National Science Board: Its Place in National Policy

Eric A. Walker

The recent article on "Federal science policy," by Philip Handler (3 March, p. 1063), in which he discusses the role of the President's Science Advisory Committee and of the National Science Board, raises some interesting questions. Among other things it suggests a very careful reconsideration of the mechanisms by which the National Science Board can most effectively make its contributions to federal science policy. This same matter has in the past received considerable attention from the House Subcommittee on Science, Research, and Development (the "Daddario committee"), and a bill proposing changes in the status of the Board is once again before the Congress. Indeed, the whole question of the nation's scientific and technological progress, particularly in terms of the useful application of our accumulated scientific knowledge and its relation to the national economy, has become a matter of general concern. And the operations of the National Science Board clearly play an important part in this larger picture.

These considerations have prompted me to put on paper some of the impressions and opinions I gained during a term on the Board.

Throughout the history of the National Science Foundation, and indeed even before its formal establishment, the question of how much responsibility and authority the National Science Board should have has been a matter of contention and uncertainty. The original enabling act, after 5 years of congressional debate on the subject, was vetoed by President Truman on the grounds that it granted too much authority to the Board and thus infringed on the constitutional duties of the Chief Executive. The act which was finally signed in 1950 was far from clear with respect to the Board's role. And subsequent legislation, designed to resolve some of the initial uncertainties, has actually had the effect of making the Board's position more, rather than less, anomalous.

The Foundation, as originally conceived, was very largely the brainchild of Vannevar Bush, the director of the World War II Office of Scientific Research and Development. To him and to the other founding fathers, the concept was paramount that the nation's science policies should be determined by responsible leaders in science, education, and public affairs—men representative of the best scientific thinking in the country. To achieve this end, Bush, in his original report proposed an organizational structure for the new agency which provided for an unusual degree of autonomy and a very clear-cut pattern of authority and responsibility (*1*):

> Responsibility to the people, through the President and Congress, should be placed in the hands of . . . [the] Members, who should be . . . selected by the President on the basis of their interest in and capacity to promote the purposes of the Foundation. . . . The Members should elect their own chairman annually. . . . The chief executive officer of the Foundation should be a director *appointed by the Members*. Subject to the direction and supervision of the Members (acting as a board), the director should discharge all the fiscal, legal, and administrative functions of the Foundation.

Thus, as Bush and his committee conceived the Foundation, its organizational structure was to be modeled after the pattern of the large private foundations of the country rather than that of a typical government agency. The Board was to run the show, and the director was to be, in effect, the Board's employee. It was a simple and straightforward arrangement. The members of the Board, free both from external political pressures and from internal administrative duties, could apply their talents and exercise their collective judgment in the development of a meaningful science policy for the nation. Both the responsibility for establishing programs and the authority for carrying them out would rest clearly with the Board, with the director serving as its executive officer.

It was too much to hope, of course, that such an idealistic arrangement would meet with either congressional or presidential approval. Thus the enabling act, as finally passed, included complications and anomalies that made the Board's role in the operations of the Foundation cumbersome from the outset and almost assured the defeat of the founding fathers' intentions.

In the manner of compromise legislation, the act was too specific in some respects and too vague in others. The director of the Foundation, rather than being chosen by the Board, was to be appointed directly by the President (with the advice and consent of the Senate) and was to be a nonvoting ex officio member of the Board. These provisions seemed reasonable enough in the light of the Foundation's governmental character, but the act went on to enumerate specific responsibilities for the director which served to complicate his relationship to the Board. He was authorized to "exercise the powers of the Foundation" with respect to awarding scholarships, granting fellowships, and entering into contracts. Thus he was to be the agency's "contracting officer." But he was to perform this function "in accordance with the policies established by the Board" and with the express provision that no final action was to be taken in these matters "unless *in each instance* the Board has reviewed and approved the action proposed to be taken."

The Board was given the privilege of making recommendations to the President with respect to the appointment of the director and was granted the power to create its own executive committee (of which the director was also to be a nonvoting ex officio member), but was prohibited from assigning to its executive committee "the function of establishing policies, or the function of review and approval" of contracts and awards. The Board was to elect its own chairman. And it was specifically stated that the Board "shall, except as otherwise provided by this Act, exercise the authority granted to the Foundation by this Act."

It was an unusual and cumbersome arrangement. The Board, it is true, was free to determine overall policy, but it was the director who reported to the President. On the other hand, the Board was saddled with what actually

The author is president of the National Academy of Engineering and of Pennsylvania State University, University Park, Pa. 16802.

amounted to a large part of the organization's administration, while the administrative control of personnel rested with the director. And although the Board was charged with the development and pursuit of a national science policy, no mechanism was provided for the implementation of whatever decisions might be made in this respect.

Moreover, it was not at all clear just what was meant by a national science policy. Did this mean simply determining the overall needs of the nation as far as scientific research and education were concerned, or did it involve a composite of specific policies for the scientific affairs of Congress and the various executive agencies? Did it include an investigation and evaluation of the programs of other—frequently larger and more influential—federal agencies, and if so, by what means? In the light of these anomalies, it is understandable that, during the early years of the Foundation, little attention was paid to large-scale policy matters. Uncertain of the Foundation's place among the many federal agencies supporting research, limited by inadequate funds, and burdened with operational duties, the Board devoted most of its energies to working out practical arrangements for carrying out its own programs. The determination of overall policy, even for the Foundation itself, was by no means a simple matter. In this respect the act had provided for a troika-like arrangement which did not make for easy sledding. Three groups clearly played a direct part in policy guidance and control of the agency—the Congress, the Executive Branch, and the Board itself, each of which had, and still has, some measure of veto power over the Foundation's activities. As long as all three are in favor of a given policy or project, there is no problem. But if one of them wishes to exercise a veto, it can do so. Either the Congress or the Administration can thus negate a policy promulgated by the Board.

In 1958, an executive order clarified to some extent the Foundation's external responsibilities by instructing it "to recommend to the President policies for the Federal government which will strengthen the national scientific effort and furnish guidance toward defining the responsibility of the Federal government in the conduct and support of Federal research." And in 1959, the internal situation was improved by amendments to the National Science Act which permitted the Board to delegate authority to the director and to its executive committee to approve grants and contracts in certain situations. Yet in spite of these attempts to overcome some of the difficulties inherent in the original act, the Foundation seemed unable to fulfill the expectations of its founders.

To many the trouble appeared to lie in the Foundation's unusual structure. Complaints were heard that the NSF was "not like other Federal agencies," that it was not sufficiently responsible to or controlled by the executive branch, that it was too directly responsible to the Board. Suggestions were made that the Foundation should be put into the more regular pattern of other government agencies. For this and other reasons, the Foundation was reorganized by an act of Congress in 1962. What the reorganization plan did in effect was to push the Foundation further away from the concept which had been of prime importance to its founders—that of providing a workable mechanism by which the best scientific thinking of the country could be brought to bear on the development and pursuit of a sound science policy for the nation. By the 1962 reorganization, the Board—supposedly the representative of the nation's top scientists and educators—was placed in a curiously restricted position, both in relation to the Foundation's own operations and to its broader influence in the government's scientific affairs.

The tendency to strengthen the director's position vis-à-vis the Board had been evident in a 1959 executive order which designated him as a member of the Federal Council for Science and Technology. The act of 1962 further strengthened his position at the expense of the Board. First, he was made a full voting member of the Board. Since such an arrangement is fairly common in many universities and industrial corporations, this step was not seriously resisted by the Board. But the really curious provision of the 1962 act was that, in overhauling the executive committee to give it a more effective role in the Foundation's operations, it was specified that the director, rather than the Board chairman, should be chairman of the Board's executive committee!

The 1962 act also removed from the Foundation "so much of the function conferred upon" it by the original act —"to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences . . . as would enable [the director of the Office of Science and Technology] to advise and assist the President in achieving coordinated Federal policies" for this purpose. In addition, the act removed the Foundation's charge "to evaluate scientific research projects undertaken by agencies of the Federal Government" and transferred this function as well to the Office of Science and Technology. Thus the Board's opportunity for influencing federal science policy was further and severely restricted. As a matter of fact, if it had not been for the vigilance of some alert Board members, the Board would, at that time, have been stripped of all real authority and reduced to an advisory function. Discussions then took place and a compromise "truce" which lasted 3 years was the result.

The fate of the advisory committees under the provisions of the reorganization act is also significant. These committees, made up of scientists in separate disciplines, such as mathematics, astronomy, engineering, and others, had been an important communication link between the scientific fraternity and the Board. By making them responsible to the director, the 1962 act removed them from direct contact with the Board. And a later reorganization act (1965) abolished completely the statutory requirement for these committees. Since the committees had been removed earlier from the jurisdiction of the Board, the Board had no chance in 1965 to vote on the desirability of their statutory position.

What it all adds up to is that gradually, by successive steps, the National Science Board—originally envisioned as a largely autonomous group of leaders who were to have a powerful voice in the conduct of the scientific affairs of the nation—has become what amounts to little more than a routine committee for determining the specific awards and contracts of the National Science Foundation, with little power to enforce policy decisions. This is not to say, of course, that the larger purposes of the Foundation have, over the years, been unsuccessful. The present strength of United States science speaks to the Foundation's overall achievements. Nor does it mean that there has been serious contention or bickering between the Board and the director. It is to the credit of both the director and the members of the Board that they have been able to work effectively together

in spite of the curious organizational pattern forced upon them. What it does indicate, however, is that the Board, in its efforts to carry out its responsibilities, has found itself constantly hamstrung by operational restrictions and bureaucratic encumbrances.

It is not strange therefore that the Board has been regarded in some quarters as an ineffective body, nor that it has been charged with neglecting some of its basic duties. No reports have been separately issued by the Board, although until the last few years the Board chairman has contributed statements to the annual report of the director. But the Board's neglect in this respect can be at least partially explained by the fact that it has never been empowered to have a staff of its own, and although the suggestion has been made that it depend for its staff work on the regular Foundation personnel, this has not proved very practical. These people are part of a line organization headed by the director, and work for the Board is regarded by them as temporary additional duty, with a low priority. They have other duties and cannot be expected to serve two masters. Thus on many occasions, the Board's effectiveness has been seriously limited by its inability to get the facts on which it can base the policies it is responsible for.

On other occasions, where the facts are available and a policy has been formulated, the suggestions or directions of the Board have not been implemented. For example, the problem of what percentage of the cost of the research projects supported by the Foundation should be paid by the colleges or universities concerned has long been under discussion. On this question, there has never been, to all appearances, a firm Board policy. Yet the Board did direct that some fraction of the support of these projects should come from the university, and when the matter was discussed in Congress, it was suggested that this fraction be of the order of 5 percent. But this, as one of our congressmen has pointed out, is far too simple, and instead the country's research effort finds itself entangled in provisions which are complex, inequitable, and whose reasons for existence seem to be such a dark secret that they cannot be shared with the universities (*2*).

As mentioned before, the suggestion has been made on a number of occasions that, since the Board's position is so obviously an anomalous one, it might be advisable to simply make it, by legislative action, a purely advisory body. This suggestion has been vigorously resisted, on what appear to me to be very solid grounds. It seems to me that the original purposes of the Board are at least as important today as they were when the Foundation was established. Indeed, the nation's expanding research activity seems today to be more in need of capable direction than ever before. And it seems eminently desirable that this direction should come from the men whose technical competence and rational judgment have fitted them to make the decisions necessary for a sound science policy—men who are intimately familiar with the discovery and application of knowledge and who are willing to contribute a substantial portion of their time to the performance of an important public service.

Indeed it seems to me very likely that, if the National Science Board were to be further stripped of its authority and be made a purely advisory body, it would be impossible to get the same calibre of men to serve on it. As an advisory board, it would lose even the vestige of influence in national affairs that has been left to it. I cannot help but feel that whatever steps are taken by Congress to reorganize the National Science Foundation, they should be taken in the direction of strengthening the Board's role rather than diminishing it. The national policymaking role of the Board should be clarified not only in relation to the Foundation itself, but also in relation to the Office of Science and Technology, the Office of the Special Assistant to the President for Science and Technology, the President's Science Advisory Committee, the Federal Council for Science and Technology, the National Academy of Sciences, and the National Academy of Engineering. All of these groups can play an effective part in a national science program, but they can do so only with well-defined responsibilities and clearly understood assignments.

And there would be real advantages in restoring to the National Science Board some of the authority that, either by default or intent, it has gradually lost. The National Science Board has been made up, over the years, of men who to a large extent are as objective in their judgment and as conscientious in their decision-making as could be found anywhere. Their essential loyalty is not to the Congress, or to the Administration, but to science itself. Moreover, they are appointed by the President, with the consent of the Senate, for 6-year terms, which means that at least six of them span a 4-year presidential term. They are, in short, better qualified to carry out the task that men like Vannevar Bush envisioned for them than almost any other group that could be named. What they need is a clarification of their duties, an assurance of adequate authority, and as much freedom as possible from bureaucratic pressures and entanglements.

The legislation currently being considered for revamping the Foundation is a short step in the right direction; at least, it leans the right way. To some extent it supports the Board's own suggestion that the Board should "establish and be responsible for the policies and programs of the Foundation." At least it states specifically that the Board should "determine policy."

Yet it seems to me that many of the problems of the past could be alleviated if the Board were given a more clear-cut mandate, not only to establish policies but to determine programs as well, and to be made responsible for seeing that the programs really carry out the policies. It is for this reason that the Board by unanimous vote proposed the wording referred to above, wording which in my opinion was intended to mean (i) that the Board should establish the purpose and nature of the various individual programs supported by the Foundation; (ii) that the Board should exercise a continuing general surveillance of the awards made under such programs; (iii) that the Board should be empowered to modify or terminate such programs when in its judgment they no longer appear to serve the national interest adequately; and (iv) that the director bring to the Board those applications for grant or contract funds which raise matters of policy or of the interpretation of policy. In addition, the Board should obviously choose its own chairman, operate its own executive committee, appoint its own functional committees on the basis of practical needs, and be assigned a small staff to aid in necessary research and report-writing.

Yet even if all this were done, the question still arises as to who really runs the Foundation. The matter of administrative discipline is sometimes raised. Should Board members be permitted to raise questions publicly without approval of the Executive Branch, the Bureau of the Budget, or the President's Scientific Adviser? Or if

the Board promulgates a policy which it thinks is in the best interests of the country, should approval be obtained from the Executive Branch before such a policy is announced?

Some Board members object to the constraints of this sort of administrative discipline, and at least in the past have felt that prior approval of this type should not be required. It might be reasoned that the director—who is a presidential appointee, who is on the federal payroll, and who is making a career of federal service—is obviously subject to administrative discipline. But does the same reasoning apply to Board members? In fact, the question of giving testimony before a congressional committee itself has been raised. Must Board members offer only "approved" testimony? If so, this would seem to seriously weaken the Board's voice in terms of the purposes for which it was established. In my opinion, the nation would best be served by making that voice stronger. Unless some provisions are made to really strengthen the National Science Board, we are likely to witness a gradual shift of the control of national science policies and programs from the scientific community to the bureaucracy—with a consequent weakening and distortion of the whole scientific effort.

Reference and Note

1. V. Bush, *Science—The Endless Frontier,* 1945, reprinted by the National Science Foundation, Washington, D.C. (1960).
2. I have commented more fully on this matter in my letter to *Science* **155,** 1489 (1967).

Extraordinary Sex Ratios

A sex-ratio theory for sex linkage and inbreeding has new implications in cytogenetics and entomology.

W. D. Hamilton

The two sexes are usually produced in approximately equal numbers. Fisher (*1*) was the first to explain why, under natural selection, this should be so, irrespective of the particular mechanism of sex determination. His rather tersely expressed argument has been clarified by subsequent writers (*2*) and seems to be widely accepted. In bare outline, the factor of parental care being ignored, it may be given as follows:

1) Suppose male births are less common than female.

2) A newborn male then has better mating prospects than a newborn female, and therefore can expect to have more offspring.

3) Therefore parents genetically disposed to produce males tend to have more than average numbers of grandchildren born to them.

4) Therefore the genes for male-producing tendencies spread, and male births become commoner.

5) As the 1:1 sex ratio is approached, the advantage associated with producing males dies away.

6) The same reasoning holds if females are substituted for males throughout. Therefore 1:1 is the equilibrium ratio.

The argument is not affected by the occurrence or nonoccurrence of polygamy, or by any differential mortality of the sexes, provided this is uncorrelated with the sex-ratio genotypes.

More precisely, what has been called "Fisher's principle" of the sex ratio states that the sex ratio is in equilibrium when, in the population as a whole, the totals of effort spent producing the two sexes are equal. If the totals are not equal, producers of the sex corresponding to the lesser total have an advantage.

This article is concerned with situations where certain underlying assumptions of Fisher's argument do not hold. It will be seen that such situations must be quite widespread in nature. As regards ecological assumptions, for example, Fisher's argument is restricted to the actually unusual case of population-wide competition for mates. A contrary case wherein the competition is local is discussed in some detail. In some features it has an unexpectedly close similarity to certain types of situations considered in the "theory of games." Already the above outline seems to show that an individual supposedly able to choose the sexes of offspring would do best under natural selection by selecting the extreme opposite to the current sex ratio of the population—that is, by producing a unisexual progeny of whichever sex was currently in the minority. This game-like feature, which has already led one writer (*3*) to refer to genetically determined sex ratios as "strategies," in the sense of a play by the individual against the population, becomes accentuated as we proceed into circumstances of local competition.

Before considering local competition, however, it is convenient to discuss the consequences of failure of some of the genetic assumptions latent in Fisher's argument.

Sex-Linked Drive under Random Mating

Fisher's argument does apply to all cases where sex-ratio control is by genes acting in the homogametic sex, or in the female under the male-haploid system [contrary to some earlier statements of mine (*4*)], or by genes on the autosomes acting in the heterogametic sex. In all these cases the total number of the gene-bearer's grandchildren is a true measure of the propagation of the gene. This is not so in the case of sex-linked genes acting in the heterogametic sex.

For simplicity of argument, suppose the male is heterogametic. Then grandchildren through daughters are obviously irrelevant to the fitness of a gene on the Y chromosome. This fitness is measurable entirely by the number of sons. Sex-ratio control in the male is effectively the same as genetic control over the relative success of the X-bearing and Y-bearing sperm in fertilization. Suppose the Y chromosome has mutated in a way which causes it always to win in the race to fertilize. A male with the Y mutant then produces nothing but sons. Provided these

The author is lecturer in genetics in the department of zoology and applied entomology, Imperial College, University of London, working at Imperial College Field Station, Silwood Park, Sunninghill, Berkshire, England.