differences more precisely. (See Table 2.)

The profiles of **Germany** and **Japan** show clearly-differentiated strengths and weaknesses, in other words clear-cut scientific priorities:

—Fields II, III, IV, V and VI (materials sciences, electronics, solid-state physics, chemistry), all parts of what we call strategic basic research, are never below the mean. In fact, four of them for Japan and two for Germany are indeed areas of important relative strength. (The third area of important relative strength for Germany—machine tools—might also be considered strategic.)

—Fields VIII, X, XI and XIII (earth sciences, renewable resources, agronomy, and part of the health sciences) are relatively weak.

—Fundamental research is around average. We note, however, that in the life sciences (Field II), another area of strategic research, Japan has a relative strength, while Germany exhibits a relative weakness.

—Japan shows an important relative weakness for Fields IX and XII (space and environmental sciences plus medical sciences, including pharmaceuticals) while Germany is around its average for these.

France and the **United Kingdom** have much more homogeneous profiles, showing almost no important relative strengths nor weakness.

—Among the fields of strategic research (II to VI), none is above average, except field VI (computer science) for the U.K..

—Fields XII and XIII (health sciences) are the (rare) relative strengths.

—Fields VIII and X (earth sciences and renewable resources) are at average or just above.

—Fundamental research is a relative weakness, except for life sciences where the U.K. is at average.

—For France, Fields IX and XI (space and environmental sciences, plus agronomy) are areas of relative weakness.

Even though it is not very different from the profiles of France and the United Kingdom, the scientific profile of the **United States** shows some interesting particularities.

—Fields V and VI (electronics and computer science) are respectively areas of relative and important relative strength, showing here a focus even sharper than that of Japan and Germany. Fields III and IV (materials science, solid-state physics, chemistry), unlike Japan and Germany, are areas of relative weakness for the U.S., as they are for France and the U.K..

—Field II (fundamental research in the life sciences)

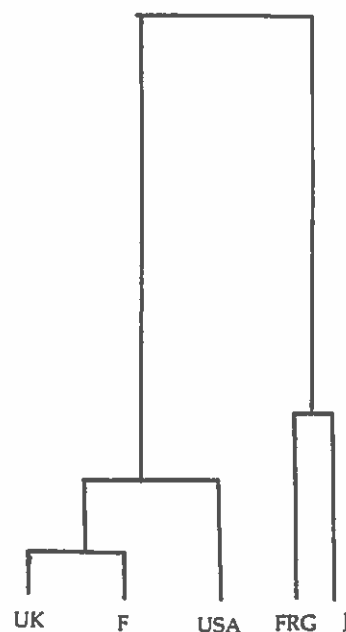


Figure 2. The distances of the scientific profiles of the five countries. The higher one must go to link two countries, the more different their scientific profiles are. UK = United Kingdom F = France FRG = West Germany J = Japan.

is an area of important relative strength. This is another sharp focus in a strategic research area, again sharper than Japan. (In Germany, Field II is an area of relative weakness.)

—Field IX (space and environmental sciences) is another area of important relative strength, all the more remarkable since the U.S. is the only country where this field stands above average.

—Fields XII and XIII (health sciences) are, as in France and the U.K., areas at or above average.

Comparing strengths and weaknesses in absolute terms

Using the same definition of the fields, we now compare the absolute weights (world shares) of each country. This amounts simply to calculating the percentage of total articles in the field produced in each country. This being done, we arbitrarily set the value for France at 100 for each field. (See Table 3 and Figure 3).

The United States compared to the other countries. The U.S. is dominant in all fields without exception; but the level of dominance varies widely from field to field.

—For Fields III and IV (material sciences, solid-state physics, chemistry), where Japan and Germany have a strength and the U.S. a weakness, the U.S. dominance is only between 2.0 and 2.2, that is, the U.S. share is twice as great as Japan's and twice as great as Germany's (3.5 as much for Field III)

—For Field V (electronics) the dominance is also only 2.2 with Japan, even though this is an area of relative U.S. strength. The reason is that the Japanese focus is much sharper here; European countries for which this is not a strength are dominated by factors of 6.0 to 7.5 times in this field by the U.S.

—For all other fields the U.S. dominance is at least by a factor of 3; it is particularly striking for Field II (fundamental research in life sciences) where dominance is by a factor of 5 to second-place Japan, even though it is an area of relative Japanese strength. For Field IX (space and environmental sciences), the U.S. dominance is by a factor of 5.6 to second-place U.K. The U.S. dominance is not as strong in the health sciences (around a factor of 4).

—Japan is in second place in Fields I to V, the U.K. for Fields VI, IX, XI and XIII, France for Fields VIII, X and XII and Germany for Fields IV and VII.

Europe as compared to the United States and Japan. An aggregation of the relative scientific specialization indices of the U.K., Germany and France gives an idea of where Europe would stand⁹ as compared to the U.S. and Japan.

—Europe is dominant over Japan in all fields except Field V (electronics), where the shares are approximately equal. In Fields I to VII the dominance is moderate (a factor 3 to 4). In Fields VIII to XIII the dominance is stronger (factors greater than 5).

—Europe is never dominant over the U.S.; nevertheless, its scientific weight is similar to the U.S. in Fields III and IV (materials sciences), which are strategic research areas. It is also similar for Fields VII, VIII, X, XI and XII. On the contrary, the U.S. has dominance over Europe in Fields II, V, and VI (life sciences, electronics, information sciences) which are also strategic research areas, as well as in Field IX (space and environmental).

Summary of the results

Japan and Germany share a marked focus on all areas of strategic basic research. The only exception is biotechnology for Germany, but the German profile includes a focus on Field VII, which includes machine-tool automation and could also be labelled "strategic." Almost all other areas of science are below average for these two countries. (The exception is environmental and health sciences which are at average for Germany.)

The U.S. is focused on some of the strategic areas (biotechnology and computer science plus electronics) but below average on others (material sciences, chemistry). The U.S., however, is highly concentrated on environmental and space sciences, as well as health sciences and technologies.

France and the U.K. share a profile which shows little contrast among fields; furthermore the contrasts apparently have little to do with the concept of strategic basic research. On the contrary, France has no areas of strategic basic research above its average but three below; and the

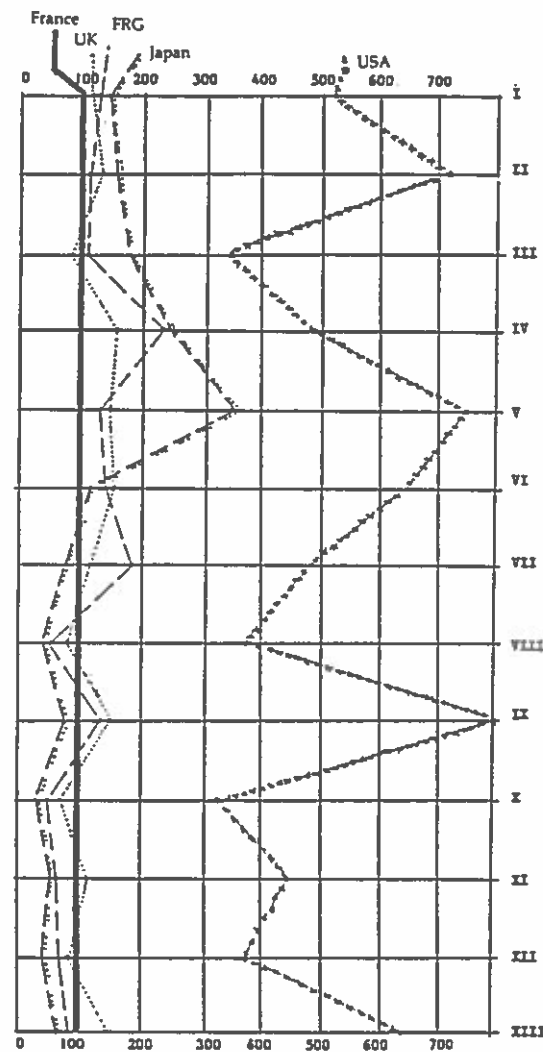


Figure 3. Absolute scientific weight of the five countries on the 13 macro-profile fields. By convention, the weight of France has been set at 100.

U.K. has only one above (computer science) and one below. The relative emphasis in both countries is in health sciences, as well as, for France, earth sciences and renewable resources.

The fields of relative strength for the U.S. are totally dominated by it (by a factor of 4 or more as compared to the next strongest country), with the exception of Field V (physics and technology of electronic components) where Japan is even more highly focused. In fields where the U.S. is not focused, while Japan and Germany are, dominance by the U.S. again is only by a factor of 2.0 to 2.5. This applies to several areas of strategic basic research.

Europe (as represented by its three major countries) has a scientific weight which is comparable to the U.S. in areas of strategic basic research such as materials sciences, chemistry, some aspects of electronics, machinery and machine tools. This holds true also for some aspects of the health sciences. In all fields European levels of effort are significantly above Japanese, sometimes by a wide margin

Table 3:
Absolute Scientific Weight of the Countries on the Macro-profile Fields

	Field	F	FRG	UK	USA	JPN
I	Theoretical physics and chemistry	109	118	116	518	128
II	Life sciences, basic research	100	103	121	722	146
III	Semiconductors; analytic and electro-chemistry; catalysis; condensed matter	100	101	96	349	177
IV	Materials science plus applied and organic chemistry	100	223	156	498	221
V	Physics and technology of electronic components, integrated circuits, "Group III-V" semiconductors, photomemistry	100	123	128	755	345
VI	Computer science and imaging technology	100	131	144	655	108
VII	Technology for pollution treatment, energy storage, civil engineering, plus machine tool research	100	192	116	489	83
VIII	Earth sciences	100	63	94	378	53
IX	Environmental sciences and space sciences	100	124	144	807	81
X	Renewable resources	100	61	84	310	35
XI	Agronomy, food production, biotechnology for agriculture	100	71	110	443	69
XII	Life sciences: health and drugs	100	74	93	376	45
XIII	Other applied life sciences	100	91	145	632	64
	Mean	100	100	100	100	100

(as in renewable resources, health, and earth sciences). The notable exception is electronics, where Japan and Europe are about equal.

Notes and References

1. For a more detailed definition of "strategic research" or "strategic basic research" see J. Irvine & B. Martin, *Foresight in science: picking the winners* (London: Frances Pinter, 1984), 1-13.

2. This leads to the concept of strategic management; see R. Barré, "Science and technology in France: from planning to strategy", *Futures*, April 1986, 298-308.

3. These indicators appear in *Science Indicators*, a biennial volume prepared for the National Science Board. The CHI-NSF data base, from which many of the bibliometric indicators in the volume are drawn, is prepared under contract at CHI, Inc.

4. This study was been done by R. Barré with J. P. Bordet from Applications Scientifiques Statistiques et Informatiques (ASSI) Company and D. Pelissier from Centre de Documentation Scientifique et Techniques (CDST) of the Centre National de la Recherche Scientifique (CNRS).

5. Law No. 85-1376, 23 December 1985, concerning research and technological development, Article 16.

6. In fact, the work was done with a total of 11 countries (the five already mentioned, plus Canada, The Netherlands, Sweden, Italy, India, and Australia); the clustering of the subfields discussed later in the article was done according to the profiles of those 11 countries and not on the five countries only.

7. These figures for world share of scientific articles per country are underestimates, since the articles which do not mention a country of origin (about 15%) are counted with "rest of the world." It is interesting to compare those figures with those published recently for 1982 by D. C. Smith, P. M. D. Collins, D. M. Hicks and S. Wyatt, "National performance in basic research," *Nature* 323 (1986), 681-684. They get the following results with the CHI-NSF data base: USA, 37.2%; UK, 8.3%; Japan, 7.3%; West Germany, 6.3%; France, 5.4%. It is to be noted first that the figures are comparable to those found with the PASCAL data base, and, second, that what could be interpreted as an overrepresentation of France in PASCAL has little importance for our study which deals with profiles and not with absolute levels (except in the last section).

8. The clustering was done with a hierarchical ascendant classification of the subfields using a CHI-square distance. The modifications of the clusters we introduced to ease interpretation are the following: 2 clusters have been split in two and one split in three; five subfields have been shifted from one cluster to another.

9. Germany, the U.K. and France together account for 80% of the total R&D spending of the 12 countries which belong to the European Economic Community.

Steven Shapin and Simon Schaffer. 1985. *Leviathan and the Air Pump: Hobbes, Boyle, and the Experimental Life*. Princeton: Princeton University Press. xiv + 440 pp.

Ever since Luther posted those reknowned theses on the church door, the problem of method has been central to all western thought. In this well-written, carefully researched volume, Shapin and Schaffer (S&S) recount one episode of fundamental importance in that still on-going debate. Moreover, in so doing, 1) they re-establish the importance of issues some have seen as long since settled; 2) they provide a model for doing research in the social studies of science that integrates the methods of history, philosophy, and sociology and; 3) they open huge new vistas for research and philosophical reflection. Indeed, this work is likely to be ranked with those of Bachelard (1935), and Kuhn (1962) as one that sets the agenda in the social study of science for years to come. Given the complexity of this volume, no review can do it justice. However, I shall try to touch upon several of the major themes.

S&S show that the experimental approach to science, now taken for granted as part of scientific practice, is subject to limitations not generally recognized by either practitioners or many in the social studies of science community. These limitations are underlined by the debate between Hobbes and Boyle over the role of experiments. S&S begin by asking what historical circumstances led to the general acceptance of the use of experiments as a systematic means for generating scientific knowledge. They assert that "Boyle's air-pump experiments were designed to provide (and have since provided) a heuristic model of how authentic scientific knowledge should be secured" (p.4).

Though Hobbes wrote at length on natural philosophy, since 1800 this aspect of his work has been largely ignored. Indeed, until its appearance as an appendix to this volume, a key essay had not even been translated from its original Latin into English. Thus, in concrete terms, the task that S&S set out for themselves is to take Hobbes' writings on natural philosophy as seriously as Boyle did—no mean feat indeed.

The dispute between Boyle and Hobbes took place in the 1660s and early 1670s, during and after the English civil war. Hence, the problem of social order, discussed at length in Hobbes' more well-known *Leviathan*, was not of interest for merely philosophical reasons. It was an attempt by Hobbes to undo the damage done by the war. Boyle, too, was concerned with the problem of order, but whereas Hobbes saw order emanating from a sovereign, Boyle saw it arising out of consensus. The dispute is revealed in all its detail in the air-pump experiments.

To Boyle the solution to the problem of order lay in conducting experiments. Experiments would provide clear,

concise knowledge of the facts as witnessed by a group of trained observers. These witnesses would arrive at consensus without the need for coercion. This seemed far less plausible in the 1660s than much of it does now. Indeed, at the time it appeared that free debate could only lead to further civil strife. The idea that it could actually help to resolve strife seemed at best far-fetched.

Moreover, "[E]xperimental practices were to rule out of court those problems that bred dispute and divisiveness among philosophers, and they were to substitute those questions that could generate matters of fact upon which philosophers might agree" (p. 46). Metaphysics and theology, seen by Boyle to be at the root of the dispute that led to the Civil War, were to be abandoned as fruitless. In short, Boyle's method "solved" the problems of knowledge and order by avoiding those issues not resolvable experimentally. And, at the same time, by insisting that only those properly trained could observe and accurately witness experiments, Boyle restricted the size and nature of the community within which consensus was to be achieved.

In contrast, Hobbes argued that true knowledge could never be derived from consensus. Order, in turn, could only be produced by settling the metaphysical problem and not by avoiding it. He took geometry as his model, arguing that geometrical knowledge was indisputable. The theorems of geometry were not subject to dispute as they were self-evident to all rational persons. Hobbes's epistemology emphasized the importance of starting with careful definitions and using reason to develop theorems. Hobbes also believed that one could only understand what one made; geometry was the paradigm case because both its definitions and its objects were created by human beings. In contrast, factual knowledge was always based on sensory impression and was, therefore, never privileged the way that reason was.

Furthermore, "Hobbes noted that all experiments carry with them a set of theoretical assumptions embedded in the actual construction and functioning of the apparatus and that, both in principle and in practice, those assumptions could always be challenged" (p. 112). As a test case, Hobbes challenged the physical integrity of the air-pump, arguing that there was no way to insure that it worked as Boyle described it. (Given the great difficulties under which Boyle labored, and the difficulty that others had in reproducing his results, this was no trivial point of contention.) Finally, Hobbes dismissed the testimony of "expert" witnesses by arguing that they were no more likely to avoid the errors of the senses than others.

The volume makes clear that this dispute influenced in many ways the formation of experimental and scientific practices that we now take for granted. For example, Boyle felt that short articles were more appropriate to experimental philosophy than were books, since his effort was

to discern the facts rather than to build a system. Similarly, Boyle felt it was necessary to describe in minute detail with the aid of drawings and charts the results of an experiment; only in this way could the reader become a "virtual witness." Moreover, Boyle insisted on distinguishing the language of interpretation from the language of observation, thereby attempting to accord greater ontological status to his facts.

Of particular interest is the catalogue of reasons why an experiment might fail according to Boyle. These included adulterated materials, natural diversity in the composition of materials, inept tradesmen misconstruing the instruments, and differences in scale. As S&S explain, "Thus Boyle proffered a set of factors that could be brought into play so that a given expectation or theory need not be invalidated by experimental failure" (p.185). In short, as Kuhn noted some years ago, no failed experiment could invalidate a theory.

S&S also provide us with a model for doing research in the social studies of science, integrating the methods of history, philosophy, and sociology. To accomplish this task, they argue that we must jettison the prejudices we have inherited from the 17th century; we must take an "anthropological" approach to the subject. Drawing explicitly upon Wittgenstein, S&S assert that we must examine our subject as a contest between (at least) two alternative language games, between two competing "forms of life." Moreover, unlike many studies of contemporary science that take a social constructionist stance, S&S are not content merely to show what happened in the laboratory; they insist on showing how the civil war, the religious disputes of the day, and the philosophical assumptions and assertions of the actors entered into the arguments over what one could conclude from the air-pump experiments.

Thus, they move between the Scylla of assuming that each encounter creates the world anew, and the Charybdis of assuming that the contents of each encounter are determined fully by historical circumstance. For S&S Hobbes and Boyle negotiate, persuade, even coerce in their efforts to convince their contemporaries, but they do so within the more or less clearly defined limits created by their circumstances. In addition, S&S clearly state and discuss the philosophical implications of the positions taken by Hobbes, Boyle, and their contemporaries (while maintaining an agnostic position themselves). In so doing they raise philosophical questions about the nature of knowledge and order that are as important today as they were in the seventeenth century. For example, the current debate over evolution and creationism echoes many of these concerns with few of the subtleties of which Hobbes and Boyle were aware.

This volume also sets a new agenda for research in the social study of science. By revealing the link between the problems of order and knowledge once again—as they were inextricably linked for both Hobbes and Boyle—they

create an exemplar for future studies. Their exemplar links micro and macro, theoretical and empirical, cognitive and behavioral, philosophical and historical. Kuhn and Bachelard, in their own ways, opened the doors to the social study of science. Yet, both remained concerned more with the dynamics of relations amongst scientists than with science's connections with the larger social world. Neither treated scientific knowledge claims in the way that other knowledge claims are usually treated: as inherently political statements. Rather than attempting to show how politics impinges upon the pursuit of science, they reverse the problem. As they put it, "The language that transports politics outside of science is precisely what we need to understand and explain" (p. 342). This should provide members of the social studies of science community with interesting theoretical and empirical problems for some time to come.

Other themes are also discussed in the volume but cannot be dealt with adequately here. We find out that the pump as an artefact took about a decade to become a standardized mechanical technology. We learn how this mechanical technology was linked to what S&S call "literary" and "social" technologies. We find that the air-pump was the "Big Science" instrument of its day, requiring the funding of the Royal Society, and probably a crew of "technicians" to keep it in working order. We are reminded that Boyle and his contemporaries were not only interested in the esoteric but also in the resolution of the issues of the day including the creation of better, more accurate artillery, and the explanation of fever. And we are confronted with the enormous perception-enhancing power that the creation of scientific instruments made possible (viz., Idhe, 1979).

Ultimately, as we all know, the experimentalists won the debate and Hobbes's natural philosophy lapsed into obscurity. Until recently, experimental methods have been so taken for granted that no one would have questioned them. We are indebted to S&S not only for investigating and once again making problematic the origins of "the experimental life" but for providing us with a volume that is at once eloquent, incisive, and finely detailed. Even at the rather high—indeed, outrageous—price of \$60.00, this is a volume that those interested in the social study of science cannot afford to miss.

To summarize, I can do no better than to quote S&S: "The establishment of a set of acceptable matters of fact about pneumatics required the establishment and definition of a community of experimenters who worked with shared social conventions: that is to say, the effective solution to the problem of knowledge was predicated upon a solution to the problem of social order" (p. 282). S&S have admirably shown us just how true this is—and much more as well.

Reviewed by Lawrence Busch
University of Kentucky

The President's Page **An Exciting Time to Be Alive!**

Things seem to be moving so fast that I have no guarantee that anything I write now will be relevant by the time you read it. But let's try to summarize some of the events and developments since the Pittsburgh Meeting:—

1. We were all very sorry to hear of Nick Mullins' illness and surgery, and wish him a speedy recovery. And we look forward to his cheerful presence at Worcester: Society meetings would not be the same without it.

2. We welcome Mary Frank Fox, Ron Johnston, and Helga Nowotny to the Council, and look forward to the roles they will play in the Society's affairs in the next three years. And we congratulate them—and Arie Rip, who is our (first) President-Elect. We wish him a happy and fruitful term of office.

3. Discontent in certain quarters over the local arrangements at Pittsburgh seemed to have put the future of such four-society meetings in some doubt. The SHOT Council firmly *rejected* any regular commitment, and also threw out a proposal for a four-society standing liaison committee. But PSA and HSS are interested in another joint meeting in 1990, and are also supporting the proposed committee. Since the 4S Council are of the same mind, moves are afoot for 1990. Seattle has been proposed as the venue, and "late October" as the date. Any comments?

4. Susan Cozzens has offered to assemble an "archive" of the Pittsburgh Meeting, so that the experience is not lost by 1990, and organizational mistakes are not repeated. Anyone who has anything (memories and views, as well as documents) that could usefully go into that record should contact her.

5. There was concern among the Council at Pittsburgh over our falling membership. There is no evidence that the new membership dues are to blame. A small group is now considering tactics, and will welcome suggestions. A publicity flyer is being drafted, and help will be required in distributing it as widely as possible. The Liaison Committee will have a crucial role. It has been suggested that we institute an "introductory membership fee" for rookies—say, \$20, with \$10 for students.

6. Obviously, arrangements for the Worcester Meeting (19-22 November) are now well in hand. John Wilkes is taking several exciting initiatives, including a Student Project Competition and a Lecture Series which will culminate in Evelyn Fox Keller's Keynote Address to 4S: he is

now actively seeking funding for these ideas, and we wish him well! It promises to be an innovative (and, I hope, not *too* exhausting) Meeting.

7. The 1988 Joint Meeting with EASST will take place in Amsterdam, on 17-20 November (i.e., the weekend before Thanksgiving). A convenient downtown hotel location has been booked, and arrangements are well in hand. As to 1989: anyone for Chicago? Ron Johnston (Wollongong, NSW) is Chair of our Future Meetings, and bids should be sent to him.

8. The 1986 Bernal Prize Committee are to be congratulated on the successful outcome of their labors. And now to the 1987 nomination. It seems to me that, so far, the historians and sociologists have had a good innings. How about a nomination now from our more "policy-oriented" members? I will be happy to receive suggestions.

9. We were all sorry to hear that pressures of work had forced Daryl Chubin to resign as Co-Editor of *S&TS*. We thank him most warmly for his heroic labors on behalf of the Society: the image and standard of the journal owe a very great deal to his distinctive input. Meanwhile, Susan Cozzens will edit *S&TS* singlehanded: she has our full support—and, too, our grateful thanks for a tough job well done. Any 4S members wishing to be involved actively in our publications should contact me, Susan, or Tom Gieryn.

10. Exciting developments are possible over the journal. When Marcel LaFollette announced her resignation as Editor of *Science, Technology, & Human Values*, we expressed immediate interest in acquiring the title, and merging *STHV* with *S&TS*. Negotiations are, as they say, proceeding, and what will emerge is as yet unclear. Meanwhile, since whatever arrangement transpires will involve publication delays, the idea of a separate *4S Newsletter* to carry the Society's business (as is done in PSA, HSS, and SHOT) has surfaced. This, of course, has financial (and other) implications: much depends on the terms of any deal with Wiley. All this will be on the agenda at Worcester, and I hope that you will all come to play your part in our decisions.

11. Another potentially exciting development is the emergence, under the leadership of Rustum Roy (Penn State), from the by now well established "Technological Literacy" Conferences (TLCs), of a new "STS Society" (or some such name, as yet undecided). Its constituency will lie primarily in the two-year colleges and high schools, and

its main aim will be "educational outreach"—especially in technical education. It looks as if 4S and STS should be essentially *complementary* Societies. Many of those involved in the STS initiative will be in Worcester for the Conference that John Wilkes is organizing to precede, and partly overlap, our 4S Meeting, so we hope that some consultations will take place there. And, again, discussion of this development and its implications will be on our own agenda at Worcester.

Is that all? Well, not really . . . But it's plenty to be getting on with. At least it should be clear that we will have a lot to discuss at Worcester. Meanwhile, please send me your comments on all these items, and any suggestions for the Society's future role. My call code on JANET is EASS02@UK.AC.ED.EMAS-A.

David Edge

Registration information for the 4S Meetings in Worcester, Massachusetts, November 19-22, 1987, will appear in the summer issue of *Science and Technology Studies*.

Call for Future Meeting Proposals

Volunteers are needed to present proposals for future meeting spots for 4S; 1989 is not so far away. For further information, contact Ron Johnston at the Centre for Technology and Social Change, University of Wollongong, P.O. Box 1144, Wollongong, NSW 2500, Australia. 042-270639.

Special Events in conjunction with the Annual 4S Meeting

Conference on the State of S.T.S. programs

Just prior to the 4S meeting in Worcester, Mass. at the Hotel Marriott November 19-22, Worcester Polytechnic Institute will be sponsoring a conference on the state of Science, Technology and Society Studies in North America, Europe, and Australia.

This conference will begin early on November 18 and end at the time of the joint 4S-S.T.S. banquet, November 20th. The 4S meeting will start the evening of the 19th, and no competing events are scheduled for that night, so the meetings will overlap only on the 20th. It is hoped that those coming to represent their programs at the S.T.S. conference will stay on for the 4S meeting. Those 4S members interested in coming early are advised that there will be a separate registration, but that the combined registration fee will be about \$75.00 for both conferences and a room rate of \$69.00/night has been negotiated with the headquarters hotels. Other cheaper accommodations in the area also been located for those who request them early.

The theme of the S.T.S. conference will be to share the experiences of the various academic S.T.S. programs regarding their accommodation to various academic environments, founding motivations and experience in fostering the educational side of the field. The first part of each day will be devoted to program case studies offered by attending representatives. The second part of each day will be devoted to discussion of common issues ranging from start-up problems and curricular issues to program mission career lines for graduates. Preliminary results from the S.T.S. program survey that will be used to select speakers should also be available to stimulate discussion.

Student Competition and Conference in S.T.S.

November 21-22 the winners of an international projects competition of S.T.S. studies at the undergraduate level will be invited to come and present papers based on their work. 4S members are asked to bring the event to the attention of their most promising students. The 4S and the WPI chapter of Student Pugwash are co-sponsoring the competition. Student Pugwash will solicit entries and convene a local screening panel to identify 20 semifinalists. WPI will organize the event and put up a \$500.00 prize. The 4S will convene a final review panel to identify the finalists and select the 3 top prize winners, as well as offer a second \$500.00 top prize. Intention to submit paper must reach Peter Johnson, c/o Dept. of Social Science and Policy Studies, Worcester Polytechnic Institute by September 10, 1987 with all 3-5 page abstracts in hand by Oct. 10, 1987. Semi-finalists will be notified by November 1, 1987 and awards will be made at the time of the 4S meeting on November 21, 1987. Contact Peter Johnson for entry details.

Election Results

Officers of the Society

PRESIDENT: David Edge (term expires November 1987)

PRESIDENT-ELECT: Arie Rip (assumes Presidency November 1987, to serve through November 1989)

COUNCIL:

Term Expires November 1987

Ruth Cowan
Bruno Latour
Steven Shapin

Term Expires November 1988

Susan E. Cozzens
Ronald Giere
Rachel Laudan

Term Expires November 1989

Mary Frank Fox
Ron Johnston
Helga Nowotny

The four revisions of the 4S Charter were approved. A revised copy of the Charter is available upon request from: Thomas F. Gieryn, 4S Secretariat, Department of Sociology, Indiana University, Bloomington, IN 47405 USA.

Treasurer's Annual Report

*Status of the 4S Treasury
December 31, 1986*

OLD BALANCE	December 31, 1985	\$10,162.01
INCOME	Conference Fees (Troy 1985)	391.00
	Membership Dues	8,986.00
	Interest	367.91
	Bernal Prize 1986 (Gift)	500.00
	TOTAL INCOME	10,244.91
EXPENSES	PUBLICATIONS (<i>Science & Technology Studies</i>)	6,075.63
	Academic Services, Inc. (Subscription Mgt.)	874.87
	1985 Bernal Prize	500.00
	Establishment of Bloomington Secretariat	150.00
	Telephone	47.52
	Program Committee Expenses (Pittsburgh 1986)	72.82
	Withheld Taxes	60.06
	Voided Checks	53.55
	Sign	20.69
	Bernal Plaque 1986	44.70
	1986 Bernal Prize	500.00
	Postage	14.32
	Photoreproduction	178.56
	Presidential Expenses	152.97
	Supplies and Equipment	15.00
	TOTAL EXPENSES	8,760.69
NEW BALANCE	December 31, 1986	\$11,646.23

I read with interest your discussion of the issue of referee identification, and applaud your decision to list "Endorsing Referees" for papers published in *Science & Technology Studies*. I am somewhat troubled, however, that your discussion is largely limited to *accepted* papers. The issue of referee anonymity is both more problematic and more important in the case of *rejected* papers. The same arguments for open reviewing that you (and Stephen Lock) cite apply to such papers, but open reviews also probably would make the editorial process a lot more acrimonious and difficult for editors. . . . It is *not* self-evident that knowing the identity of the specific reviewers would be helpful, but authors might be in a better position to respond to biased, self-serving, or technically incompetent reviewers. I hope that you will discuss these issues, and will clarify your policy for rejected papers on a future Editor's Page. In any case, I agree that you have made the review process somewhat more open, and thank you for this first step.

James M. Richards, Jr.
University of Alabama in Birmingham

Response: When a paper is either accepted or rejected from *S&TS*, the reviews are sent, anonymously but verbatim, to both author and reviewers. An author whose work has been rejected then has a chance to respond; and in practice, I often ask for a response before making the accept/reject decision. If reviewer identities were known at this point, I suspect that the response might tend to veer away from substance and into personal factors—clearly not a productive direction when the goal is to improve overall standards of research and writing in the field through constructive criticism and quality control. Double-blind reviewing (with both author and reviewer identity withheld) holds the highest promise for focusing the review process on substance; let me remind contributors that they have the option of submitting their articles in "blind" form.—SEC

4S Electronic Mail

The 4S has been awarded twenty five accounts on an electronic mail system based in New Jersey. This system is called EIES (Electronic Information Exchange Service). This system offers the ability to send electronic mail to other users and to post messages in an electronic conference area. If you would be interested in having one of the accounts, please write with answers to the following questions: What would be your likely level of use (daily, weekly)? What be your primary use of the system? Would you use it to communicate with other 4S members or to familiarize yourself with this new medium? Would you have any secondary purposes of the system? How many other users would you need to have on line to fulfill your purposes? Would your organization be likely to pay for your account when the free accounts are no longer available? If you are interested in using the system, contact Brian Winter, c/o John Wilkes at Social Science and Policy Studies, Worcester Polytechnic Institute, Worcester, MA 01609, USA.

Call for Papers

Special Issue on the Political Economy of Sociology, of the *American Sociologist*. The editors are seeking papers that examine the political economy of sociological research. In general terms, how does the resource base of sociology, both academic and non-academic, affect the developments in the discipline and the profession? The resource base may be interpreted broadly to include governmental, private foundation, and corporate support for research, university support, consulting, and writing for commercial publication. These topics are suggestive; authors may wish to consult with the editors about the suitability of other topics. Deadline for receiving manuscripts is 15 July 1987. Contact: James L. McCartney, Department of Sociology, University of Missouri, Columbia, Missouri 65211, USA. 314-882-3542.

New Programs

Science and Technology Studies at Virginia Tech. The Virginia Tech graduate program in Science and Technology Studies (STS) offers an interdisciplinary perspective on science and its social impact. The program is primarily supported by the Center for the Study of Science in Society and the Departments of History, Philosophy, and Sociology. Faculty members drawn from—but not limited to—these units offer opportunities for interdisciplinary studies in a wide range of areas of science and technology studies. Current areas of faculty research interest include (1) scientific change, (2) technological change, (3) foundations of biology, (4) key periods in the history of science, and (5) 20th century science and technology. For information on both the M.S. and the Ph.D. programs, contact the Director, Science and Technology Studies, Price House, Virginia Tech, Blacksburg, VA 24061, USA.

Organizing effort

Petitions are circulating to form a section of the American Sociological Association on Science and Technology. An organizational meeting will be held at the ASA meetings in August, on Tuesday morning August 18. Cooperation with the ASA Section on Environmental Sociology is under discussion. For further information, contact Susan Cozzens, Department of Social Sciences, Illinois Institute of Technology, Chicago, Illinois 60616, USA. 312-567-5134.

Projects

The National Science Foundation has recently completed a survey of grant recipients to evaluate *how well NSF's proposal review procedures are working*. A 43-item questionnaire was mailed to all 14,282 individuals whose proposals for research support were awarded or declined by NSF in FY1985. The questionnaire dealt with a variety of subjects, including applicant characteristics; field; professional experience; proposal process; followup activities; and overall satisfaction with the proposal handling and review process. For more information on survey and results, contact James McCullough, Program Evaluation Staff, National Science Foundation, Washington, DC 20550, USA.

The American Institute of Ultrasound in Medicine (AIUM) and the World Federation for Ultrasound in Medicine and Biology (WFUMB) are in the process of preparing a *history of medical diagnostic ultrasound*. An extensive archives file has been collected along with preliminary information required to prepare a formal history of the field. The goal of the project is to review and archive the historical material in the AIUM central office in Washington, DC, and prepare a complete manuscript by fall, 1988, so that it can be presented at a two-day seminar on the history of ultrasound which will be attended by pioneers in the field from around the world. For more information contact Barry B. Goldberg, M.D., Ultrasound Archives Committee, Division of Diagnostic Ultrasound, Thomas Jefferson University Hospital, 11th and Walnut Streets, Philadelphia, PA 19107. 215-928-8534.

Positions available

The American Association for the Advancement of Science is looking for a Senior Program Associate in its Office of Scientific Freedom and Responsibility. Contact Carolyn Bell, Personnel Office, AAAS, 1333 H Street NW, Washington, DC 20005.

The American Institute of Ultrasound in Medicine has a full-time position open on the project described in the last section. Contact Barry B. Goldberg, M.D., Ultrasound Archives Committee, Division of Diagnostic Ultrasound, Thomas Jefferson University Hospital, 11th and Walnut Streets, Philadelphia, PA 19107. 215-928-8534.

Collaborators sought

Collaborators are invited to join a small British-American *ad hoc* group come together to produce a "Reader's Guide" to Abraham Rees' *Cyclopaedia*. Because the *Cyclopaedia* is so inclusive, collaborators from many fields,

including all the humanities, the sciences, medicine, the arts and technology can be accommodated in areas coinciding with their scholarly interests. For further details, please write to either Mr. R. J. Law, c/o The Newcomen Society, The Science Museum, South Kensington, London SW7 2DD UK, or Prof. J. Z. Fuller, Department of History, Dulles Hall, Ohio State University, Columbus OH 43210.

Funding Opportunities

Grants-in-aid for History of Modern Physics and Allied Sciences. The Center for the History of Physics of the American Institute of Physics has a program of small grants-in-aid for research in the history of 19th and 20th century physics and allied sciences (such as astronomy, geophysics, and optics) and their social interactions. Grants will be for a maximum of \$1000 each and can be used only to reimburse direct expenses connected with work in these fields. Preference will be given to those who need part of the funds for travel to use the resources of the Center's Niels Bohr Library in New York City, or to microfilm papers or to tape record oral history interviews with a copy deposited in the Library, but other projects will also be considered. Applicants should either be working toward a graduate degree in the history of science, or show a record of publication in the field. To apply, send a vitae; a letter of no more than two pages describing you: research project; and a brief budget showing the expenses for which support is requested. Send to Spencer Weart, Center for History of Physics, American Institute of Physics, 335 East 45th Street, New York, NY 10017. Deadlines for receipt of applications are June 30 and December 31 of each year.

The NASA History Office invites proposals from qualified historians to research and write a book-length history of NASA's *Johnson Space Center*. To qualify, proposers should have a Ph.D. in history and successful research and publication experience. Proposals should be submitted no later than 1 September 1987 to Dr. Sylvia Fries, LHB/History Office, NASA, Washington, DC 20546. 202-453-8300.

The John D. and Catherine T. MacArthur Foundation announces grants for *Research and Writing in International Peace and Security*. The grants are intended for individuals or small collaborative groups. Through them the Foundation seeks to broaden and strengthen research on issues of international peace and security. As part of this effort the Foundation believes that researchers in disciplines not traditionally associated with peace and security studies should be encouraged to address issues in the field. Younger women and men are especially encouraged to apply. The typical grant will be one year to eighteen months in duration, from \$10 to \$60 thousand for a single

applicant or up to \$100 thousand for a team project. For more information, write Grants for Research and Writing in International Peace and Security, The John D. and Catherine T. MacArthur Foundation, 140 South Dearborn Street, Suite 700, Chicago, Illinois 60603 USA.

National Science Foundation Ethics and Values Studies Program (EVS). Next target date for submitting preliminary proposals is 1 November 1987. EVS supports research and related activities examining ethical or value aspects of current research or practice in United States science or engineering. The Foundation is particularly interested in studies or issues associated with the kinds of research and educational projects it supports. Further information is available in NSF announcement 86-48. Send preliminary proposals to Rachelle Hollander, Ethics and Values Studies, National Science Foundation, 1800 G Street, NW, Washington, DC 20550, USA. 202-357-9894.

National Endowment for the Humanities. Program in Humanities, Science, and Technology. Grants support important, original research in all fields of the humanities, in collaborative or coordinated research projects of up to three years in duration. The Program supports research that employs the theories and methods of humanities disciplines to study science and technology. Application deadline: 1 October 1987. For information, contact the National Endowment for the Humanities, Room 318, Washington, DC 20506. 202-786-0210.

Publications

Science as Culture is a new quarterly journal on science, technology, and medicine, broadly defined, as they relate to the rest of life. This includes all forms of expertise as they emerge from culture; as they influence culture; and as cultural experiences in their own right. It aims to provide accessible, clear, reflective essays. A pilot issue will soon be published as part of the Radical Science series. It is to be edited by Robert M. Young and published by Free Association Books, 26 Freegrove Road, London N7 9RQ, England, UK. Subscription rates are £20/\$35 for individuals and £35/\$55 for institutions.

Robert K. Merton. An Intellectual Profile. By Piotr Sztompka. The profile covers Merton's social theory, the method of functional and structural analysis, as well as the sociology of science. On the basis of a thorough analysis of Merton's voluminous work, including material from Merton's personal files, Sztompka argues—contrary to some earlier commentators—that there is a coherent and specific system of social theory and sociological methodology emerging from the multiple and disparate contributions produced by Merton over the last fifty years.

Available from St. Martin's Press, 175 Fifth Avenue, New York, NY 10010, USA.

The Machine in the University. Sample Course Syllabi for the History of Technology and Technology Studies. Compiled and edited by Terry S. Reynolds and the Technology Studies and Education Committee of the Society for the History of Technology in cooperation with the Science, Technology and Society Programs of Michigan Technological University and Lehigh University. This 243-page booklet includes 23 sample course syllabi typifying the broad range of courses taught in the field of the history of technology and technology studies. The syllabi are divided into two major sections: I. Technology in History and II. Technology in the Contemporary World. The first category includes courses dealing primarily with the history of technology; the second, courses dealing largely with contemporary issues relating to technology. Section II includes courses that introduce students to the area of Science and Technology Studies, courses designed to provide "technology literacy" for liberal arts students, and topical courses focusing on specific themes in modern technology. The collection is \$7.95. Inquiries should be directed to Dr. Stephen H. Cutcliffe, Science, Technology and Society Program, 327 Maginnes Hall #9, Bethlehem, PA 18015, USA. 215-758-3350.

Shifting Gears. Technology, Literature, Culture in Modernist America. By Cecelia Tichi. This book is a richly-illustrated exploration of the American era of gear-and-girder technology. From the 1980s to the 1920s machines and structures shaped by this technology emerged in many forms, from automobiles and harvesting machines to bridges and skyscrapers. Cecilia Tichi argues that gear-and-girder technology redefined the human role in relation to nature by fostering a perception of the material world as a complex of component-part constructions. Cloth \$31.50, paper \$13.46. For further information contact Customer Service Department, University of North Carolina Press, Post Office Box 2288, Chapel Hill, North Carolina 27514, USA.

Education and Careers in Science, Engineering, and Public Policy. A report from the American Association for the Advancement of Science. \$10. Available from AAAS Office of Public Sales, 1333 H Street NW, Washington, DC 20005.

Health Professionals and Human Rights in the Philippines. A report from the Committee on Scientific Freedom and Responsibility of the American Association for the Advancement of Science. It examines the role Filipino physicians and health workers have played in protecting basic health and human rights and providing medical and psychiatric care to victims of abuse. It also describes efforts to apply scientific techniques in the medicolegal investiga-

tion of the "disappeared." Copies are available from the Committee at 1333 H Street NW, Washington, DC 20005.

Biology and Bureaucracy. Public Administration and Public Policy from the Perspective of Evolutionary, Genetic, and Neurobiological Theory. Edited by Elliott White and Joseph Losco. This compilation of essays explores the biological dimension underlying public administration. The book is divided into three parts: a short introductory examination of current trends within the field of public administration and public policy; an analysis of the application of evolutionary and neurobiological theory to the study of public administration; and those issues of public policy that have become increasingly affected by an emerging biotechnology. \$32.75 cloth. Available from the University Press of America, 4720 Boston Way, Lanham, MD 20706, USA.

Sociology of Science, special issue of *Philosophy & Social Action*. Edited by Janos Farkas. For information, contact Mrs. Nirmala Sharma, Managing Editor, *Philosophy & Social Action*, M-120 Greater Kailash-I, New Delhi 110 048 India. 641-5365.

The Indian Atom. Power & Proliferation. A Documentary History of Nuclear Policies, Development & The Critics: 1958-1986. Edited by Dharendra Sharma. This book examines nuclear arguments for India's energy policy. It gives a brief history of the anti-nuclear movement in India and confirms the inter-relation of the "peaceful" atom and nuclear weapons. It focuses on social and political consequences of nuclear policy for a developing society. Rs. 75.00, £9.95, \$15.00 cloth. Order from Mrs. Nirmala Sharma, Managing Editor, *Philosophy & Social Action*, M-120 Greater Kailash-I, New Delhi 110 048 India. 641-5365.

Modelling the World. The Social Construction of Systems Analysts. By Brian P. Bloomfield. This book maps the development of the theory known as "systems dynamics"—the idea that we live in a network of social systems, that the nature of these systems determines many of the world's problems, and that "models" of these systems can be computer-generated to allow a degree of predictability in such systems. Bloomfield examines the historical and personal factors behind different systems analyses. £25.00. Further information available from The Publicity Department, Basil Blackwell, 108 Cowley Road, Oxford OX4 1JF UK. 0865-724041.

Meetings

Science in Public. An International Colloquium. 11-18 July 1987. Oxford, England. Co-sponsored by the Oxford Science Studies Summer Seminar and the Science Policy Support Group. The colloquium will bring together public

opinion researchers, media analysts, social psychologists, sociologists of science, and others who are currently employing a wide variety of approaches to the problem of the relationship between science and the public. For information contact Dr. J. R. Durant, Department for External Studies, Rewley House, 1 Wellington Square, Oxford OX1 2JA, UK.

University of Surrey Conference on the History of Technology. 3-5 August 1987. The purpose of the conference is to bring together people of different disciplines and backgrounds who share an interest in the history of technology and its significance today. Synopses of papers have been received in the following areas: the relationship between science and technology; milestones in the development of transport; technological development in medicine; ethical and social considerations in technological development. For information contact Patricia Smart, Department of Educational Studies, or Edward Wilson, Department of Mechanical Engineering, University of Surrey, Guildford, Surrey GU2 5XH, UK.

Twentieth Annual Conference of the Australian Association for the History, Philosophy, and Social Studies of Science. 23-25 August 1987. Brisbane, Australia. Offers of papers are welcome in all areas covered by the Association. Inquiries should be addressed to Prof. Ian Lowe, School of Science, or Dr. Richard Yeo, School of Humanities, Griffith University, Nathan, Qld 4111, Australia.

The Birth of Modern British Medicine, c1760 to c1840. 16-18 September 1987. Sponsored by the Royal Institution Centre for the History of Science and Technology. The theme is the new relationship of medicine to science and to institutions. Offers of papers to Roger French, Wellcome Unit for the History of Medicine, Free School Lane, Cambridge CB2 3RH, UK. Other inquiries to Frank James, RICHST, Royal Institution, 21 Albemarle Street, London W1X 4BS, England, UK.

International Conference on the Philosophy of Science and Science Policy. 14-19 January 1988. New Delhi. Broad themes in the technical program include: philosophies of science; methods of science; values of science; nature of technology; science and its social responsibility implications; science policy. For further details write to Prof. A. Nityagopal, Secretary-General, International Conference on the Philosophy of Science and Science Policy, Centre for Philosophy of Science, 10-3-161, East Nehrunagar, Secunderabad-500 026 (A.P.) India.

MEETINGS CALENDAR

10-13 June 1987. Brunswick, Maine. Nineteenth annual meeting of Cheiron: the International Society for the History of the Behavioral and Social Sciences. Contact Alfred Fuchs, Dean of the Faculty, Bowdoin College, Brunswick, ME 04011, USA.

16-20 June 1987. Blacksburg, Virginia. Summer Conference on History, Philosophy, and Social Studies of Biology. Contact Richard M. Burian, 1987 Summer Conference, Department of Philosophy, VPISU, Blacksburg, VA 24061, USA.

28 June-4 July 1987. Stanford, California. Fifth Biennial Student Pugwash USA International Conference. For applications or information contact Benjamin Austin, Conference Director, Student Pugwash USA, 505-B Second Street NE, Washington, DC 20002, USA.

11-18 July 1987. Oxford, England. Science in Public: An International Colloquium. Contact Dr. J. R. Durant, Department for External Studies, Rewley House, 1 Wellington Square, Oxford OX1 2JA, UK. (See announcement in this issue.)

3-5 August 1987. Guildford, Surrey. University of Surrey Conference on the History of Technology. Contact Patricia Smart, Department of Educational Studies, or Edward Wilson, Department of Mechanical Engineering, University of Surrey, Guildford, Surrey GU2 5XH, UK. (See announcement in this issue.)

17-21 August 1987. Chicago, Illinois. Annual Meeting of the American Sociological Association. Organizing meeting for a Section on Science and Technology, Tuesday 18 August. Contact Susan Cozzens, Department of Social Sciences, Illinois Institute of Technology, Chicago, Illinois 60616, USA. 312-567-5134. (See announcement in this issue.)

23-25 August 1987. Brisbane, Australia. Twentieth Annual Conference of the Australian Association for the History, Philosophy, and Social Studies of Science. Contact Prof. Ian Lowe, School of Science, or Dr. Richard Yeo, School of Humanities, Griffith University, Nathan, Q1d 4111, Australia. (See announcement in this issue.)

24-28 August 1987. Diepenbeek, Belgium. Conference on bibliometrics and theoretical aspects of information retrieval. Contact Limburgs Universitair Centrum, Algemeen Secretariat, International Conference, Universitaire Campus, B-3610 Diepenbeek, Belgium.

16-18 September 1987. The Birth of Modern British Medicine, c1760 to c1840. Contact Frank James, RICHST, Royal Institution, 21 Albemarle Street, London W1X 4BS, England, UK. (See announcement in this issue.)

29 October-1 November 1987. Raleigh, North Carolina. Joint Meeting of the Society for the History of Technology and the History of Science Society.

19-22 November 1987. Worcester, Massachusetts. Twelfth Annual Meeting of the Society for Social Studies of Science. Contact John Wilkes, Local Arrangements, Department of Social Sciences and Policy, Worcester Polytechnic Institute, Worcester, MA. (Registration materials will appear in *S&TS* over the summer.)

12-13 December 1987. Amsterdam, The Netherlands. Workshop on the Relations between Qualitative Theory and Scientometric Methods in S&T Studies. Contact Loet Leydesdorff, Wetenschapsdynamica, Universiteit van Amsterdam, Nieuwe Achtergracht 166, 1018 WV Amsterdam, The Netherlands.

14-19 January 1988. New Delhi, India. International Conference on the Philosophy of Science and Science Policy. Contact Prof. A. Nityagopal, Centre for Philosophy of Science, 10-3-161, East Nehrunagar, Secunderabad-500 026 (A.P.) India. (See announcement in this issue.)

11-16 February 1988. AAAS Annual Meeting. For information on 4S sessions contact Ned Woodhouse, Department of Science and Technology Studies, Rensselaer Polytechnic Institute, Troy, New York 12180-3590, USA.

11-15 July 1988. Manchester, England. Joint Meeting of the British Society for the History of Science and the History of Science Society (USA). Program suggestions should be sent to: Ronald L. Numbers, Department of the History of Medicine, University of Wisconsin, 1300 University Avenue, Madison, WI 53706 or John Pickstone, Department of Science & Technology Policy, The University, Manchester, M13 9PL, UK.

1-9 August 1989. Hamburg and Munich, Federal Republic of Germany. XVIIIth International Congress of the History of Science. General theme: Science and Political Order. Information available from Prof. Christoph J. Scriba, Institut für Geschichte der Naturwissenschaften, Bundesstr. 55, D-2000 Hamburg 13, F. R. of Germany.

Science & Technology Studies welcomes information about forthcoming events of interest to its readership. Deadline for submission of news for the Summer 1987 issue is 1 July 1987.

Information for Contributors

Science & Technology Studies is a multidisciplinary journal which publishes research, commentary, and reviews. As the official journal of the Society for Social Studies of Science, it seeks to foster exchange and communication among a variety of individuals and groups concerned with the development and dynamics of science and technology, including their relationships with politics and society.

Contributors are urged not to be constrained by the format of traditional scholarly research articles in their submissions. Contributions may also take one of the following forms: letter to the editors, commentary on a published article, opinion column, or synthetic review essay.

Contributors should submit three copies of their manuscripts, double spaced throughout including footnotes. Two review processes are available: blind and open. If a blind review is desired, all indications of the author(s) should be removed on three of the copies. If open review is desired, the author's identity will be disclosed to the reviewers.

Contributions will be reviewed for interest to a multidisciplinary audience concerned with science and technology, for communication with that audience, and for quality of data and dependability of information. Verbatim comments of all reviewers will be forwarded to authors. If publication is approved, the names of the endorsing referees may be appended to the article when it appears.

In deference to the many disciplinary writing styles represented in the Society, our referencing policy is pluralistic.

References alone, references plus end notes, or end notes alone may be used. In format, the journal follows the *Chicago Manual of Style*. In end note style, examples are:

Jarlath Ronayne, *Science in Government* (London: Edward Arnold, 1984).

Richard S. Westfall, "Science and Patronage: Galileo and the Telescope," *Isis* 76 (1985): 11-30.

Paul Forman, "Weimar Culture, Causality and Quantum Theory, 1918-1927," in *Historical Studies in the Physical Sciences*, ed. R. McCormach, Vol. 3 (Philadelphia: University of Pennsylvania Press, 1971), 1-115.

In reference style, examples are:

Latour, Bruno and Steve Woolgar. *Laboratory Life: The Social Construction of Scientific Facts*. Beverly Hills: Sage, 1979.

Roll-Hansen, Nils. "The Death of Spontaneous Generation and the Birth of the Gene: Two Case Studies of Relativism." *Social Studies of Science* 13 (1983): 481-519.

MacKenzie, D. and B. Barnes. "Scientific Judgement: The Biometry-Mendelism Controversy." In *Natural Order*, edited by B. Barnes and S. Shapin, 191-210. Beverly Hills: Sage, 1979.

Submission of accepted articles on diskette is encouraged, but not required. If you plan to use a word-processor to produce your manuscript, please contact the editor about the prospect of providing your copy on diskette.

Manuscripts should be submitted to:

Susan E. Cozzens
Department of Social Sciences
Illinois Institute of Technology
Chicago, Illinois 60616

Farewell, Daryl

Some people pass through institutions and leave them untouched. Not so with Daryl Chubin and *Science & Technology Studies*. Without Daryl, *S&TS* would not be the journal it is today. *S&TS* not only bears Daryl's mark in editorial direction; it also bears it physically. Whenever you see the name of an endorsing referee in *S&TS*, think of Daryl. Whenever you see the *&* in the journal's name, think of Daryl, too. Thank you for your creativity, style, and audacity, Daryl, as well as for all the hard work. Best wishes in your new career.

SEC

Science & Technology Studies
Department of Social Sciences
Lewis College of Sciences and Letters
Illinois Institute of Technology
Chicago, Illinois 60616

NON-PROFIT ORG. US POSTAGE PAID CHICAGO ILLINOIS 60616 PERMIT NO. 936
--

26960-ST51-8712
STEPHEN ZEHR
DEPT OF SOCIOLOGY
INDIANA UNIV
BLOOMINGTON, IN 47405