an efficient oxidative metabolism, and at the same time keeping glucose requirements low. That explains why the brain and its metabolic rate are both scaled downward. And finally, since large amounts of lactate must be generated by this system, it is advantageous to maintain large potentials for lactate oxidation by tissues such as the heart and lung, which remain on central circulation routes during diving. Not only does this latter capability minimize lactate accumulation, but also it uses a substrate that would be otherwise wastefully piled up and indirectly thus contributes to maximizing glucose conservation.

### References and Notes


1. P. F. Scholander, *Harvey Lect.* **57**, 93 (1962).
2. H. T. Andersen, *Physiol. Rev.* **46**, 212 (1966).
3. R. Elsner, in *Biology of Marine Mammals*, H. T. Andersen, Ed. (Academic Press, New York, 1969), p. 117.
4. P. F. Scholander, *Hvalradets Skri.* **22**, 1 (1940).
5. B. Murphy, W. M. Zapol, P. W. Hochachka, *J. Appl. Physiol.* **48**, 596 (1980).
6. W. M. Zapol *et al.*, *ibid.* **47**, 968 (1979).
7. R. Elsner, D. L. Franklin, R. L. Van Citters, D. W. Kenney, *Science* **153**, 941 (1966).
8. Adult Weddell seals weighing 334 to 496 kg were captured near Turtle Rock, Ross Island, Antarctica; all manipulations were carried out at the Ekland Biological Laboratory at McMurdo Station. Catheterization and blood sampling procedures and microsphere techniques for assessing cardiac output and blood flow to tissues and organs are given in (*6*). Details for metabolite experiments are given in (*5*). In order to simulate diving by head immersion, we restrained the seal on a mobile table fitted with a head box filled with seawater; the box was drained to terminate the experiment (*6*). G. B. Kooyman and W. B. Campbell [*Comp. Biochem. Physiol. A* **43**, 31 (1972)] have shown a direct relation between the depth of bradycardia and the duration of freely diving Weddell seals at sea; in long dives, the cardiovascular responses closely resemble those observed in (*6*). During short-term natural diving in ducks, however, the simulated diving response is either modified or not observed at all [P. J. Butler and A. J. Woakes, *J. Exp. Biol.* **79**, 283 (1979); J. Kanwisher, *Science*, in press; D. R. Jones, personal communication].
9. B. J. Murphy and P. W. Hochachka, *Can. J. Zool.*, in press.
10. B. K. Siesjö and C. H. Nordstrom, in *Oxygen and Physiological Function*, F. F. Jöbsis, Ed. (Professional Information Library, Dallas, 1977), p. 459.
11. M. T. Snider, unpublished data.
12. D. Kerem and R. Elsner, *Respir. Physiol.* **19**, 188 (1973).
13. P. W. Hochachka, G. C. Liggins, J. Qvist, R. Schneider, M. Y. Snider, T. R. Wonders, W. M. Zapol, *Science* **198**, 831 (1977).
14. S. Mochizuki, K. Kobayashi, J. R. Neely, in *Recent Advances in Studies on Cardiac Structure and Metabolism*, vol. 12, *Cardiac Adaptation*, T. Kobayashi *et al.*, Eds. (University Park Press, Baltimore, 1978), p. 175.
15. R. R. Wolfe, P. W. Hochachka, R. L. Trelstad, J. F. Burke, *Am. J. Physiol.* **236**, E276 (1979).
16. H. W. Wallace, T. P. Stein, E. M. Liquori, *J. Thorac. Cardiovasc. Surg.* **68**, 810 (1974).
17. W. C. Hulbert and P. W. Hochachka, unpublished data.
18. P. W. Hochachka, *Living Without Oxygen* (Harvard Univ. Press, Cambridge, Mass., 1980), p. 15.
19. R. Brill, personal communication.
20. A. B. McIntyre and W. R. Driedzic, *Can. J. Zool.* **59**, 325 (1981).
21. P. W. Hochachka and B. Murphy, *Int. Rev. Physiol. Environ. Physiol.* **3**, 20 and 253 (1979).
22. G. L. Kooyman *et al.*, *J. Comp. Physiol.* **138**, 335 (1980).
23. A. C. Burton, *Physiology and Biophysics of the Circulation* (Year Book, Chicago, 1965).
24. D. R. Jones, personal communication.
25. G. L. Kooyman, *Rapp. P-V. Reun. Cons. Int. Explor. Mer* **169**, 441 (1975); B. Strauss, *J. Appl. Physiol.* **19**, 503 (1964).
26. B. Strauss, *J. Appl. Physiol.* **19**, 503 (1964).


27. This article is dedicated to the memory of P. F. Scholander. The work was done during the 1976 and 1977 austral spring and summer seasons at McMurdo Station, Antarctica. Supported by the NSF Division of Polar Programs, grant 19054 (to W. M. Zapol) and by NSERC (Canada) to P.W.H. The work would not have been possible without the able assistance of numerous colleagues and friends in Antarctica. Especial thanks are due W. M. Zapol. The studies were performed in accordance with Permit No. 111 granted by the National Marine Fisheries Service, U.S. Department of Commerce, NOAA.


# National Science Foundation Budgets: Fiscal Years 1981, 1982, and Beyond


Lewis M. Branscomb


In the National Science Foundation Act of 1950, the 81st Congress and the 33rd President of the United States assigned to the Foundation the following purposes (Public Law 81-507 as amended):

> To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes.

The National Science Foundation's (NSF) budget request for fiscal year 1982 and the associated proposed rescissions for fiscal year 1981 present the National Science Board with both an immediate task and a longer term opportunity. The Board recognizes the emergency nature of the economic situation and the vigorous remedies the President seeks in the way of federal expenditure reductions in nonmilitary areas. The emergency precluded the normal process of discussion of program priorities in which the Board could participate meaningfully.

It is the National Science Board's statutory responsibility to assist the President by establishing policies and priorities, and by guiding the activities of the NSF to ensure that with the available resources the NSF fulfills the functions defined by the Congress and the goals established by the President in the most efficient and effective manner possible.

## Managing the Short-Term Problems

In the short term the NSF must focus the available resources on the task of contributing as much as possible to the strength of American science and technology; the quality and sufficiency of scientists and engineers educated for careers in research, development, and engineering; and maintenance of the U.S. position as a leader in international scientific and technological endeavors.

In accord with this near-term goal, the budget for fiscal year 1981 puts high priority on science and engineering research performed in academic environments to optimize both educational and knowledge benefits from a single investment. The Board fully supports this short-term priority, which reflects the federal government's awareness that the nation's basic scientific and engineering capabilities, and the academic institutions that sustain them, cannot maintain primacy for the United States without strong federal commitments.

The National Science Board is, however, faced with two problems of serious concern for the immediate future of American science and engineering. First, unless additional resources can be found—in the NSF budget or from other sources—the alarming obsolescence of research equipment in our university laboratories will accelerate. The nation's principal academic research laboratories need new instrumentation and a method of sustaining refurbishment over a number of years. University research equipment produces the most demanding technical and innovative requirements. Thus, keeping university equipment at the cutting edge sparks both innovation and productivity improvements in American industry broadly. Obviously, the research equipment problem is with us,


The author is chairman of the National Science Board and Vice President and Chief Scientist at the International Business Machines Corporation, Armonk, New York 10504.




0036-8075/81/0501-0514$00.50/0

and the NSF will have to deal with it in fiscal year 1982 by making careful choices to meet the most critical instrumentation needs within the support of research.

The NSF has, within its appropriation authority, limited capability to reprogram funds to take advantage of emerging research opportunities and to make some adjustments that deal with specific issues. The Board believes, however, that the NSF needs some additional flexibility to support opportunities in the behavioral and social sciences, science and engineering education, and international science activities, as discussed herein and as the Board continues to review these programs. Within the overall presidential budget request, the NSF will seek the appropriate authority from the Congress for these purposes.

### Behavioral, Cognitive, Economic, and Social Sciences

The National Science Board believes that the vision of the Congress in mandating NSF to support research in all the sciences, specifically including the social and behavioral sciences, has been well justified.

1) The NSF has learned how to select for support high-quality, fundamentally important, and practically useful research in these fields.

2) One of the most rapidly advancing and promising areas of research progress in the United States is in intertwining the previously separate worlds of mind and body, of neurophysiology and behavior. The new discoveries are unveiling extraordinary possibilities for making life better for humankind.

3) Many areas of basic cognitive science and related fields are important for sustaining the rapid growth of our information industries.

4) The economic policies of this new Administration, with its continuing concerns about productivity and international competitiveness of the American economy, present both unparalleled opportunities and great need to study the workings of our economy from many perspectives, conceptual and empirical.

The Board has under way an examination of the research in the social, behavioral, and related sciences to ensure that the NSF's future activities meet its demanding standards of excellence and importance. Any funding adjustments in this area would be targeted at the highest priority areas, meeting the same tests for excellence and value applied to other areas of science and engineering.

### Science and Engineering Education

As noted above, the NSF is centrally engaged with science and engineering education at the undergraduate and postgraduate levels. America's world leadership in science owes much to this unique but wise policy of focusing federal basic research investments on laboratories associated with educational institutions. The NSF is thus irrevocably engaged in sustaining science and engineering education in partnership with state and private institutions.

Several programs in NSF's Directorate for Science and Engineering Education (SEE) are part of this basic mission. For example, while the research directorates indirectly support graduate training with project grants, the graduate fellowships of the SEE directorate support research through a national competition to identify and assist the brightest students to participate in graduate research. Together these activities complement one another toward a common objective, made more important by critical shortages in certain fields, such as computer sciences and chemical engineering where industrial demand is depleting the ranks of students and faculty alike, bringing a degree of urgency to these programs. Another example is the need for equipment with which our engineering schools can offer students for the B.S. in engineering a modern technical education up to the needs of industry.

The other science education activities of NSF address problem areas where, admittedly, the federal role is less crisply defined, but where the Board can see a crisis of serious proportions coming. The postsecondary and professional schools cannot satisfy the needs of our society for highly trained researchers and engineers if our brightest young people are discouraged or unmotivated to pursue technical careers.

At a time when Japanese and Russian engineering schools are outproducing the United States by two to one or more on a per capita basis, United States enrollments in graduate engineering are declining, scholastic aptitude test scores of students aiming for science careers are declining, and the ratio of U.S.-born to foreign-born graduate students is declining. Girls and minorities who are discouraged from studying mathematics and science in high

The National Science Board, at its meeting on 19–20 March 1981, adopted a statement about the National Science Foundation (NSF) budgets for fiscal years 1981, 1982, and beyond. I would like to clarify for the scientific and engineering communities the role of the Board as a governmental institution and explain the circumstances leading to the adoption of this statement.

The National Science Board is composed of 24 scientists and engineers and the NSF director ex officio. Board members serve on 6-year presidential term appointments, thus providing for the Board's independence of judgment as a basis for policy-making at NSF. The enabling statute describes the relationship of the Board to the director and the NSF as follows: "The Foundation shall consist of a National Science Board . . . and a Director." Thus, the Board is an integral part of the policy and management structure of the NSF, which is in turn an agency of the Executive Branch of the federal government. The Board's formal communications with the Congress require coordination with the Executive Office of the President and constitute an important part of the dialogue between the Executive and Legislative branches of the federal government on science and science policy issues.

At a 5 March hearing before the Subcommittee on Science, Research, and Technology of the House Committee on Science and Technology, in response to a question from its chairman, Representative Doug Walgren of Pennsylvania, I pointed out that the National Science Board itself had no opportunity to participate in the restructuring of the 1982 budget request to be submitted to the Congress on 10 March. Representative Walgren then asked for the views of the Board on some of the policy issues implicit in the Administration's fiscal year 1982 budget proposal for NSF. These issues were primarily related to those areas which underwent large budget reductions in fiscal years 1981 and 1982: behavioral, cognitive, economic, and social sciences, science and engineering education, and certain international activities. The Board's discussion of its response at its 19–20 March meeting is summarized in the accompanying statement. After discussion between officials of NSF and the Office of Management and Budget, this statement was transmitted to Representative Walgren and other appropriate committees of the Senate and House.

school may find themselves effectively barred from technical careers.

At the present time the supply problem is largely confined to engineering, but the decline in interest and test performance of potential science and engineering students is a cause for serious concern. Continued, this could weaken the U.S. technical capability and broaden the areas of shortage beyond those now demonstrable. The National Science Board shares the deep concern of the scientific and engineering communities about these trends. The programs of the SEE directorate should represent experimental efforts to find effective ways to reverse them.

The Board agrees with the Administration that much of the burden of education is a local responsibility. At any reasonable budgetary level, the NSF's efforts would be too small to be fully effective in reversing the decline. Despite the NSF's mandate to strengthen science education, and strong support in the scientific community and the Congress for these efforts, there is not an effective consensus for federal support at a sufficient level to have adequate effect.

The National Science Board hopes that the NSF will be given sufficient flexibility to sustain the NSF's opportunity to lead a voluntary effort in collaboration with states and private institutions and the public to focus on the coming educational crisis, to evaluate its future impact on the nation's technological capabilities, and seek to define a credible, effective, and appropriate role for NSF in the future. While the Board acknowledges that solutions to science education problems at the precollege level must be accomplished by private citizens and local institutions, the Board is convinced that the NSF has an indispensable catalytic role it should not abrogate, even if the level of investments is severely curtailed.

Regarding special programs for women and minorities, the Board recommends that the director, to the extent practicable, assign responsibility to research program officers to seek increased ways to incorporate the desirable objectives of these programs into the administration of their grants. A sincere effort could mitigate the effect of elimination of the resources for these special programs.

### International Science and Technology

The National Science Board will utilize budgetary flexibility in a third area where the importance and impact on our international position outweighs the relatively modest sums involved. Our nation's scientific and technological primacy, so heavily challenged by other industrial nations today, contributes to the respect accorded in other nations to our defense and industrial strength. The NSF is frequently called upon to accept responsibility for implementation of many of the scientific commitments emerging from the President's foreign policy initiatives. It does so in cooperation with and at the request of the Department of State, for the NSF and the National Academy of Sciences, whose international activities the NSF frequently supports, are uniquely qualified to manage these activities.

Through these international cooperative activities, American scientists gain access to valuable knowledge and unique facilities in other countries. Our allies would be dismayed and more hostile countries would be dealt a political victory by default if the NSF were not able to fund an adequate level of U.S. participation. In addition, the loss of access to international facilities would place a heavy burden of capital investment on the United Stats to duplicate them.

The criteria used by the Board in program choices include three important parts. (i) Does the program accomplish the President's foreign policy objectives? (ii) Does the United States receive from its partners value commensurate with our investment? (iii) Do the cooperating countries permit their most able scientists to participate?

### Looking to the Future

From a strategic point of view, the National Science Board sees the role of the NSF strongly supportive of the President's two highest priority goals: to develop a dynamic economy and to ensure a secure nation. The Board recognizes that, while science has much to contribute, both to our culture and to the betterment of the human condition, the NSF is not a part of the "safety net" of social support, but must be measured against three stern tests. Do its activities comprise an essential component of national strength? Is it a federal responsibility to finance them? Does the NSF do so efficiently and well?

The Board recognizes that problem-solving applied research with a capturable rate of return is largely the responsibility of private industry. The Board therefore focuses the NSF's efforts on the most promising areas of nonproprietary science and engineering research—areas few, if any, companies could financially justify but from which all benefit. By recent reorganization the NSF is attempting to address the crisis in engineering research and training, so vital to industrial productivity and, thus, cost competitiveness.

At the same time, the scientific preeminence of the United States is being challenged in Europe and now increasingly in Japan, which realizes that it must match our scientific achievement if it is to advance from imitation to innovative technology. Keeping the United States strong in both areas—science and engineering—will be a serious stretch and will require continued focus on the primary policy guide to project selection at the NSF: competitive evaluation against strict quality criteria.

The National Science Board is also giving strong encouragement to urging private industry to expand its own investment in research through collaboration with scientists and engineers in universities.

The Board sees the technical content of the nation's economy continuing to shift from manufacturing to services and notes that two-thirds of the U.S. workforce is already engaged in the information sector. This trend indicates that elements of the social and economic sciences will continue to rise in practical economic importance, just as "software" in the computer industry exceeds "hardware" revenue growth rate and return in investment.

A study by the National Science Board of the role of the NSF in science and engineering education has been under way for several months and will form the basis for evaluating alternatives in the future. The Board will continue its support of research level education in science and engineering, including fellowships, and will develop appropriate programs for precollege science education suggested by the current study.

These policies will guide the National Science Board's program priorities within the total resources allocated to the NSF. To establish a rational basis for that total, it is necessary to evaluate the adequacy of the NSF's investment in research and scientific and engineering education. Such an evaluation would be most effectively conducted by the Office of Science and Technology Policy in the Executive Office of the President. The National Science Board stands ready to and is looking forward to cooperating with that Office and the Office of Management and Budget in the conduct of such an evaluation in looking toward the 1983 and 1984 fiscal year plans.