

that more research is needed to identify what factors—if not EMFs—may be causing increased rates of leukemia.

Though all the panelists on the committee signed the report, three took the unusual step of issuing statements arguing that the debate over health effects was hardly over. "It is true that there is not enough evidence to convict EMFs beyond a reasonable doubt, but there is every reason to view them as a prime suspect," said Louis Slesin, editor of *Microwave News* and a committee member. In a letter to *The New York Times*, Richard A. Lubin, an epidemiologist at the University of California, Riverside, and Daniel Wartenberg of the Robert Wood Johnson Medical School in Piscataway, New Jersey, both panelists on the research council study, observed that the report "concluded that there is a small (1.5-fold) and valid excess of childhood leukemia in households near groups of power lines. Where the real debate lies is whether this association is due to electromagnetic fields or some other factor. . . . We hope some of the continuing research on the epidemiology and basic science of this question will help clarify the issue."

'Exaggerated beyond reason'

Such statements differ only in tone from the conclusion reached by William Bennett, professor of engineering and applied science and professor of physics at Yale University, who took part in a study of EMFs conducted in 1992 by Oak Ridge Associated Universities. Writing in *PHYSICS TODAY* in April 1994 (page 23), Bennett protested that the dangers to human health from low-level EMFs were "exaggerated beyond reason." His understanding of the relationship was based, Bennett stated, "on considerations ranging from the underlying physics to the inconsistent epidemiological data and lack of concrete biological results." He went on to say, "It is appalling that close to a billion dollars has already been spent on this problem." Even so, he suggested that further research ought to proceed, though he saw no need for "any sort of crash program."

This was followed by a resolution of the council of the American Physical Society, issued the following April (see *PHYSICS TODAY*, July 1995, page 49). After reviewing the scientific literature, as well as reports by various scientific panels, the APS council stated that it could find "no consistent, significant link" between power line fields and cancer. "No plausible biophysical mechanisms for the systematic initiation or promotion of cancer by these power line fields have been identified. Furthermore, the prepon-

derance of the epidemiological and biophysical/biological research findings have failed to substantiate those studies, which have reported adverse health effects from exposure to such fields. While it is impossible to prove that no deleterious health effects occur from exposure to any environmental factor, it is necessary to demonstrate a consistent, significant and causal relationship before one can conclude that such effects do occur. From this standpoint, the conjectures relating cancer to power line fields have not been scientifically substantiated," said the APS resolution. After referring to the huge sum of money spent on mitigation and litigation over EMFs, the resolution concluded that "the burden of cost placed on the American public is incommensurate with the risk, if any."

Notwithstanding the findings by the research council's panel, the APS council and others, the controversy does not

appear to be settled. Two recent studies, one by Britain's National Radiological Protection Board and another by the Oak Ridge Associated Universities, conducted for the White House Office of Science and Technology Policy and the Department of Labor, have reviewed the galaxy of scientific papers on EMFs and concluded that the issue is long on alarm and short on meaningful research. Other groups are engaged in reviews of the subject: The Environmental Protection Agency would like to decide whether to seek regulatory controls on power lines near residences and office buildings, but has delayed its study in part for budgetary reasons. Meanwhile, the National Institute of Environmental Health Sciences, which together with the Energy Department conducts a \$65 million EMF research project, is scheduled to issue a report to Congress in mid-1998.

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Whither Physics? NRC Panel Initiates New Survey in Era of Limits

By almost any standard, the past half-century has been a golden age of physics in the US. But in the 1990s physics confronts a paradox: Reduced expectations for funding and growth are occurring alongside greater opportunities for productivity and discovery. This disjunction has led the Board on Physics and Astronomy of the National Research Council, which conducts studies on behalf of the National Academies of Sciences and Engineering, to undertake a new diagnosis of the health of the entire discipline.

The latest examination follows by a decade the last one, named "Physics Through the 1990s." That survey did not foresee some of the problems that would soon arise. When it was published in 1986 (see *PHYSICS TODAY*, April 1986, page 22), the survey was intended to be a plan for the next decade—intellectually and experimentally. But in the early 1990s, it became abundantly clear that physics was under stress—beset by shrinking funds for basic research in government and industry, by more complex and costly research instruments and facilities, and by fears that fewer students would choose physics for their life's work. No wonder, then, that the new survey bears the title "Physics in a New Era."

The three previous physics surveys prepared by committees of the research council, beginning with one completed in 1966 by a panel headed by George E. Pake, then at George Washington University in St. Louis, concentrated

mainly on documenting the achievements of physics and describing the requirements for continued progress. The Pake report, like the surveys that followed in 1972, under the chairmanship of D. Allan Bromley of Yale University, and in 1986, led by William F. Brinkman of AT&T Bell Labs, assumed that physics is a coherent and fast-moving enterprise whose values, goals and practical applications are readily appreciated by government and society. Justification for the financial support of physics was taken for granted, in part because physicists had helped win World War II with numerous innovations, such as the proximity fuze, radar, sonar and the nuclear bomb. In the years that followed, physics flourished and so too did the nation's economy, with a stunning proliferation of technologies based on physics research.

By the early 1990s, dire warnings were sounded about the perils facing physics. Some predicted that the red ink of the Federal debt would overflow into the government's R&D budgets. Among the first to sound off was Erich Bloch, who as director of the National Science Foundation cautioned that financial pressures on Federal programs would limit research investments in the decade of the 1990s. And when the period of steady-state budgets ends, the decline that follows will increasingly threaten the health of research communities into the next century, Bloch declared. Soon afterward, Leon Lederman, Fermilab's director

emeritus, issued what he termed "a cry of alarm about the state of academic science" and boldly called for doubling Federal funds for basic research, which approached \$10 billion in fiscal 1991 (see *PHYSICS TODAY*, February 1991, page 75).

The current \$12 billion basic science budget doesn't satisfy Lederman or other Cassandras in the scientific community, but few considered Lederman's number at all realistic at the time. Still, says David Schramm, vice president for research and professor of physical sciences at the University of Chicago, chairman of the research council's latest survey group, "the time has come to look at the physics enterprise from the bottom up and to approach the question of the value of physics to society. The frontiers of knowledge in physics have become increasingly challenging to reach, and the costs of expeditions to the forefronts of some areas have mounted. We have tended to assume that society will bear the increasing costs without complaint, even as some of the realms of exploration grow ever more difficult."

"In the present state of budget cutting in Washington," says Schramm, "it does not seem realistic to rely on the continued growth of the GDP to mask the increasing cost of doing some kinds of forefront physics. We have to confront the question 'How can the intellectual vitality of physics best be continued into the next millennium?' We must optimally convey the importance and the excitement of physics to politicians in Washington and ultimately to the public at large."

So the panel proposes not only to conduct an examination of the current health of physics but to assign priorities for advancing research. Donald Shapero of the research council believes it will be more important but also more difficult to come to grips with setting priorities for this survey than it was in the relatively good times in which previous panels operated. "When more money was available for new facilities and investigations," says Shapero, "the issue was 'What new things are we going to do?' Now the issue may be 'What do we have to give up in order to do new things.'"

Instead of lamenting the lack of public understanding and the cuts in government funding, the leaders of the new survey propose to show how investigations in many fields intertwine and lead to advances in other fields, citing specific benefits such as the use of lasers in health care, the applications of geophysics in locating new oil fields and the connections of physics to the invention of semiconductors, computers, software and Internet com-

munications systems.

It has long been the case that the pervasiveness of physics in research and technology was a strong force in the education and careers of physicists. The survey will devote a section to current issues of physics education. "Now that our system of higher education is no longer expanding as it was for the last 30 years or so, graduate students and postdocs find opportunities waning in academe and government, but jobs are opening in high-tech start-up companies and in other areas where the physicist's approach to prob-



SCHRAMM: Surveying the value of physics.

lem solving is proving useful," observes Robert C. Dyne, chancellor of the University of California, San Diego, and vice chairman of the survey team. "Physics departments must think about whether the program they offer undergraduates and graduate students prepares them with the versatility and flexibility they will need in a changing labor market."

The new survey differs from the previous ones by dealing with only a few areas of physics at a time. In the past, the surveys issued simultaneously a range of reports on various subfields. In the current survey, the reports are to appear in phases. Accordingly, the first phase has already resulted in releasing "Atomic, Molecular and Optical Science: An Investment in the Future," in 1994 and "Plasma Science: From Fundamental Research to Technological Applications" the following year. Three research briefings were published last year on neutrino astrophysics, cosmology, and cosmic rays, which have already proved useful in updating courses at several universities and in recommending research projects to be undertaken by NASA, the National Science Foundation, the

Department of Energy and possibly the National Institute of Standards and Technology.

In the second phase, which is now in progress, subpanels are preparing reports on elementary particle physics, under the direction of Bruce Winstein of the Enrico Fermi Institute of the University of Chicago, condensed matter and materials physics, led by Venkatesh Narayanamurti of the University of California, Santa Barbara, and nuclear physics, chaired by John Schiffer of the University of Chicago and Argonne National Laboratory.

The third phase is expected to cover increasingly significant cross-disciplinary areas, such as biological physics, computational physics and gravitational physics. Shapero is particularly excited about the section on biology. "It's not generally known that physicists contribute to biology," he observes. "Just consider the prominent contributions by three physicists: Francis Crick, Max Delbrück and Walter Gilbert."

The survey will conclude with the publication of an overview volume, which will summarize the reports that have already been published and examine several critical topics—namely, education and career paths, international collaboration, the changing environment for physics research, the uneasy unity of the field and the uncertain relationship of physics with society. In reaching the goal of setting priorities, Schramm, Dyne and their committee will need to navigate carefully through reefs and sandbars identified with various constituencies in physics and on the Washington scene. Recommending new projects to start and old facilities to abandon are likely to cause headaches for the committee.

Schramm is convinced a compelling case can be made for sustained support of physics on the grounds of its practical payoffs to all of society. There are, to be sure, plenty of examples of that observation.

On the planning committee of the survey are members of the executive committee of the research council's board on physics and astronomy. Besides Schramm and Dyne are Steven Chu, professor of physics at Stanford University, Jerome I. Friedman, professor of physics at MIT, and Anthony C. S. Readhead, professor of astronomy at Caltech.

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Readers can find more information about the survey and contribute to it by accessing the Board on Physics and Astronomy's web site at <http://www.nas.edu/bpa/> or e-mail at bpa@nas.edu