shows that the development of the steam press in the first decade of the 19th century transformed the production of newspapers and periodicals and made possible their diffusion at a very low price, thus making information accessible to the masses. Newsworthy scientific information changed the rules of the diffusion and validation of knowledge. Secord's detailed analysis of the evolution of the controversy and of the fate of the acari, the insect allegedly created by Crosse, is not without similarity with the recent cold fusion affair, and reminds us that newspapers can become important actors in scientific debates.

Political actors can also play a role in fixing the use of experiments. As John Krige shows in his paper on the negotiations surrounding Britain's decision to join CERN (the European Organization for Nuclear Research), the decision process was far from being linear. Contingent factors and competing interests and styles of doing physics played a central role in determining an outcome that was not logically fixed at the start. In a study of debates over the accuracy of nuclear missiles, Donald Mackenzie extends the analysis of controversies to the case of technological testing. His constructivist approach suggests the important conclusion that test-ban treaties could have important effects on the development of nuclear technology.

Philosophers of science use experiments as ingredients in their theory of scientific change and in arguments against competing theories. John Worrall usefully deconstructs the myth that the famous observation of a diffraction white spot at the center of a disc's shadow served as a crucial experiment in the acceptance of the wave theory of light to argue that prediction of novel facts is not a criterion for accepting a new theory. Using different case studies, Allan Franklin describes ten "epistemological strategies" used by scientists to convince their colleagues of the validity of their results and argues that they are not conventional cultural practices but compelling rational arguments. Thomas Nickles attacks the hypothetico-deductive method by suggesting that an inductivist methodology gives experiments a more active role in the justification of knowledge. Pointing to the tendency of recent historical and sociological research to emphasize the local and contingent character of scientific knowledge, Nickles concludes his paper by asking a question that will have to be addressed: how is delocalization, decontextualization of scientific results possible?

The richness and diversity of the questions raised in *The Uses of Experiment* make this book an important contribution to the unending debate on the nature of science. However, focusing alternatively on theory and experiments should not lead to the neglect of the important question of the relation between mathematics and experiment: How do numbers emerging from these two sources come to match?

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Energy Efforts

Synthetic Fuel Technology Development in the United States. A Retrospective Assessment. MICHAEL CROW, BARRY BOZEMAN, WALTER MEYER, and RALPH SHANGRAW, JR. Praeger, Westport, CT, 1988. xiv, 175 pp. $39.95.

In 1973, the United States discovered it had become dangerously dependent on petroleum imports from the Middle East. The federal government had intermittently funded several projects that promised to produce liquid fuels from American coal. Why have such attempts failed? The authors of this book seek to answer this question by combining the methodologies of technology assessment and the history of technology. The question is important and their chosen method is appropriate, but Crow *et al.* unfortunately limit their analysis to one family of oil-from-coal processes, the direct liquefaction of coal by hydrogen (DCL). The generally more promising processes of indirect liquefaction by way of coal-based carbon monoxide are not considered at all.

We are given a modest but competent history of the development of DCL processes. The book's account of the H-Coal process, taken as a "baseline case," is a good illustration of the damaging effect of on-off funding. The process was introduced by Hydrocarbon Research, Inc. (HRI) in 1955, as a spin-off of its earlier H-Oil process. The federal Office of Coal Research underwrote the construction of a demonstration unit in 1965 but canceled its support in 1967 to concentrate on an alternative oil-from-coal process. HRI was able to get financial support from ARCO and later Ashland Oil. The federal government reentered the project after the 1973 oil shortage and provided over 80% of the funding. A pilot plant was completed in 1980, but the operation was suspended two years later when Ashland pulled out, citing falling oil prices as the main reason. The analysis given by Crow *et al.* shows that H-Coal would be uneconomic whatever the price of natural oil. The cost of synthetic oil increases in step with that of natural oil, as a result of the energy inputs required. It is also clear that the project was dogged by poor management, not least because its operation was usually divided between two firms and its oversight was shared by various federal agencies.

Given such difficulties, do we have to look any farther to explain the failure of synfuels in the United States? Only if we agree with the authors' concluding remark that the "ultimate need for synthetic fuels seems a certainty." They insist that synfuels projects have been burdened with misplaced expectations. Instead of being compelled to become competitive in price with natural oil, which they describe as a "moving target," synthetic liquid fuel should be regarded as a long-term safeguard against oil embargoes and shortages. (They note that South Africa, which has a compelling need to create a domestic source of liquid fuels, has avoided the pitfalls of the American efforts and has, in technological terms, succeeded.) Crow *et al.* argue that DCL should be treated not as a conventional private-sector technology but as a government-sheltered pioneering technology.

These conclusions reveal the limitations of the intense focus on DCL technology. Crow *et al.* have not attempted to demonstrate that synfuels will in fact be required in the future. Nor do they seek to strengthen their argument by drawing supporting evidence from the development of other pioneering technologies, bar a passing reference to the early history of computers. Consideration of the development of other synthetics and the alternatives to synfuels reveals factors that Crow *et al.* overlook.

The United States successfully developed synthetic rubber, which now accounts for around 70% of virgin rubber consumption. Why has synthetic rubber succeeded where synfuels have not? The successful technology was identified at an early stage and quickly taken, with federal support, to commercialization. The federal government controlled the price of rubber during the crucial development period, and synthetic rubber soon became competitive in price with natural rubber. Rubber was always imported from areas outside American control and hence was more subject to supply disruptions and price fluctuations. Furthermore, styrene-butadiene copolymer rubber (GR-S) offered certain advantages, notably wear resistance, over natural rubber. Synthetic rubber thus displays four features characteristic of a successful synthetic: rapid commercialization, competitive cost, advantages over the natural product, and acceptability to consumers of the natural product. Synthetic indigo and nylon, to name only two

other successful synthetics, also fulfilled these criteria. Synfuels fail on most of them. No process has stood out as uniquely promising. The federal government has been unwilling to push up the price of gasoline, and the cost of synfuels is not likely to fall dramatically. Nor do synfuels display advantages over natural fuels that would justify a higher price. Despite the 1973 shock, disruptions in the supply of petroleum have not been sufficiently frequent or severe, so far, to compel the oil majors to divert R&D heavily to synfuels.

A liquid fuels shortage is indeed likely in the next 40 years, but oil-from-coal technologies are not necessarily the best solution. The scale of the problem is too great for it to be overcome by production of synthetics. Most synthetic products succeed by transforming an abundant raw material into a higher priced commodity, as in the conversion of petroleum into synthetic rubber. The United States produces around 2 million tons of synthetic rubber a year. To replace just 15% of America's petroleum consumption, it would be necessary to produce that amount of synfuels each week. Furthermore, synfuels based on coal are inherently uneconomic. As petroleum reserves run dry, coal will escalate in price, since it will also be in demand as an alternative to oil for power generation, as a domestic fuel, and for chemical manufacture. Moreover, a significant number of synfuel plants would be required to make up the petroleum deficit, and they would be dusty and polluting. In the western United States there would also be problems of water supply. The current political problems surrounding nuclear power station construction indicate the difficulties that could be faced by synfuel producers. And even if all the technological, economic, and political problems were overcome, oil-from-coal technologies would only win America a breathing space of a hundred years or so given the size of economically recoverable U.S. coal reserves.

Effective solutions to the future liquid fuels crisis lie elsewhere. The federal government could do more to encourage the use of economical automobiles (and energy conservation generally) by raising fuel duties to levels found in other Western countries. All levels of government could adopt a long-term strategy of promoting public transportation at the expense of automobiles. There are alternative routes to liquid fuels. Carbon monoxide (from a variety of sources), and even carbon dioxide, can be reduced to methanol and higher-boiling products. Ethanol can be produced from renewable crops by fermentation and is already used for fuel in Brazil. Electricity is clearly the major energy source of the future, however produced, and more research into electric transportation would be a better use of federal funds than coal-based synfuels. DCL and other oil-from-coal technologies will ultimately fail, not because of a lack of commitment by the federal government but because they are a technological and economic dead-end.

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Some Other Books of Interest

Modulation of Defined Vertebrate Neural Circuits. MICHAEL DAVIS, BARRY L. JACOBS, and RONALD I. SCHOENFELD, Eds. New York Academy of Sciences, New York, 1989. viii, 195 pp., illus. $49. Annals of the New York Academy of Sciences, vol. 563. From a conference, Elkridge, MD, Sept. 1988.

This collection of 13 papers is concerned with "defining anatomically, chemically, and physiologically, the neural circuits that directly mediate specific physiological processes and behaviors," a circuit being defined as "a complete neural system in which the afferent and efferent pathways and the nuclei subserving a specific function are characterized." The functions or processes on which experimental work is reported or summarized include motor pattern selection in the turtle (Stein); the escape response in goldfish (Faber *et al.*); spinal cord reflexes in cat and rat (Barnes *et al.*); jaw control in mammals (Jacobs *et al.*) and birds (Zeigler); the blank reflex in rabbits (Evinger *et al.*); auditory space mapping in owls (Takahashi); modulation of breathing in mammals (Feldman and Smith); lordosis in rodents (Pfaff); auditory-motor interactions involved in bird song (Williams); and startle reflex in rats (Davis). The volume also includes a brief general discussion of withdrawal from pain in mammals (Fields and Heinricher) and a discussion of electromechanical analogs of human reflexes (Littman *et al.*).—**K.L.**

Advances in Mutagenesis Research. Vol. 1. G. OBE, Ed. Springer-Verlag, New York, 1990. x, 217 pp., illus. $79.50.

The series *Advances in Mutagenesis Research* is intended to treat both basic and applied aspects of the subject—the molecular mechanisms leading to mutation and effects of mutagens introduced into the environment. In this first volume the opening paper, by H. Hayatsu, deals with "blue cotton," a form, discovered in 1983, bearing phthalocyanine pigment and useful in assaying mutagenicity in food. R. M. Speed next surveys the history of research on "meiosis in mammals and man." H. Nöthel, noting that mutations "are most often detrimental to their carriers [but] also represent the ultimate source of genetic variability," discusses mutagen-mutation equilibria in evolution with reference to *Drosophila*. R. Huber and M. Bauchinger discuss the occurrence of micronuclei (accessory nuclear bodies in the cytoplasm) in human lymphocytes in response to exposure to chemicals or ionizing radiation, and C. Kessler expounds the use of non-radioactively labeled probes (such as ELISA) for detecting DNA sequences. In the last two papers, C. A. Smith and I. Mellon review research on the organization of DNA repair systems in rodents and humans, and F. K. Ennever considers the use of genotoxicity tests in risk assessment, noting that the issue "appeared simpler 15 years ago, when carcinogenicity appeared to be a rare property of chemicals, and the paradigm that 'carcinogens are mutagens' . . . had few counterexamples." That English is not the native language of all the contributors is evident in some chapters. The volume includes a subject index.—**K.L.**

Books Received

The Analysis of Directional Time Series. Applications to Wind Speed and Direction. Jens Breckling. Springer-Verlag, New York, 1989. viii, 238 pp., illus. Paper, $23. Lecture Notes in Statistics, vol. 61.

Archäobotanik am Zürichsee. Ackerbau, Sammelwirtschaft und Umwelt von Neolithischen und Bronzezeitlichen Seeufersiedlungen im Raum Zürich. Stefanie Jacomet, Christoph Brombacher, and Martin Dick. Fussli, Zürich, 1989. 348 pp., illus. SwF 129. Berichte der Zürcher Denkmalpflege, vol. 7.

The Conquest of Water. The Advent of Health in the Industrial Age. Jean-Pierre Goubert. Princeton University Press, Princeton, NJ, 1989. vi, 300 pp., illus. $29.95. Translated from the French edition (Paris, 1986) by Andrew Wilson.

Deterrence and Juvenile Crime. Results from a National Policy Experiment. Anne L. Schneider. Springer-Verlag, New York, 1990. x, 127 pp., illus. $49. Research in Criminology.

Group Beliefs. A Conception for Analyzing Group Structure, Processes, and Behavior. Daniel Bar-Tal. Springer-Verlag, New York, 1990. x, 140 pp. $49.50. Springer Series in Social Psychology.

Handbook of Physiology. Section 6, The Gastrointestinal System. Vol. 3, Salivary, Gastric, Pancreatic, and Hepatobiliary Secretion. John G. Forte, Ed. 2nd ed. American Physiological Society, Bethesda, MD, 1989 (distributor, Oxford University Press, New York), x, 779 pp., illus. $195.

Inverse Schrödinger Scattering in Three Dimensions. R. G. Newton. Springer-Verlag, New York, 1989. x, 170 pp. $39.50. Texts and Monographs in Physics.

Maximum-Likelihood Deconvolution. A Journey into Model-Based Signal Processing. Jerry M. Mendel. Springer-Verlag, New York, 1990. xiv, 227 pp., illus. $45.

El Niño, La Niña, and the Southern Oscillation. S. George Philander, Academic Press, San Diego, CA, 1989. x, 293 pp., illus. $59.50. International Geophysics Series, vol. 46.

Noyaux et Particules. Modèles et Symétries. Luc Valentin. Hermann, Paris, 1989. x, 375 pp., illus. Paper, 196 F.

Principles of Magnetic Resonance. C. P. Slichter. 3rd ed. Springer-Verlag, New York, 1990. xii, 655 pp., illus. $49.50. Springer Series in Solid-State Sciences, vol. 1.