

state & society

New director forecasts fresh commitments for NSF

The National Science Foundation has produced a program of applied research that manages to be healthy without submerging basic-science efforts, according to NSF's new director, but it needs to improve this performance by supporting so-called "hot-pursuit" projects that fall into the chasm between basic and applied work. Richard C. Atkinson, who was sworn in as the Foundation's new head by President Jimmy Carter on 1 June (after serving as acting director since August 1976), also believes that the NSF should do more for researchers working in industry, and he explained to us how the problems facing basic research there and in the academic world are tied together. He expressed great concern over the effects of highly targeted, excessively difficult science curricula in the high schools, which may be excluding a whole generation of young people from active careers in the national research enterprise.

Atkinson, an experimental psychologist and applied mathematician, joined the faculty of Stanford University in 1956, and except for brief stints at UCLA and the University of Michigan he has remained there since. (Throughout his NSF service he has been on leave from Stanford, which status he maintains as director.) He is a professor in the psychology department, which he headed in the period 1968–1973, and he also holds



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appointments in Stanford's Schools of Engineering and Education and in the Institute for Mathematical Studies in the Social Sciences. Atkinson's research has dealt primarily with experimental and theoretical analyses of memory and cognition, but he was also among the first to develop a computer-controlled system for

classroom instruction. He is the first head of NSF whose background has been in the social sciences.

NSF in hot pursuit. When the Foundation's charter was revised in 1968 to include applied research among its responsibilities, Atkinson told us, there was considerable and long-lasting debate; now he thinks the debate is ended. Applied research does indeed belong in NSF—the persistent question is one of balance. Atkinson told us a review of the Foundation's whole science-applications effort was underway and would soon be available to him and the National Science Board for setting future policy in this area. "My own feeling," he said, "is that although we have had a very successful and powerful effort" through NSF's Research Applied to National Needs program, "I still see a gap between basic research on the one hand and highly focussed, applied research on the other."

Atkinson spoke of a middleground of activity, where good ideas coming out of the research laboratories need money to move into applications but cannot get it from the basic-sciences program and have difficulty finding support from mission agencies such as ERDA and NASA. The Foundation, he said, should concern itself with selecting some of these ideas—in the research area but not tied to particular

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APS fuel-cycle study finds nuclear technology sound

A recently completed study of nuclear fuel cycles and waste-management problems and alternatives finds that safe and reliable management of nuclear waste "can be accomplished with technologies that either exist or involve straightforward extension of existing capabilities." The study, commissioned by The American Physical Society and supported by a grant from the National Science Foundation, also finds that fast breeder reactors represent the most resource-efficient option of all long-term nuclear-fission prospects. The Study Group found other advanced types of reactors, notably heavy-water-moderated converters, to be sufficiently attractive as an alternative to warrant further evaluation.

The Study Group on Nuclear Fuel Cy-

cles and Waste Management, headed by L. Charles Hebel (Xerox Corp), first convened in March 1975 and met many times thereafter; its purpose was an independent evaluation of the technical issues concerning the use of fissionable materials in nuclear fuel cycles. The work of the 12-member Study Group and the technical content of its report was examined by an APS review committee, and the report was also scrutinized by the APS Panel on Public Affairs. The main conclusions and recommendations of the study were made public at the APS Washington meeting in late April, and it is anticipated that the complete text will be published this fall.

Reprocessing and waste management. The Study Group identifies four "major

options" for the disposition of spent fuel elements from light-water reactors: permanent disposal as wastes ("throw-away"), storage that permits eventual recovery and utilization ("stowaway"), reprocessing to recover uranium only, and reprocessing to recover both uranium and plutonium. The participants found throwaway inappropriate and saw no purpose to reprocessing operations that would save the uranium and discard plutonium, so only the second and fourth options are recommended. Reviewing the present status of the reprocessing operation, the study reports that "an essentially complete technical base" exists for the reprocessing of uranium fuel elements from light-water reactors at the industrial scale, but that the technology

for handling mixed-oxide fuel rods (plutonium-uranium) from such reactors is not yet complete. The reprocessing of spent fuel from breeder reactors and from those that use thorium will, according to the study, require extensive engineering development. Mixed-oxide fuel fabrication, in contrast, has been developed and demonstrated at the pilot-scale level, and designs for commercial plants are "already quite advanced." The study concludes: "If reprocessing-refabrication is to be a major component of the US nuclear industry in the near future, we recommend that appropriate existing reprocessing facilities be completed and operated to gain experience with integrated technology on an industrial scale and further, that the corresponding refabrication facilities be built and operated with a similar goal." This conclusion is directly contrary to President Jimmy Carter's recommendation that the nation's only reprocessing plant in a state of near-readiness (at Barnwell, S.C.) not be operated. The study also points out, however, that "resource considerations alone for LWR fueling provide little urgency to begin industrial-scale reprocessing within the next decade."

As for the isolation of harmful radioactive wastes, the Study Group anticipates no difficulty in the location of suitable geologic-repository sites in the near future. The study examines the feasibility of long-term isolation from the biosphere of commercial high-level wastes (from spent fuel assemblies or reprocessing) and transuranic wastes (mostly solids and miscellaneous wastes from reprocessing and refabrication operations); the problem of weapons-associated wastes is not included in the analysis. "We expect that a repository site in bedded salt with suitable hydrogeology can be found," says the group; "certain other rock types, notably granite and possibly shale, could offer even greater long-term advantages." Of primary importance is the solution of problems of groundwater flow and mass transport where "an adequate data base does not yet exist." As a major recommendation, the study emphasizes that at least two demonstration-type facilities should be developed, one in a geologic medium other than salt, before selection of a site for licensing as a full-scale repository. The group foresees no important *technical* barrier [their italics] to the demonstration of the technology for solidification, encapsulation, transport and emplacement of high-level wastes. As for the stowaway of spent fuel itself, "safe interim-stowaway measures exist, and geologic stowaway could be safely continued indefinitely."

Fast-breeder alternatives. "The fast breeder reactor," states the Study Group's report, "offers the potentiality for large extensions in uranium resources and is the most resource efficient of all fission options." The US program has emphasized



Study Group members report. Participants in the APS study of nuclear fuel-cycle and waste-management issues presented a summary of their conclusions at the Society's April meeting in Washington, D.C. Shown here are (left to right) Fred A. Donath (University of Illinois), L. Charles Hebel (Xerox Corp), Leon J. Lidofsky (Columbia University) and Ernest J. Moniz (MIT).

the plutonium-uranium-fueled fast breeder, which produces new Pu^{239} in a blanket of depleted U^{238} by neutrons leaked from plutonium-uranium mixed-oxide fuel pins in the reactor core. Reprocessing technology is already available to provide plutonium for breeder start-up by reprocessing light-water-reactor fuel. ERDA's Liquid Metal Fast Breeder Reactor program has been aiming at commercialization in the early 1990's; that program, however, has run into opposition from the President and may be substantially delayed.

The Study Group's evaluation of the breeder deals mainly with its perceived utility in stretching the country's uncertain uranium resources, which are estimated in the report to be sufficient to fuel light-water reactors installed through the year 2000 (assuming 30-year reactor lifetimes). The excess plutonium produced in breeder reactors could be used to start-up other breeders, ensuring adequate supplies of electrical power into the

indefinite future. However the Study Group made no attempt to examine reactor-safety issues for breeder operations, nor did it try to fully analyze the implications for weapon proliferation and for domestic safeguards entailed in the large amount of plutonium produced by such breeders.

There are other ways to fuel the fast breeder reactor than with plutonium. The study notes that they could also be started on uranium enriched to 20% U^{235} , but the economic penalties relative to plutonium start-up would be "very large." The cost of start-up for fast breeders using enriched uranium initially is estimated by the Study Group at 2.5-3.3 times that using plutonium, because larger quantities of fissile material are required with U^{235} (which is more expensive) and because the breeding gain is substantially lower than for plutonium. Fast breeder reactors might also be started with U^{233} , the report notes, if thorium fueling of thermal reactors were

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★ **Robert A. Frosch has been nominated** by the President to head the National Aeronautics and Space Administration. Frosch, who holds a PhD in theoretical physics from Columbia University, has directed the Woods Hole Oceanographic Institution's applied-oceanography program since 1975. Another high-level nomination is that of Hans M. Mark, director of NASA's Ames Research Center, to be Under Secretary of the Air Force.

★ **OTA Director quits.** Emilio Q. Daddario recently resigned as head of the Congressional Office of Technology Assessment. A former Congressman, Daddario is president of the American Association for the Advancement of Science.

to precede the introduction of commercial breeders. The Study Group sees this alternative as intermediate in efficiency, with some possible benefits with respect to nuclear safeguards; on the other hand, reprocessing and refabrication of fuel would apparently be more difficult for this option. With respect to breeder start-up, says the report, "Although U^{233} is far better than U^{235} for this purpose, it is still inferior to plutonium."

Other reactor options. The bulk of the Study Group's report deals with light-water reactors' fuel cycles using low-enrichment uranium with the options of recycling or discarding as wastes the decay products. But group members also examined the possible contributions of other advanced fuel cycles. As an alternative to the fast breeder, the heavy-water reactor or converter is described in the study as providing the most significant resource extension of all non-breeder reactors. The Study Group considered various operational modes for a CANDU-type reactor (a pressure-tube heavy-water reactor already commercialized in Canada) and concluded that the best reduction in ore requirements would be achieved using thorium fuel with plutonium make-up and uranium recycle. "If the fast breeder is significantly delayed or cancelled," says the study, "some version of the CANDU reactor may become necessary to conserve uranium resources." The Study Group has recommended that the US evaluate the CANDU for future application in this country.

Also examined were possible improvements in light-water reactors that might provide near-term alternatives for improved uranium-ore utilization. The group found that "spectral shift" operation of an LWR, using some heavy water mixed with the ordinary light-water moderator, could provide at least a factor of two improvement in lifetime ore commitment and could be implemented with minor modifications of existing LWR technology. The Study Group recommends this "spectral-shift" technique for the near term while long-term alternatives such as the breeder and advanced heavy-water converters are evaluated more fully. The group notes that reprocessing is necessary to derive significant resource extension from any of the advanced options.

Safeguards considerations. "It is not our purpose in this report," said the study participants, "to dwell on the complex political and institutional considerations required for protection of fissionable materials on a national or international scale." But they did examine questions of safeguards as well as resource efficiency, from a technical perspective. The group placed its emphasis on technical measures that might be used to complement conventional physical security barriers to theft or misuse of strategic

nuclear materials. Technical barriers included the degradation of the nuclear materials, dilution, the natural hazard of high radioactivity and improved accountability systems. The study indicates that the dangers of sabotage and theft are inherent in any fuel cycle, with or without the recycling of plutonium; however, while the Study Group states that the low-enriched uranium fuel cycle now in use in the US "does not represent a great safeguards risk . . .," they point out that the advent of reprocessing and plutonium use *would* change this situation.

The Study Group also outlined several approaches for international safeguards and control of nuclear fuel cycles. One of the near-term approaches calls for participating nations to burn low-enrichment uranium in their own "national" reactors, with all plutonium-related activities performed at "international centers" where plutonium could be used as fuel. A longer-term scenario involves national reactors fueled with thorium and denatured uranium; fissile make-up could be performed at international reprocessing centers by thorium-blanketed fast breeder reactors. Such options, says the report, should be evaluated further.

The APS Study Group reached a number of other conclusions concerning the nuclear fuel cycle and waste disposal, both with respect to the technical aspects of the field and to the Federal actions and regulations needed. In particular, they assert that uncertainties about nuclear-waste disposal do not justify a moratorium on the construction and licensing of new reactors, as some have proposed. They also state that reprocessing is "not an essential step in the management of nuclear wastes but rather a means of extending fuel resources . . ." —FCB

Fresh commitments for NSF

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problems or well defined national needs—and supporting them as "hot-pursuit" projects. Atkinson told us such projects could be supported through the RANN program; indeed, the RANN advisory board has recommended that a good portion of the program's funding be set aside for just such open-ended activities. Atkinson described the current round of budget maneuverings as "bleak" for RANN, however, though the NSF's *basic-research* activities have so far come through the funding meatgrinder in fair shape.

A commitment to basic physics. With a desire to expand the applied-science sphere for "hot-pursuit" efforts, and with the Foundation's FY 1978 budget request on behalf of its materials-research program larger than the corresponding request for physics (for the first time in NSF history), isn't there some danger that

basic science may indeed be submerged by an increasing stress on less fundamental activities? Atkinson responded by pointing out that only since the Pentagon dropped its materials-science activities under the ARPA program has the NSF begun to play a significant role in that area. Further, he said, NSF's materials-science budget includes all funds for solid-state physics research, as well as \$5 million for the upgrading of synchrotron-radiation sources that will be used by physicists as well as those in biology and other sciences. "I don't think there's any indication that applied work or materials research is somehow more important than basic research in physics," he told us. "Physics is not an area of science that the Foundation is going to ignore." He said that the NSF has two obligations to the physics community: One is to ensure sustained good funding from the Foundation itself; the other is to ensure also that the need for basic research in physics is well understood in other agencies as well.

A fairer share for industry. Whether or not the Foundation increases its sponsorship of industrial research, Atkinson told us, will be decided by the policy-making NSB—much influenced by the Congress's thinking. "I am of the view," he went on, "that more research—in particular, more basic research—should have our support in industry." Atkinson believes that NSF ought to facilitate *joint* research in the basic sciences between the universities and industry, and he told us "plans are afoot" for doing so. He appears less enthusiastic about the possibility of direct funding from NSF for basic-research investigators in industry, though he says he'd not be opposed to such a move. If direct support were to become a significant part of the NSF program, according to Atkinson, then either the Foundation's budget would have to rise correspondingly or its academic research institutions would be undercut.

The problem of support for industrial research has achieved growing prominence, the new director told us, not only because economic conditions have prevented industry from spending what it used to on research activities, but also because of a new factor: A number of capable young scientists who in previous years would have gone on to research careers in the universities now find themselves assimilated into industry. "They're of the opinion, and I think properly so," says Atkinson, "that they were trained for research, that's their primary interest, and they should have the same opportunity to engage in basic research as their academic colleagues." Thus the problems of research in industry and research in the universities are inextricably entangled.

"What's going to happen to our scientific research in the universities," asks