THE ISSUE OF PEER REVIEW: A CASE STUDY OF THE AGENCY-TO-INDIVIDUAL APPROACH TO FEDERAL FUNDING OF SCIENTIFIC RESEARCH

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ABSTRACT

THE ISSUE OF PEER REVIEW:
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by

Edmund F. Vandette

The federal government historically has chosen to support scientific research in a number of areas through two basic mechanisms. One is the agency-to-institution approach wherein the federal agency concerned provides a research grant directly to a selected institution. The second, which has become more prevalent since World War II, is the agency-to-individual approach wherein the federal agency concerned awards a research grant directly to the individual involved. Therefore, the decision regarding who does the research and how it is done is not decentralized, but, to a large extent, lodged in the federal agency which thus retains the ultimate decision-making power rather than the institution having such authority as in the first basic mechanism.

A prime characteristic of the agency-to-individual approach is peer review, the underlying assumption of which is that proposals should be judged by people who have the substantive expertise needed to make such a judgment. Yet in recent years there has been increasing criticism directed at this approach. This study's focus was the nature of that criticism and its implication for the workability of the peer

review system.

The model for this study was the National Science Foundation because either individual or peer panel review is utilized by the Foundation in its evaluation of the vast bulk of formal requests for funds. Moreover, the process employed by NSF was made particularly visible in a series of oversight hearings held in the summer of 1975 by the Congressional Subcommittee on Science, Research, and Technology.

In addition to testimony from these hearings and recommendations made by the Subcommittee based on this testimony, this study utilized the historical method to determine past trends in policies and practices relative to the awarding of research grants. This researcher also employed the interview technique in gathering relevant data on a personal basis from many sources in government and educational institutions and within the National Science Foundation itself.

The study was conducted in order to answer questions regarding whether or not the peer review system (1) provides for the advance of science in the most effective way possible; (2) is fair and impartial and subject to political influence and geographical favoritism; (3) is economically feasible; (4) promotes "grantsmanship" and is too secretive.

Based on the anwers to these questions gained through the research methodology described above, this study concluded that there is confidence in the peer review system, that, indeed, data indicate that agency staff could not perform as well without the system intact. In addition, though

a lack of confidence in the willingness of the system to support innovative research was expressed, consensus was that no method superior to peer review has been found for judging the scientific competence of proposals. Regarding secrecy, favoritism, and "cronyism," this study found that less candid reviews would be made if signed verbatim reviews were available to applicant and public; that the existence of "cronyism" is possible, though it had not been witnessed by those consulted by this researcher; and that geographic and economic distribution of grants appears normal. Finally, the research suggests a need for further study of the overall effect of the competition promoted by peer review on university communities.

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INTRODUCTION

The federal government historically has chosen to support scientific research in a number of areas through two basic mechanisms. One mechanism, which had its origin in the agricultural land grant system, initiated by the Morrill and Hatch Acts in the mid-1800s, is the agency-to-institution approach wherein the federal agency concerned provides a research grant directly to a selected institution. Because the institution makes the majority of the decisions on the specific areas of research to be pursued, the approach typifies the decentralized research effort. The prime focus of the federal agency is simply to supply the necessary resources without giving much more than general direction as to the type of research that is going to be done and the manner in which it will be carried out.

The second basic mechanism, which has become more prevalent since World War II, is the agency-to-individual approach wherein the federal agency concerned awards a research grant directly to the individual involved. This

approach has a number of variations, but is best characterized by the fact that the federal agency indicates that it wants certain research undertaken and then awards grants directly to the individual concerned with the expectation that he or she will complete the research. In other words, the decisions regarding who does the research and how it is done are not decentralized but, to a large extent, lodged in the agency. The federal agency thus retains the ultimate decision making power rather than the institution having such authority as in the first basic mechanism.

THE PROBLEM

In recent years there has been been increasing criticism directed at the agency-to-individual approach when that approach involves, as one of its prime characteristics, a review of individual project proposals by peer groups. A "peer review system" is here defined as a method of evaluating a specialized creation--such as a proposal to perform scientific research--which involves having a group of people knowledgeable in the area of specialization evaluate the creation. The experts are called "peers," the term loosely deriving from the relationship between the proposer and the evaluators.[1] Thus, the underlying

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[1] National Science Foundation Peer Review, Vol. I., A Report of the Subcommittee on Science, Research, and Technology of the Committee on Science and Technology, U.S. House of Representatives, Ninety-Fourth Congress, Second Session (Washington, D.C.: U.S. Government Printing Office, 1976), p. 13.

assumption of such group review is that proposals should be judged by people who have the substantive expertise needed to judge the proposal. The present investigation is concerned with that variation of the second basic mechanism described, namely the agency-to-individual approach involving peer review as an essential element, and with the various criticisms which have been aimed at its operation (hereinafter agency-to-individual approach and peer review system will be used interchangeably).

BACKGROUND OF THE PROBLEM

The Origin of the Agency-to-Institution Approach

Federal involvement in higher education is not a new phenomenon. Federal lands were set aside for public education in the Northwest Ordinance of 1787.[2] Further, the federal government was basically responsible for the creation of America's unique system of land-grant colleges and universities when, through the passage of the Morrill Act of 1862, it granted substantial amounts of land to the states on the condition that they sell the land to endow at least one college in each state.[3] The Morrill Act did not specify that these were to be "public" colleges,

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[2]Christian K. Arnold, "Higher Education: Fourth Branch of Government?" Saturday Review (January 1964), p. 61.

[3]Ibid.

but the establishment of the institutions under the provisions of the Act helped to crystallize the concept of public higher education in the United States. The Act did require that these institutions be under the jurisdiction of the state legislature and did define, in general terms, the types of programs, students, and oversight that were to be involved. In 1953 the National Manpower Council could report that "the most important single government step in connection with the training of scientific and professional manpower" was the Morrill Act.[4]

As an extension of the philosophy and principles of the Morrill Act, the Hatch Act in 1887 directed the establishment of tax-supported institutions for agricultural research, and its comprehensive phraseology permitted a broad range of agricultural station functions. The preamble marked out the wide limits of authorized activity, from "acquiring and diffusing . . . practical information" to "scientific investigation and experiment respecting the principles and applications of agricultural science."[5] With equally generous phrasing, Section 5 instructed the governing board of each experiment station to use the Hatch funds for "paying the necessary expenses of conducting investigations and experiments and printing and distributing

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[4] Ibid.

[5] H. C. Knoblauch, E. M. Law, and W. P. Meyer, State Agricultural Experiment Stations (Washington, D.C.: United States Department of Agriculture, 1962), p. 81.

the results."[6] Thus, the law, which allowed each station to shape its own definition of research activity, approved both "pure" science and "applied" science; yet it did not prescribe the features which research activity must possess in order to be classified as "scientific" or "applied" and, therefore, to qualify for federal support. Moreover, the lack of specificity in the statute let the stations specialize, if they chose, in providing only known information to the farmer rather than in discovering new knowledge.

The broad latitude of the Hatch Act became the keystone of its popularity. It won the support of those people who saw in it a means for stimulating scientific effort toward new discovery. It also gained cooperation from an increasing number of people who regarded it not only as an incentive toward new discovery, but also as an immediate and practical method for wide application of scientific knowledge to farming.[7]

Under the Act, funds appropriated annually by the Congress are distributed among the states by a formula that takes into account such factors as the size of the rural population in each of the several states and plans for regional, interstate research. Programs supported by these funds are initiated by plans outlined within the

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[6] Ibid.

[7] Ibid.

institutions under the supervision of the directors of the experiment stations and of the extension programs. These directors are solely responsible for the administration and guidance of the programs, but both past performance and future plans are reviewed and evaluated annually by the Secretary of Agriculture and by the Congress during appropriation hearings.

The institutions have a wide degree of freedom in in the use of these funds (a clear example of the agency-to-institution approach at work). Experiment stations, for instance, may undertake basic research, as in biological science, or applied research. The directors may--in fact, are encouraged to--pool their resources with other experiment stations to attack regional problems; and the funds may be used for research carried out in cooperation with industrial organizations, state and county governments, and foundations.

To a considerable degree, federal funds can also be used for overhead expenses. They can even be utilized to pay the institution's contribution to retirement systems, social security, and group insurance programs. They may be used to pay the necessary expenses of administrative planning and direction and, for research programs, they may be employed in the construction of buildings, the buying of lands, and the purchase of fixed equipment.

The basic legislation for these Hatch Act programs is "open-ended," and the continuity provided through the

annual appropriations makes it possible for the university officials to plan their programs years in advance. Actually, the law authorizes the experiment stations to anticipate appropriations in order to contract for equipment essential for carrying out the research programs. The research effort operationalized through this system is totally integrated with the instructional programs of the institutions involved and has strengthened, rather than weakened, them. In fact, the agricultural experiment stations, under the law, must be departments of the universities in which they are located.[8]

The Origin of the Agency-to-Individual Approach

The type of research that grew up during World War II, which was "new" only in its expanded degree of federal involvement, did not lend itself to the agency-to-institution type of relationship promoted by the Hatch Act encouraging agricultural research. The government needed specific answers to specific questions, and the answers were often in the form of "hardware."[9] To get these answers, the federal agency that needed them simply went out and purchased the services of the person or organization the agency felt most likely to do the best possible job. Unlike the system established under the Hatch Act,

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[8]Harold Orlans, Science Policy and the University (Washington, D.C.: The Brookings Institution, 1968), p. 90.

[9]The term "hardware" is here used to mean tools, machinery, etc., the production of which is in high demand during wartime.

there was little pretense in the arrangements for providing general and continuing support of research; the government was simply purchasing short-term services it needed and which it could not itself provide. This approach led, at one extreme, to the establishment of laboratories essentially owned by the government but operated by universities, such as the wartime Harvard Underwater Sound Laboratory, and, at the other extreme, to the temporary employment of a university scientist by a governmental agency.

Federal involvement in research did not stop at the end of World War II, but rather grew and flourished. Wartime experiences, in fact, demonstrated and accelerated the growth of our national dependence on the extension and application of scientific knowledge as a necessary condition for the continued welfare of our people, the preservation of our national integrity, and even the maintenance of human dignity and freedom.

However, the nature of the research needed did change. The need became generalized, and long-term goals replaced short-term objectives. "Hardware" became less important than broad-based explorations of fundamental phenomena. The "production" of engineers and scientists rated equal priority with the employment of those already available. During the war the United States had engaged in a "frantic and rather ruthless exploitation" (said J. Robert Oppenheimer) of the basic knowledge accumulated in the years before the war. Now it needed to engage in a "sober

modest attempt to penetrate the unknown," to replenish and increase our stock of basic knowledge.[10]

Some people foresaw this change, and legislation was passed to provide mechanisms for coping with it. The National Institutes of Health were established with broad responsibilities for research relating to health; in 1946 the Atomic Energy Commission was given research responsibilities involving nuclear processes. Then, four years later, the National Science Foundation was created to "promote the progress of science." Even for the more narrowly "mission-oriented" agencies, research tended to become broader, more basic, less "hardware"-ish.[11] The posture of the government became more that of a patron of research than that of a purchaser of services.

In this emerging system the university itself was largely bypassed. Individual members of faculties began to submit proposals for research to the appropriate agency, often after formal discussions with staff personnel at the agency. These proposals were reviewed by advisory boards composed of eminent scientists (often the elder statesmen in the field), and, on the basis of their recommendations, grants were made or contracts let. The basic relationship established, then, was an agency-individual one, in contrast to the agency-university relationship established with

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[10]Arnold, p. 62.

[11]Orlans, p. 93.

agricultural research and extension.

The Variations of the Agency-to-Individual Approach

Under the agency-to-individual approach federal agencies use five basic means to support research activities: invitation for bid, request for proposal, grant announcement, unsolicited proposal, and sole source contract. Within these means there are specific elements of the peer review system which can be operative alone or in combination. These elements include:

1. staff judgment - there are two extremes here: the heavy reliance on staff to determine how a proposal will be reviewed, select reviewers, use reviewers as only advisors, and make the decision on funding; or the minimal use of staff for only clerical functions;

2. individual peer review - occurs when an expert outside the staff evaluates a proposal without consulting other evaluators;

3. panel peer review - occurs when a group of experts meets together to evaluate a proposal; the panel may be a standing or an ad hoc group;

4. site visit - takes place when a team composed of agency staff and/or outside experts visits a scientific facility when the quality of that facility is a determinant in the funding of the proposal;

5. policy board - usually a standing group with rotating membership that considers especially crucial

questions regarding a proposal's appropriateness for a particular agency;

6. consultation with other funding agencies - is necessary when a proposal requests partial funding from several agencies.[12]

Invitation for Bid

The most directive type of procurement is one whereby the agency specifies and justifies some clear need and gives the detailed specifications of the outcome it wants. In such cases the agency itself issues its developed specifications in as full detail as possible in what is called an Invitation for Bid.[13] The bid acceptance consists of nothing more than the offerer signing his name to the solicitation, thereby indicating that he will comply with the specifications, and giving a price; indeed, the only consideration in this kind of procurement is price--the low bidder gets the contract.

Request for Proposals

The second type of procurement, and one which is used very extensively at the National Institute of Education, is called the Request for Proposals. In this case the requirement again is clear and indeed there may be an indication by the agency of what the end product should

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[12] NSF Peer Review Vol. I, pp. 13, 14.

[13] Tom Clements, Personal Interview, National Institute of Education, Washington, D.C., December 1975.

look like; but the requirement is in an area where there is sufficient ambiguity so that alternative paths to attaining that requirement may be used. There is a little bit more opportunity for offerer initiative and creativity here.

In this second type of agency procurement, the proposals that come in go through a two-stage review. The first review is one of the technical merits of the proposals, with no idea whatsoever as to the price on any of them; at this stage a competitive range is established. Next, those proposals which do not merit further consideration are identified and discarded with a justification as to the reasons for their rejection. This process is usually conducted by staff but with the cognizance of the Director.

Following staff review and evaluation, the second stage usually uses outside field reviewers who establish the competitive range of proposals which may not be perfect but in which there is enough merit to consider negotiation. These reviewers then quantify the resultant scores to the greatest extent possible. For each proposal they develop a schedule of negotiable items indicating those technical issues which have to be addressed in any revision of the proposal in order to raise it to what they consider the acceptable level. At that time, then, the bids are open, the cost proposals made, and, here again, the outside reviewers identify those which are

completely unreasonable and those which are in range. They then associate the price bid with the technical proposal to make sure that they are appropriately supportive of each other and identify places where the agency thinks there are again negotiation issues.

The contract officer (who may act by himself at this point, though frequently, in technical matters, a program person may be involved) will present this schedule of negotiable items to each bidder who is within the competitive range. The bidders then usually have about two weeks to think through their approach and costs and give the agency what is called the best and final offer. The staff again does a technical review and scales the revised work plans according to their technical merits, again without any examination of price. If the staff then finds two or three which are good enough, the contract goes to the low bidder.

Grant Announcement

In the third method by which federal agencies can support research the agency has some kind of a broad area of interest or concern but wants to encourage the best ideas in the field; an example might be a program of research on reading comprehension. Rather than issuing a Request for Proposals, then, a Grant Announcement is issued. If there is any way in which the competition is going to be limited, for instance to non-profit corporations, then

formal rule making is required as well as the Grant Announcement itself. The Grant Announcement simply specifies a broad area of interest by defining the limits of that area, presents the criteria and review procedures, and gives the date for proposal submission. Then, usually a fairly pure peer review process prevails here and the end result of their approval is not a contract but a grant. This method has a tendency to encourage not only initiative at the application end by the individual scholar, but it also provides him with a good deal more latitude in terms of the way he operates (a quality unique to the rendering of a grant rather than a contract).

Unsolicited Proposal

The fourth way in which procurements are engaged by federal agencies is via the Unsolicited Proposal. In fact, it is a matter of HEW policy that agencies are always open to Unsolicited Proposals which means that anybody with an idea can send that idea in any form with a price attached to it and that proposal gets attention. What happens on a formal basis is that about every three months an agency has a small panel of internal people examine the group of unsolicited proposals that has been submitted to make sure that the proposals are indeed germaine to what the specific agency is about and that there is sufficient information on the topics to do a fair and honest review job. A selected proposal goes to a staff

office where it undergoes staff review. If the proposal has a good deal of promise or if the staff feels it does not have the competence to judge it, external reviewers are used as well, not as a panel, but as individual reviewers, and they provide individual opinions, without any consensus, about the proposal. The staff then processes the range of comments and comes to a determination to fund or not fund the proposal. Significant to note here is that an Unsolicited Proposal is a reward for originality. In essence, then, what an agency is doing is reinforcing creativity with an unsolicited award.

Sole Source Contract

There is one last method of research solicitation which is a kind of a variation of the first two directive types discussed above, and that is the Sole Source Contract, which is usually avoided unless it is the only alternative. In the Federal Procurement Regulations there are some thirteen to fourteen conditions which govern when competitiveness should be relinquished for this type of procurement. These conditions include national exigencies, for example. An agency takes the position that anytime there is going to be a sole source procurement, the staff must first of all do an honest and energetic job of seeking sources of performance. If it finds that there is only one performer who can do the job, it then, before any involvement with that performer at all, must attain approval from the highest agency levels first,

that the work to be performed is important enough to take this step; second, that this performer has the qualifications that are needed to do the work; and, third, that there is documentation that only this performer has the competency to do the work. Only when these three conditions are met and acknowledged by the agency's Deputy Director or Director will the agency use the Sole Source Contract.

SIGNIFICANCE OF THE STUDY

The underlying assumption of the peer review system (a system which is an integral part of the five types of agency-to-individual research support methods just outlined) is that proposals should be judged by people who have the substantive expertise which is needed for such judgment, people who are the peers of the eminent scholars in the field. Indeed, as early as 1963, Philip H. Abelson had this to say: "The influence of the peer review system or any other method of support potentially affects all researchers in the United States."[14] Yet in 1975 Rep. R. E. Bauman of Maryland denounced the system in bitter terms on the floor of the House by saying:

> I suggest that there is a need for revision of the basic system by which . . . research grants are made. They are handed out in an unregulated and secretive manner known as the "peer review system." This system allows cronies to get together and finance their pet projects, where grant application

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[14]"Proliferation of Bureaucracy," Science 163 (February 1969).

> writing has become an art and where many people are not devoting themselves to basic research needs but rather to feathering their own nests.[15]

Such criticism led this researcher to an investigation of the peer review system in an effort to determine both its strengths and its weaknesses--and the possibilities for change. This investigation began with a review of current articles on the subject from research journals and newspapers, the majority of which were mostly critical. Also observed was the fact that these criticisms were not isolated to educators or research specialists at universities but included business and Congress itself. Occasionally embodied in the criticism was reference to past governmental techniques of funding research and suggestions that they were more equitable and produced better results than current modes.

The reliability of such criticism is not to be accepted blindly. Rather this researcher chose to examine the peer review system in federal funding of research himself. This examination, based on information from the literature and experts' observations of the process at work, can then lead to a greater understanding of peer review and thus put the system into proper perspective for evaluation.

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[15]U.S. Congress, Rep. R. E. Baumann denounced the peer review system on the floor of the House. Congressional Record, 24 June 1975, p. H6015.

STUDY DESIGN AND RESEARCH QUESTIONS

The model for this study was the National Science Foundation (NSF) because either individual or peer panel review is utilized by the Foundation in its evaluation of the vast bulk of formal requests for research funds. Moreover, the process employed by NSF was made particularly visible in a series of oversight hearings held in the summer of 1975 by the Congressional Subcommittee on Science, Research, and Technology.

In addition to testimony from these hearings and recommendations made by the Subcommittee based on this testimony, this study utilized the historical method to determine past trends in policies and practices relative to the awarding of research grants. Moreover, this researcher employed the interview technique in gathering relevant data on a personal basis from many sources in government and educational institutions and within the Foundation itself. The results of a poll conducted by Industrial Research on peer review were also used as supportive data for the conclusions of this study. Finally, telephone contacts were made with various individuals and universities when expediency demanded information from them relative to the focus of this study.

The study was conducted in order to answer the following critical questions regarding the peer review system employed in the agency-to-individual approach to federal funding of scientific research:

(1) Does the agency-to-individual approach, which employs peer review, provide for the advance of science in the most effective way possible?

(2) In terms of the samples involved, is the agency-to-individual approach, with its operative system of peer review, a fair and impartial approach? Is it subject to political influence, "cronyism," geographical/institutional favoritism?

(3) What are the economic arguments for and against the peer review system?

(4) Is there opinion to substantiate the charge that the agency-to-individual approach promotes "grantsmanship" at the expense of scientific excellence? What kinds of grants are being made? What types of research are being supported? Is the system too secretive?

LIMITATIONS OF THE STUDY

The first major limitation of the study resulted from the investigator's decision to restrict himself to the examination of the second general category of federal funding for research, the agency-to-individual approach, with its peer review system, and the operation of that approach within NSF. This limitation, of course, was introduced purposely to make the study manageable. The decision proceeded from the writer's early realization that to study the problem more comprehensively would be an overwhelming task.

A second limitation flowed from the first. Because of ease of access, NSF was chosen for specific study instead of all federal agencies which have monies for the support of individual researchers. Thus, this is an exploratory case study since at this point a scientific sample of all agencies is not available. The researcher of course realizes that generalizations from this limited study cannot be applied to all of the agencies supporting research in the federal government.

A third limitation resulted from the inherent biases which the subjects interviewed possess and which are present, to some degree, in the documents investigated.

A fourth limitation grew out of a certain amount of reticence on the part of those participating in the entire investigation. Because of this situation, certain key actors (although surprisingly only a very small number) would not submit to personal interviews; nor was the writer able to gain free access to all of the documentary evidence extant. This limitation hopefully may be removed for future research once some of this information is revealed and discussed.

OUTLINE OF THE STUDY

Following this introductory chapter, Chapter II of this study will review the literature relevant to federal funding of research, in general, and to the growth and development of the agency-to-individual approach to such

funding which utilizes the peer review system, in particular. This review will encompass an historical overview of the movement from the agency-to-institution approach to the agency-to-individual approach. The second chapter will also describe the National Science Foundation (the model for this study) and define its peer review process.

Chapter III will present the design of the study and describe the methodology used to attain data relevant to the research questions. Chapter IV will reveal the findings of this researcher with regards to the research questions posed concerning the effectiveness and impartiality of the peer review system. And Chapter V will offer suggestions for change in the system, if research indicates such are warranted, and recommendations for areas of future research on this topic.

CHAPTER II

AN HISTORICAL REVIEW OF FEDERAL RESEARCH FUNDING: FROM LAND GRANT COLLEGES TO THE NATIONAL SCIENCE FOUNDATION

INTRODUCTION

Any review of literature in the area of federal funding of research reveals a pattern in the development of a government philosophy regarding such funding. That pattern is a clear reflection of this nation's growing technology, a growth which demanded from science and government that research keep pace with the changing needs of the American populace. Thus, one finds that the early land grant colleges and agricultural experiment stations were funded on an agency-to-institution basis because the government believed it could best encourage and monitor the agricultural research needed by a farming oriented nation through a partnership with the nation's centers of learning. That belief began to alter with the shift in our country's needs brought on by a wartime economy, a shift which signaled a greater emphasis on industry precipitated by the demands of the war machine and America's growing defense technology. Now the federal government saw its role in research funding going beyond its

partnership with universities; it needed, instead, to deal directly with those researchers who could develop "hardware" to meet its particular defense specifications.

At the close of the War President Franklin D. Roosevelt was anxious to continue the scientific advances begun in the name of defense, to perpetuate the federal government's actual encouragement, through funding, of research efforts by universities, laboratories, and individual scientists. As a result of his desire, Vannevar Bush, Director of the wartime Office of Scientific Research and Development, was commissioned to report on how Roosevelt's dreams could be made reality. Bush's history-making document, Science - The Endless Frontier, laid the groundwork for a whole new philosophy for government funding of basic research. And the National Science Foundation, established in 1950 as a result of Bush's recommendations, made that philosophy operative as its peer review system began the task of stimulating individual scientists to contribute their knowledge to a technologically changing America.

THE AGRICULTURAL EXPERIMENT STATION: THE DEVELOPMENT OF THE AGENCY-TO-INSTITUTION APPROACH

The best example of institutional grant development and procedure is contained in Knoblauch, Law, and Meyer,[16] whose purpose in their work is to document and evaluate

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[16] p. 3.

administrative policy developments in the operations of the State Agricultural experiment stations. It is a history of cooperative research procedure and policy development under the dually administered system of publicly supported agricultural research of the State Experiment Stations and the U.S. Department of Agriculture. Although intended primarily to aid agriculture, this development combining laboratory research and classroom training became the model now used in most areas of preparation for a career in science and technology; it also set in place a unique pattern that many still regard as the model for effective State-Federal cooperation in scientific endeavor.

The German Experiment Station Movement

A pioneer in this endeavor was Samuel W. Johnson who spent a lifetime searching for the most effective way to institutionalize research in agriculture. He personally observed the German experiment station movement in its infancy and became America's first advocate for a similar movement in the United States, noting that:

> There have been lately established in Germany, especially in Saxony, a number of so-called experiment stations, or experimental farms, with laboratories in connection, for the exclusive object of promoting scientific agriculture. These are intended to make science practical, and practice scientific, and no agency can be desired better adapted for these important purposes.[17]

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[17] S. W. Johnson, On the Relations that Exist Between Science and Agriculture (New York: State Agricultural Society Trans., 1855), 15: 73-80.

Johnson also proposed that American farmers ignore their slow-moving state legislatures. He urged each county to recruit a large membership with a minimum of 2,000 dues-payers, incorporate itself as a "Scientific Institution," adopt a constitution, and elect officers, a board of directors, and "one or more professors of agricultural science"; he also urged the construction of a building containing lecture rooms, a library, and, in particular, an analytical chemistry laboratory.[18]

In 1854 Johnson travelled to Moeckern in Leipzig, Germany to visit a new institution which its founders called an Agricultural Experiment Station. He later translated into English the statutory provision authorizing the new institution to conduct scientific research in agriculture. The station concentrated in one location all necessary facilities for the conduct of research in the laboratory and in the field. Thus, the station was directed to concentrate on research as a profession.

The Hatch Experiment Act

In the United States the movement to institutionalize experimentation on a formal and practical basis at federal expense gathered momentum from 1855-1861. Johnson and his advocates made their influence felt in the discussion and policy formulation that took place between 1862 when the Land Grant Act was passed and 1887 when the

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[18] Ibid.

Hatch Experiment Station Act became law.

The Land Grant Act of 1862 established the United States Department of Agriculture and helped give the Department a scientific reputation. However, the Act did not require the Commissioner to be a scientist, nor did it designate scientific research as his sole duty.[19] In fact, not until the late 1880s was there crystallization of any clear departmental research policy based on long continued experiments.[20]

The basic legislation authorizing the establishment of federal grant payments to agricultural experiment stations came with the First Morrill Act of 1862, "an Act donating public lands to the several States and Territories which may provide colleges for the benefit of agriculture and the mechanic arts." This Act provided the first federal, legal authority under which the cooperative features of today's nationwide agricultural research system were to develop.

Slow progress in developing the Agricultural Department as a national experiment station served as an incentive in the states to go ahead with state stations. As A.C. True has noted:

> . . . up to 1872 only 6 colleges in the country taught either chemistry or physics by the laboratory

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[19] Knoblauch, Law, and Meyer, p. 25.

[20] E. D. Ross, The U.S. Department of Agriculture During the Commissionership (Washington, D.C.: Agricultural History, 1946), pp. 129-143.

> method. The early use of the method, thus, was scattered and purely experimental. It remained for the land-grant colleges to assist in a development basis of necessity rather than design.[21]

A station founding decade followed from 1877-1887.

The winning of federal support for the Land-Grant college system came when the Hatch Act became law in 1887. This Act produced the land-grant college agriculture experiment stations and, in the process, set a precedent for federal-state cooperation in agricultural research.[22]

The preamble to the Hatch Act marked out the widely spaced limits of authorized activity which ranged from:

> acquiring and diffusing . . . practical information to scientific investigation and experiment respecting the principles and applications of agricultural science.[23]

Furthermore, the Act had broad latitude which became the keystone of its popularity as well as a mark of its future weakness. As Knoblauch has noted:

> Could not the trustees, often more zealous for teaching than for research, apply the funds to college instruction at the expense of the station interests envisioned by career directors and scientists?[24]

Also, the generous inclusion of the word "diffusion" in the Hatch Act placed the interest of research at a serious disadvantage. The states most in need of a concentration on research lacked either the resources to accommodate the

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[21] Knoblauch, Law, and Meyer, p. 3.

[22] Ibid., p. 52.

[23] Ibid., p. 90.

[24] Ibid.

extension movement, or the willingness to preserve the Hatch income as a trust fund for research.[25]

New Developments in the Twentieth Century

Therefore, led by Dr. A. C. True, Director of the Office of Experiment Stations, a movement for a new federal endowment authorizing and directing only original research emerged as the necessary solution to the problem. In a scholarly statement Needs of the Station: U.S. Department Agricultural Office Stations Annual Report 1903, True declared that the stations could not produce, without an immediate and substantial increase in revenue, the scientific discoveries basic to a steadily improving technology in agriculture. He noted:

> Under present conditions it is useless to expect that . . . our stations will discover many of the principles on which permanent improvement of our agriculture must rest, but unless the way is open for them to seriously attack these fundamental problems their future work will necessarily be comparatively fragmentary and inconclusive. They may, as in the past, obtain many results which can be usefully applied in practice but they will not be able to furnish solid foundations for the enlargement of our agricultural industries.[26]

What was being requested,then, was a second federal donation based on the precedent of the Hatch Act, a request which was fulfilled with the passage of the Adams Act in 1906. This Act firmly established the principle in American governmental policy that federal aid shall join with

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[25]Ibid., p. 95.

[26]Ibid., p. 100.

state aid for the purpose of subsidizing scientific research in the state stations.[27]

The Purnel Act of 1925 and the Bankhead-Jones Act of 1935 added to an even more complete endowment of the Agricultural Experiment Stations.[28] And legislation in 1946 and 1955 further extended research in the land grant colleges.[29] This development of agency-to-institution funding thus set a pattern for federal and state and university relations and became the model for research grants referred to as "agency-to-institution" grants.

THE NEED FOR WARTIME "HARDWARE": THE DEVELOPMENT OF THE AGENCY-TO-INDIVIDUAL APPROACH

The relationship between government and the scientific community was changing as a result of new demands foisted upon research by the nation's defense needs in World War II. Over 100 years earlier, the National Academy of Sciences had been created to serve as a link between science and the special needs of the government during the Civil War. The Academy's first report dealt with a naval subject: the intriguing and practical problems of calibrating compasses aboard ships equipped with iron smokestacks. Since that time, however, the technical problems had become more complicated and so had the

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[27]Ibid., p. 107.

[28]Ibid., p. 108.

[29]Ibid., p. 119.

relations between government and science.[30]

World War I led to the formation of the National Research Council to enable the Academy to make more effectively the contributions which a considerably matured structure of science could offer to a new set of wartime needs. And World War II generated additional organizations, such as the National Defense Research Committee and the Office of Scientific Research and Development, as part of the Executive Branch of the government itself. In the course of those wartime years the basic sciences and the universities were mobilized in strikingly effective ways to support wartime objectives.[31] And though the methods by which these scientific resources were put to work were informal, by the end of World War II there were quite a number of responsible people who understood the essential national needs of a continuing connection between the government and basic research, a connection to be forged by expanding government support of scientific research. The agricultural research needs attended to by the experiment stations established under the Hatch Act (and supported by government funds paid to the institutions connected to these stations) were now joined by the country's growing need for a different kind of science and

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[30]Ibid., p. 119.

[31]F. Joachim Weyl, ed., Research in the Service of National Purpose (Washington, D.C.: U.S. Government Printing Office, 1966), p. 126.

technology to serve industry, medicine, and education.

The Forerunners

The Bush Report

In March 17, 1944 President Franklin D. Roosevelt sent a letter to Dr. Vannevar Bush, Director of the Office of Scientific Research and Development, requesting that he submit to the President his recommendations with regards to the following areas:

1. Diffusion of knowledge, consistent with military security, to world nations regarding American contributions to science made during the war effort.

2. Organization of a program to further research into disease.

3. Government aid to research activities conducted by public and private organizations.

4. Proposal for a program for discovering and developing scientific talent in American youth.[32]

Responding to the President's demand that the information, techniques, and research experience developed by the Office of Scientific Research and Development and by scientists in universities and industry be used in the days of peace for "improvement of the national health, creation of new enterprises bringing new jobs, and the betterment of the national standard of living,[33] Dr. Bush

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[32]Vannevar Bush, Science - The Endless Frontier (Washington, D.C.: National Science Foundation, 1945), pp. 3-4.

[33]Ibid., p. 19.

charged that, indeed, the federal government had no real national policy for science, nor a government body with responsibility for formulating or executing a national science policy.[34] And to correct these deficiencies, Bush presented a blueprint for implementation of such a policy and such a body, Science - The Endless Frontier. In that report Dr. Bush viewed the public and private colleges and the endowed research institutes as the centers of basic research that must furnish both the new scientific knowledge and the trained research worker. And Bush saw five fundamentals that must underline government support with respect to the organization of the administration of scientific activities within the government:

> (1) Whatever the extent of support may be, there must be stability of funds over a period of years so that long range programs may be undertaken.
> (2) The agency to administer such funds should be composed of citizens selected only on the basis of their interest in and capacity to promote the working of the agency. They would be persons of broad interest in and understanding of the peculiarities of scientific research and education.
> (3) The agency should promote research through contracts or grants to organizations outside the Federal Government. It should not operate any laboratories of its own.
> (4) Support of basic research in the public and private colleges, universities, and research institutes must leave the internal control of policy, personnel and the method and scope of the research to the institutions themselves.
> (5) While assuring complete independence and freedom for the nature, scope, and methodology of research carried on in the institutions receiving public funds, and while retaining discretion in the allocation of funds among such institutions, the

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[34] Ibid., p. 34.

> Foundation proposed herein must be responsible to the President and Congress. Only through such responsibility can we maintain the proper relationship between science and other aspects of a democratic system. The usual controls of audits, reports, budgeting, and the like, should, of course, apply to the administrative and fiscal operations of the Foundation, subject, however, to such adjustments in procedure as are necessary to meet the special requirements of research.[35]

The final chapter of the report recommended the establishment of a National Research Foundation, conceived as the principal means for carrying out the other major recommendations contained in the report.

The Bush Report thus provided the blueprint for the future. The fundamental premise was that only the systematic pursuit of scientific research on a broad front, with the financial support of the federal government, would ensure the choice our nation would require to pursue an effective course of development along the lines which history had prescribed. And although the agency-to-institution approach still held sway, the groundwork had been laid in this expanding funding philosophy for a change in that approach to meet new needs.

The Office of Naval Research

The Bush Report persuasively induced the Congress to make unprecedented appropriations for the support of research, and the Office of Naval Research resulted from the first successful Congressional action implementing

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[35]Ibid., p. 33.

the Bush Report. The Office of Naval Research was organized to act on the principle that the resources of scientific research and invention are the mainspring for sustaining technological innovation. This concept is written in Public Law 588 of the 79th Congress, 1946, which provides that the Office of Naval Research will:

> plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power and the preservation of national security.[36]

Indeed, the Office of Naval Research, as an outgrowth of Bush's emphases in his historic report, was to be the very model for federal support of research. According to one distinguished scientist:

> "The creation of ONR, the selection of its goals and ideals, and the skill and efficiency with which these were carried out in the intervening years have served as a beacon to show the Government and the scientists of the United States how to cooperate and keep world leadership in scientific research and development here in this country."[37]

For the Navy ONR was responsible for the identification and endorsement of the significance of basic research as an important part to the solution of the fast unfolding developmental problems associated with modern sea-power. In drawing from the lessons learned in naval warfare and in recruiting an able group of civilian scientists and engineers to work with young naval officers to extend these lessons into further research, the ONR has furnished

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[36]Weyl, p. 55.

[37]Ibid., pp. v, vi.

within the Navy a focal point for leadership and coordination of the fundamental research and development essential to unified progress.[38] Alan P. Waterman perhaps best summarizes the role the ONR played in the development of changing federal government philosophy regarding funding of research, a change which would lead to the agency-to-individual approach utilized by the National Science Foundation:

> . . . in mutual consultation with academic and industrial scientists and administrators the ONR evolved policies and procedures . . . which pioneered the way for increasing participation of the Federal Government in a comprehensive program of scientific research throughout the country.[39]

THE NATIONAL SCIENCE FOUNDATION

The scope of the program to which Waterman refers was broadened in 1950 with the establishment by an act of Congress of the National Science Foundation. Recall that in his report to President Roosevelt, Dr. Vannevar Bush had suggested just such an organization to insure the continuance of the scientific advances of wartime.

NSF Purposes and Organizational Policy

The purposes of the National Science Foundation (NSF) are to: increase the nation's base of scientific knowledge and strengthen its ability to conduct scientific research;

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[38]Dr. Alan P. Waterman, "Pioneering in Federal Support of Basic Research," in Weyl, p. 8.

[39]Ibid., p. 9.

encourage research in areas that can lead to improvements in economic growth, energy supply and use, productivity, and environmental quality; promote international cooperation through science; and develop and help implement science education programs that can better prepare the nation for meeting the challenges of the decades ahead.[40]

Reorganization Plan No. 1 of 1973, effective July 1, 1973, transferred to the Director of NSF the functions of the Office of Science and Technology which was abolished by the reorganization plan. The Foundation consists of the National Science Board of twenty-four members, and a Director, all appointed by the President with the advice and consent of the Senate. The National Science Foundation Act also provides for a Deputy Director and four Assistant Directors, appointed by the President and subject to Senate confirmation. The Director is the chief executive officer of the Foundation and serves ex officio as a member of the Board and as chairman of its Executive Committee.

The National Science Foundation initiates and supports fundamental and applied research in all the scientific disciplines. This support is made through grants, contracts, and cooperative agreements awarded to universities, nonprofit, and other research organizations. Most of this research is directed to unresolved scientific questions concerning fundamental life processes, natural laws

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[40]U.S. Government Manual, p. 544.

and phenomena, fundamental processes influencing man's environment and the forces impacting on man as a member of society as well as on the behavior of his society. Additional research is focused on societal problems of national importance and is directed toward contributing to the knowledge required for their practical solution. The Foundation also supports major national and international science programs including the U.S. Antarctic Research Program, International Decade of Ocean Exploration, Ocean Sediment Coring Program, and others. And among the centers supported by the Foundation are: the Kitt Peak National Observatory, the Cerro Tololo Inter-American Observatory, the National Radio Astronomy Observatory, the National Astronomy and Ionosphere Center, and the National Center for Atmospheric Research.[41]

Procedures for Grant Allocation

The National Science Foundation employs either individual or peer panel review to evaluate the majority of formal requests for funds.[42] A more detailed summary of the Foundation's procedures for awarding individual grants is described below. This summary encompasses only the major aspects of NSF funding procedures, aspects

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[41]Bush, p. xxi.

[42]These methods are described in "Peer Review and Proposal Evaluation," an NSF study dated June 1975 which is included in the peer review hearings record.

which will serve later in this paper as a basis for interpretation and analysis of the workability of the peer review system.

The Foundation's methods for selecting the recipient of an award begin when it is decided what form an award will take. For the most part, the award is a grant to or contract with an institution (which assumes financial responsibility) for its use in support of a project directed by a principal investigator (who assumes responsibility for the work). Two other types of awards include one for education (e.g., NSF Graduate Fellowships), which involves an institution and a person, but no project, and one made to an institution to improve itself. The Foundation does not normally make:

1) awards to individuals in the absence of an institution to sponsor the individual;

2) research grants to institutions for a particular scientist, not specifying that work in a particular field be done.[43]

In deciding award recipients, NSF acts on applications which may have been unsolicited or which may have been solicited and received by the Foundation in response to its request for proposals for research projects in a specified broad field or to its request for proposals to carry out a project already defined.

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[43] NSF Peer Review Vol. I, p. 15.

National Science Foundation staff play a large role in most review processes in the stage when decisions are made on an application for funds. In fact, when small amounts are involved in an individual award (the case for foreign travel awards) staff judgment alone may determine the decision.

Basic scientific research receives over half the funds of NSF (more than $300 million annually); most basic research awards fall into the $10,000 to $100,000 range.[44]

Review procedures for these awards vary; staff judgment is used along with individual peer review (both these methods play a role in evaluating all basic research applications), while peer panels are utilized in fewer than half of NSF basic research programs.

The following flow chart and list of processes in Figure 1 illustrate the procedures utilized in the evaluation of an application by the former Directorate for Research, procedures which are still basically similar though NSF has reorganized.

For applied research NSF annual expenditures in recent years have reached $70 million with most applied research grants falling within the range of $40,000 to $400,000 (an average of two to three times the size of basic research grants).[45] In awarding these funds, the

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[44] Ibid.

[45] Ibid., p. 17.

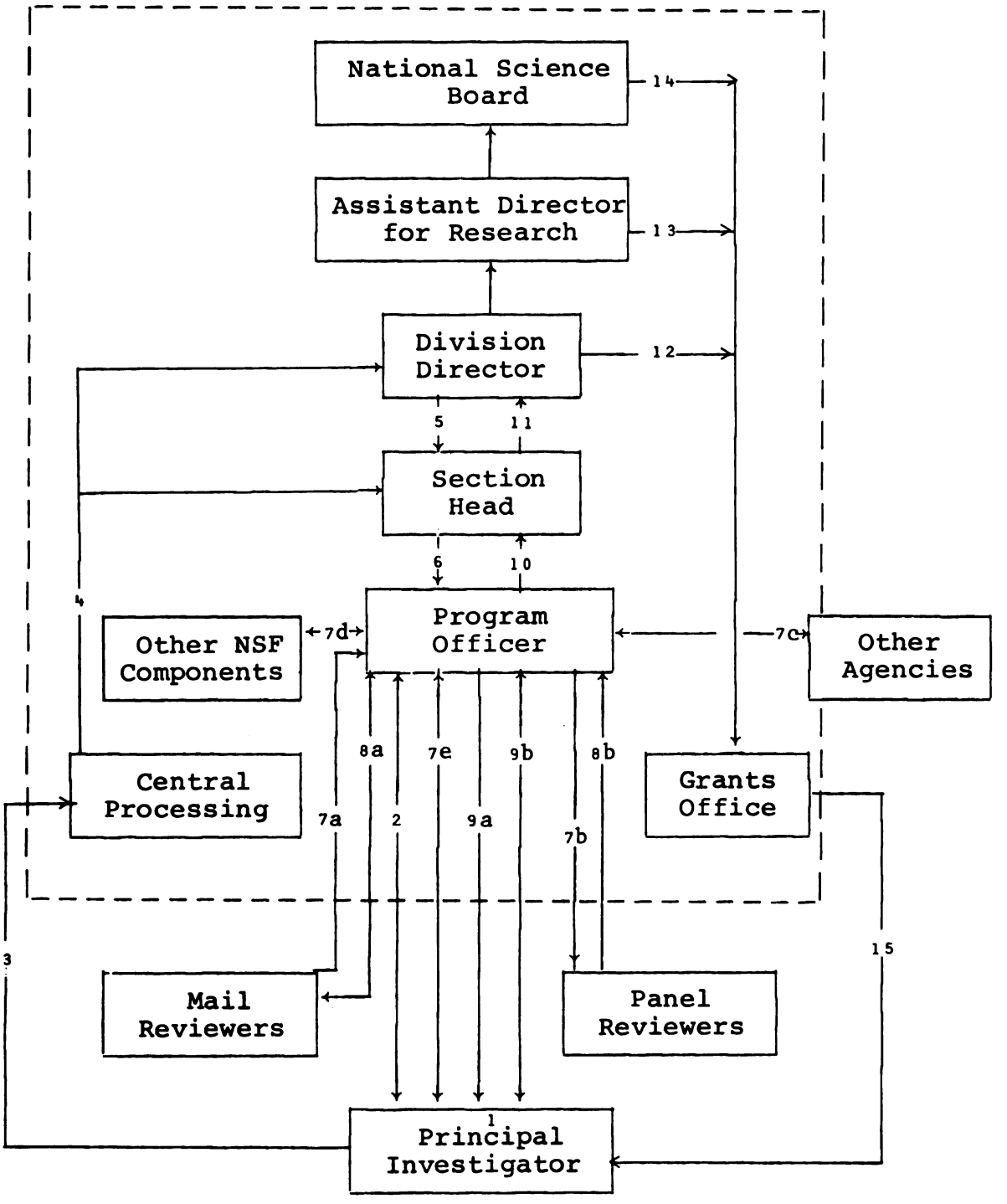

Figure 1. Flow Chart of the Movement of a Research Proposal Through the Foundation*

*Source: National Science Foundation Peer Review, Vol. I., A Report of the Subcommittee on Science and Technology, U.S. House of Representatives, Ninety-Fourth Congress, Second Session (Washington, D.C.: U.S. Government Printing Office, 1976), p. 16.

Notes:

1. Principal Investigator (P.I.) conceives research plan.

2. P.I. may hold preliminary discussions with Program Director (P.D.) and/or submit preliminary proposal for evaluation.

3. Final proposal is prepared by P.I., approved by Institution and sent to NSF.

4. Central Processing assigns proposal to a Division.

5. Division Director assigns proposal to a Section.

6. Section Head assigns proposal to a Program.

7a. Program Director chooses reviewers and sends out proposal for independent mail review.

7b. Program Director may choose panel members and send them copies of proposal in preparation for panel meeting.

7c. Program Director may discuss proposal with another agency.

7d. Program Director may discuss proposal with other components of NSF.

7e. Program Director may make site visit (or site visiting team may be appointed and report back to P.D.).

8a. Independent mail reviewers evaluate proposal and return signed, written reviews.

8b. Panel members discuss proposal and indicate rating.

9a. Program Director may decline proposal but suggest some major modification that would make it more acceptable or may suggest that a new proposal may be written.

9b. Program Director may decide to recommend funding and negotiates revised budget with P.I.

10. P.D. recommends funding of revised amount.

11. Section Head reviews recommendation, approves and transmits, or rejects.

12. Division Director reviews recommendation, approves and transmits, or rejects.

13. Assistant Director for Research may review recommendation.

14. If grant is large enough, National Science Board must review.

15. Grant is made to Institution, which disburses funds to P.I.'s project.

Foundation selects projects that will bring benefits soon after completion. Thus, the Research Applications Directorate decides on a specific benefit and then solicits projects designed to achieve the known goal (a program solicitation); or the Foundation may issue a "request for proposal" wherein the project needed to attain the outlined benefit is described beforehand. Then, too, NSF must consider unsolicited proposals for applied research. To adequately screen these three types of proposals, then (program solicitation, request for proposal, and unsolicited proposal--all of these are described in Chapter I of this paper), the Directorate employs three different types of proposal solicitation and evaluation:

1. Proposals submitted under program solicitations are screened by the staff. Those judged by the staff to be above a minimum quality level generally receive peer panel review. The peer panel commonly considers a batch of proposals addressed to a given program solicitation and makes the primary decision. The decision is reviewed at higher staff levels.
2. The evaluation of proposals submitted in response to RFP is closely governed by Federal regulations. Primary decision-making on such proposals in the Research Applications Directorate lies with a panel usually composed of scientifically or technically qualified Federal employees.

> 3. An unsolicited proposal is generally discussed with the Foundation's program manager before being submitted; this constitutes a pre-review. A formally submitted unsolicited proposal will receive individual peer review. The staff makes the primary decision, which is reviewed at higher staff levels.[46]

In the field of education about $15 million is expended annually by the Foundation for fellowships (about $10,000 each) based on review and decision by ad hoc panels, while $50 million annually goes for support of projects reviewed by peer panels and individual reviewers.[47]

Other sources receiving NSF monies include National and Special Research programs of the Foundation itself ($90 million annually), which are reviewed by staff and individual reviewers, and National Research Centers (which include the Ocean Sediment Coring Program) ($60 million annually) that are funded through relatively few, but large, contracts.[48]

The Role of the Reviewer

How does the reviewer actually operate within the scope of the funding procedures outlined above? A distinction must be drawn between the individual peer reviewer and the panel peer reviewer. The former receives a single proposal at a time to evaluate; he or she studies

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[46] Ibid.

[47] Ibid.

[48] Ibid., pp. 17, 18.

that proposal and related material, writes a short review, and mails the review and the proposal back to NSF.

Of what is the review composed? It considers the proposal's technical adequacy, its importance to science, and the likelihood of success by the proposer (here the proposer's past performance plays a role).

The panel peer reviewer receives several proposals to evaluate. He or she may be asked to read them all but review only selected ones in depth. After the private review, the panel meets to discuss each proposal, a rating of which by the panel as a whole "will normally be generated--either by panel agreement or by some balloting procedure. Depending upon the format of the panel meeting, the panel's rating may be morally binding on the program manager to a greater or lesser extent."[49]

Economic Aspects of Peer Review

According to the report of the Congressional Oversight Hearings of NSF, it would appear from the results of the process that the scientific community has accepted peer review as a professional obligation. Thus, NSF reported that 92 per cent of its requested reviews are performed.[50] The Foundation reimburses peer reviewers for expenses incurred in reviewing (individual reviewers require no such payment, panel reviewers, payment only for

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[49] Ibid., p. 32.

[50] Ibid., p. 33.

travel and living expenses associated with their meetings), but they receive no payment for their services.

> The value of an average review, were it paid for at a rate reviewers might charge if they were acting as consultants, would likely lie between $20 and $100. The value of the roughly 100,000 reviews contributed free to the Foundation by the scientific community each year is thus in the range of $2,000,000 to $10,000,000.[51]

It is important to note that reviewers do receive non-monetary benefits from their work, however. Thus, the reviewer encounters the research ideas of others in his field and his service renders him visible to the Foundation's program manager who can appraise his performance and capabilities.

Evaluations of the Agency-to-Individual Approach Employed by NSF

Despite the aforementioned merits of this approach to federal funding, there have been numerous criticisms made of its organization and operation by Congressmen, government officials, university administrators, and scientists themselves. A good example of such negativism can be found in a statement by Rep. John Conlan of Arizona:

> I know from studying material provided to me, by NSF that this is an "Old Boys' System," where program managers rely on trusted friends in the academic community to review their proposals. These friends recommend their friends as reviewers....
>
> It is an incestuous "buddy system" that frequently stifles new ideas and scientific breakthroughs, while carving up the multimillion dollar Federal research and education pie in a monopoly game of grantsmanship.[52]

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[51] Ibid.

[52] Ibid., p. 40.

Countering such bitter denouncements are positive comments, however, by individuals like Dr. Joseph Crosswaite, from Ohio State University, who served as a rotator to NSF:

> I came up in August of '74 and was here for 4 months and came to work on a very well-defined program, the implementation project. In that case, the peer review was handled in an admirable fashion. They had almost 180 people from the field come in and review the proposals and two independent panels reviewed each proposal. Those panels represented not only the scientific community, but also the school community . . . . I thought it was just as clean as one could ask for and each proposal in that set of projects was reviewed by 6 people independently, working in two panels of 3 each. Those reviews were used very heavily in making decisions about funding and in that particular program I saw no problem whatsoever.[53]

Thus, it is clearly evident that the peer review system employed in the agency-to-individual approach to federal funding of research has its advocates as well as its detractors, though the latter group is perhaps the most vociferous. Indeed, it was the adamant nature of its critics which led this researcher to an investigation of the system's workings within the National Science Foundation. The following chapter will delineate the methods used in that investigation.

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[53]Personal Interview, Washington, D.C., January 1976.

CHAPTER III

DESIGN OF THE STUDY AND RESEARCH METHODOLOGY

DESIGN OF THE STUDY

Most broadly speaking, a "peer review system" is any method of evaluating a special criterion--such as a proposal to perform scientific research--which involves in that evaluation a group of people knowledgeable in the area of specialization. The experts are called "peers," the term loosely deriving from the relationship between the proposer and the evaluators.[54] In science the chief uses of peer review are to help determine whether a proposed piece of work or study should be funded or to help determine whether an existing scientific paper should be published. Peer review, then, is used for these purposes because it is believed to be the best practical method of identifying excellence.[55]

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[54]Two particular pitfalls should be borne in mind in any consideration of peer review. First, the label "peer review system" does not reveal who is actually making the decision as to whether or not to fund a given proposal; it may be the group of peers, or it may be the person or organization controlling the money. Second, the "peers" involved in a peer review are often not the equals of the proposer. For example, proposals from postdoctoral students may be evaluated by full professors (NSF Peer Review Vol. I, p. 14).

[55]Ibid., pp. 13-14.

In spite of such noble aims, however, the peer review system, an integral part of the agency-to-individual approach to federal research funding, may have its disadvantages. But before these disadvantages, as well as advantages, can be evaluated, they must be clearly identified and appraised for their effect on the entire system. To aid this identification and appraisal process, the following research questions were formulated:

1) Does the agency-to-individual approach, which employs peer review, provide for the advance of science in the most effective way possible?

2) In terms of the samples involved, is the agency-to-individual approach with its operative system of peer review, a fair and impartial approach? Is it subject to political influence, "cronyism," geographical/institutional favoritism?

3) What are the economic arguments for and against the peer review system?

4) Is there opinion to substantiate the charge that the agency-to-individual approach promotes "grantsmanship" at the expense of sceintific excellence? What kinds of grants are being made? What types of research are being supported? Is the system too secretive?

The answers to the research questions designed for this study were sought by several means. As outlined in the previous chapter, an historical review of past trends

in government policies and practices relative to the awarding of research grants was necessary. This review, which also traced the development of both the agency-to-institution and agency-to-individual approaches in federal funding procedures, uncovered relevant information in journals such as Science, Research and Development, Industrial Research, C & EN, Scientific Research and The Chronicle of Higher Education.[56]

In addition to such literature review, this researcher relied on a report of a series of oversight hearings, held for six days during the summer of 1975 by the Congressional Subcommittee on Science, Research, and Technology, which investigated peer review procedures of the National Science Foundation (NSF). In fact, due to the copious amount of information available on NSF's funding procedures (much of which was provided in the Congressional report), NSF became the actual model for this study.

For further study of this model, the interview technique was elected as the principal method of investigation because it seemed to be the best way to obtain the opinions and attitudes of people involved in government funding of research.

Results of a poll conducted by Industrial Research on peer review were also used as supportive data for the

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[56]These sources in particular were consulted because individuals contributing to them have been involved in various facets of the peer review process.

conclusions of this study. In addition, telephone contacts were made with individuals and universities possessing information relevant to this research.

It is important to note here that the investigation of the activities of the National Science Foundation in funding research through the peer review system did not lend itself readily to a precise systematic mode of enquiry. The essential task was to describe the two major methods of government funding and to focus on the primary characteristics of the agency-to-individual approach, which has the main ingredient of peer review, and then to develop the major threads running throughout the process and relate these to one another in an attempt to understand more clearly the actual operation of the process. The design of the study had to allow for the discovery of relevant phenomena--phenomena of which the investigator may have been unaware at the beginning of the research, such as biased opinions of researchers. Further, the study design had to permit the finding of heretofore undisclosed variables which might influence the operation of the peer review system and the interviewed subjects' observations of that system. There appears to be justification in the literature for such an approach.

RESEARCH METHODOLOGY

Documentary Data

Sources of documentary data included:

(1) Government reports and documents, including Hearings of Congressional subcommittees, House and Senate Reports of Committees, the Congressional Record, government press releases, etc. concerned with legislation relevant to government funding of research and peer review.

(2) Reports and documents of the National Science Foundation.

(3) Guidelines of the National Science Board.

(4) Published articles and editorials in newspapers and periodicals regarding peer review.

(5) A statement by R. C. Atkinson, Deputy Director, National Science Foundation, before the Subcommittee on Science, Research, and Technology of the House Committee on Science, Research, and Technology, 23 July 1975.

Gottschalk's primer of historical method was utilized frequently during the documentary research phases of the study to ensure proper treatment of the evidence gathered.[57]

Interview Data

Personal interviews were considered an essential part of the investigation. Indeed, it is felt that some of the most significant information in the study came from these interviews. As Bailey has noted, " . . . unless live sources are used, a meaningful analysis is virtually impossible. What is committed to writing represents only

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[57]Cf. Louis Gottschalk, Understanding History (New York: Alfred A. Knopf, 1963).

the seventh of the iceberg above water."[58]

Interviews were sought with persons in the following categories: (1) National Science Foundation directors and their staffs; (2) rotators within NSF; [59] (3) eminent scholars who had served as peer reviewers; (4) Directors of Research within universities; (5) the Associate Director of the National Association of State Universities and Land-Grant Colleges; and (6) university professors (see Appendix A for a complete listing of the names and titles of those interviewed).

A guide sheet was used by the investigator and answers to the following questions were sought (these questions were later incorporated into the four general areas indicated by the research questions in Chapter I).

1. Does the peer review system promote "cronyism," favoritism? Is the system too secretive?
2. Is the system inadequate? Does it promote "grantsmanship"?
3. Does the peer review system provide for the advance of science in the most effective way possible?
4. What are the economic arguments for or against such a system?

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[58] Stephen K. Bailey, Congress Makes a Law (New York: Columbia University Press, 1950).

[59] Rotators are members of the university community who join NSF as program managers for a period of one to two years. They provide the Foundation with a fresh perspective on what's happening out in the field and have helped modify the peer review process based on their experience.

5. What are the direct and indirect factors of political influence on this system?
6. Has the criticism of the peer review system had an impact?

Despite a general focus provided by these questions, however, the method, technique, and content of the interviews varied from one respondent to another depending upon different factors. Initially, interviewees were considered as informants from whom general information could be obtained concerning the factors and events surrounding the process of the peer review system. From the information gained through these informants, as well as from documentary evidence, major actors were identified and subsequently interviewed. The focus of these latter interviews shifted from the gathering of general information to the gathering of highly specific information regarding the role of the interviewee in the process.

Another factor affecting the method, technique, and content of the interview was the general category into which the respondent was placed, i.e., director, administrative official, legislator, or interest group member. A third factor was the respondent's apparent knowledge of the factors and events involved in the peer review system.

Initially, the open question interview technique was used since the open question appeared to be an effective mode of interviewing when the objective was to learn

something about the respondent's level of information, the basis on which he formed his views, the frame of reference in which he answered, and his feelings on the topic, as well as his overall attitude toward the issue.[60] When it appeared that the interviewee was a key actor in the process, the focus of the interview shifted to more specific questions.

Sixteen personal interviews were conducted, some of which were taped. Three of these were from NSF (one rotator) in Washington, D.C.; six from the National Institute of Education; one from the National Association of State Universities and Land Grant Colleges, Washington, D.C.; and six from peer reviewers (one from Northern Michigan University and the other five from Michigan Technological University) (see Appendix A for a complete listing). Additionally, over the course of eighteen months this researcher was fortunate enough to have access to numerous informal discussions with individuals involved in the peer review process which provided additional insights into this study's major focus.

Essentially two methods were utilized for recording the interviews. Whenever possible, the actual interview was recorded verbatim on tape. Where this was not feasible, notes were taken during the course of the interview and an account, based on these notes and memory recall, was

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[60]Robert L. Kahn and Charles F. Cannell, The Dynamics of Interviewing (New York: John Wiley and Sons, 1957), p. 135.

tape recorded immediately following the interview. Subsequently, written or typewritten transcriptions of all interviews were made.

It is the combination of documentary evidence and knowledge obtained through personal interviews that constitutes the basic source material from which inferences were drawn by this researcher in compiling the findings of this study which are found in the next chapter.

CHAPTER IV

STUDY FINDINGS

INTRODUCTION

This study was undertaken in order to examine some of the most prevalent criticism regarding the use of the peer review system in the agency-to-individual approach in federal funding of scientific research. The National Science Foundation (its organization and funding policies and procedures are described in Chapter II) became the model for the study because it exemplifies this approach and because its internal workings were made so visible in a series of Congressional oversight hearings held in the summer of 1975. Data from these hearings, which focused on the workability of peer review within NSF, were then supplemented by the author's interviewing of individuals (agency, government, and university personnel) directly or indirectly involved with the system and his review of pertinent agency and government documents and science periodicals. Those data and the documentary and interview results centered on four major areas proposed by the following research questions:

1) Does the agency-to-individual approach, which employs peer review, provide for the advance of science in the most effective way possible?

2) In terms of the samples involved, is the agency-to-individual approach, with its operative system of peer review, a fair and impartial approach? Is it subject to political influence, "cronyism," geographical/institutional favoritism?

3) What are the economic arguments for and against the peer review system?

4) Is there opinion to substantiate the charge that the agency-to-individual approach promotes "grantsmanship" at the expense of scientific excellence? What kinds of grants are being made? What types of research are being supported? Is the system too secretive?

PROVISION FOR THE ADVANCEMENT OF SCIENCE

> An odor of sanctity surrounds peer review. Rather too much has been claimed for it, considering how human and potentially fallible it is. Stripped of its elegance, it is simply a sensible arrangement for enlisting volunteer referees to call balls and strikes on proposals pitched to the funding agencies. Its credibility and durability rest on the integrity and responsibility of the referees. That in itself is no small thing, and indeed is the center beam which holds up the house of science. From this standpoint, peer review is a proxy for assaying the standards of the scientific community.[61]

The above evaluation of the peer review system, issued

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[61] "Peer Review Revisited" (August, 1975), editorial page.

by William D. Carey in an editorial in Science, strikes directly at the central issue of the first research question examined for this study. Does the agency-to-individual approach to federal funding of scientific research provide for scientific advancement? Though the general consensus at the Congressional oversight hearings was that the peer review system employed by NSF does not impede the progress of science, there are many facets of this issue that require close scrutiny. Indeed, the comments of peer review critics cannot be ignored; their departure from the consensus offers a valuable perspective for evaluation of how the agency-to-individual approach can better promote scientific innovation and change.

The Brookings Institute Seminar

The issue posed by this first research question is not a new one. Indeed, since its inception the agency-to-individual approach employing peer review has been compared to the agency-to-institution approach with regards to the quality of research supported by the government. In the fall of 1964 the Brookings Institute[62] began a seminar on "Science, Technology and Public Policy," the objective of which was to advance understanding of some

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[62]The Brookings Institute is an independent organization devoted to nonpartisan research, education, and publication in economics, government, foreign policy, and the social sciences generally. Its principal purposes are to aid in the development of sound public policies and to promote public understanding of issues of national importance.

current problems of policy regarding government programs of scientific research and development by providing an opportunity for the informal, dispassionate discussion of these problems by public officials and private citizens.[63] One of the central problems discussed regarded the balance which should be struck, in the federal financing of academic research, between project funds awarded to individual investigators by the advisors and staff of Washington agencies (the agency-to-individual approach) and research grants made directly to universities and colleges, the monies of which should be dispersed at the institution's discretion (the agency-to-institution approach). In striking such a balance, it was the seminar participants' objective to evaluate which approach promoted more progress in scientific endeavor. The group ended up favoring a relative (not absolute) decrease in project (i.e., individual), and a corresponding increase in institutional funding.[64]

Unquestionably, the project (agency-to-individual) system has great merits, permitting able men to conduct work of their own choosing, the value of which is determined by their professional peers on the basis of national standards. Indeed, its merits were so evident they did not require (or at any rate, receive) much elaboration.[65]

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[63]Orlans, Forward, p. vii.

[64]Ibid., pp. 38-51.

[65]Ibid., p. 38.

One seminar member did observe that projects with limited objectives are ideally suited to a heterogeneous, pragmatic society with diverse and shifting goals, which is seemingly incapable of establishing and hewing to larger national purposes:

> ...In a society where you have very little in the way of particular goals on what research should do,...a project orientation should be perfect. That is, you can move and you can shift and you can make grants in terms of whims, in terms of power and influence as it may develop...Now, if we had even general goals--and this is where Congress should play a very important role--then...institutional grants would be very, very important. We would begin to say, "Well, we ought to have a center of education some place, we ought to have a center of biology some place," and you would have these things beginning to develop. But in the kind of society where we don't have any articulate goals, who decides whether we ought to put money in biology or physics? It just seems to float up to the top. A project orientation is perfect.[66]

This view was challenged on two grounds: one, the Congress had at that point clearly enunciated and consistently backed certain national goals (such as the development of advanced weapons and nuclear energy, space exploration, and medical and agriculture research); and two, the apparent chaos of project research is often regarded as a kind of system superior to any that could consciously be devised to advance preordained goals. Nevertheless, the government supports "science...in terms of its own goals because experience has taught that this is one way you achieve social goals...and...this may be a more economical

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[66]Ibid., p.39.

and more effective way for certain goals."[67]

A university scientist warmly endorsed Eric Ashby's conception that a university is and properly should be an institution in which initiative comes from below;[68] as the project system bolsters faculty initiative, he suggested, it helps in the American context, to preserve the essence of a university: "...to carry the institutional control of funds (via institutional grants) to the point where this tradition (of faculty initiative) is destroyed ...would really be a disaster for American education."[69]

Yet despite such clear endorsement of the project system's benefits, the Brookings' seminar felt it desirable to increase the amount of funds going to institutions. The arguments for their decision fell under three headings: administrative, scientific, and institutional. And all arguments were related to the fact that research funding

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[67] Ibid.

[68] Ibid., p. 40

[69] Ibid., p. 39. See Orlans' reference to Ashby's Technology and Academics (Macmillan and Co., 1959), particularly Chapter 5, "Postscript on Self-Government in Civic Universities." One pertinent passage follows: "Modern universities differ greatly as to the number of items of business which flow from below upwards...By and large it is true to say that the main direction of flow of new ideas and proposals is from below upwards and not in the reverse direction."

"In a university where the flow of business is upwards and not downwards through the hierarchy, members of the academic staff are able to determine their own policies and to manage their own affairs, notwithstanding the fact that sovereignty formally resides in a governing body composed predominantly of laymen" (p. 101).

of universities and colleges would promote higher quality results.

With regards to administration, arguments went along this line: "...as long as university administrations think the conduct of research under project grants is really only the business of the individual investigator they will not try to police it, even to the limited extent that...they ought to police it."[70] In fact, simplification of administration was one of the two principal reasons advanced in the Federal Council of Science and Technology for the National Science Foundation's initial institutional grants. The other was restoration to the institution of greater control over its destiny.[71]

Another dimension pointed out was the greater likelihood that institutional funds would be put to good use. This facet of the argument was supported by the experience of one university to which a substantial grant had been given by a private foundation for research in a broad field, in lieu of project grants: "...Instead of forty or fifty little packets of project money, each one of which sits there, whether it is being used or not, year by year the university president reviews the whole thing and, if it is not being spent...it will be used for something else."[72]

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[70] Ibid., p. 40.

[71] Ibid., p. 41.

[72] Ibid., p. 42.

On scientific grounds the argument favoring more funds to institutions stated that such grants would facilitate the conduct of research that falls between the disciplinary and project lines of current federal financing. "What I really sweat to do," one dean declared,

> is...to get from a private foundation some unrestricted money for support of research and experimental efforts in teaching. And with this money, not in the aggregate 20 percent of the total of these project grants, I have done things in shaping the program of...(the) school that would never have been accomplished by any stretch of the imagination if I had waited for individual faculty members to bring the money in.[73]

In addition, it was claimed that as institutional funds would be used only for research meeting the intellectual standards of the institution (which, it was plainly said, were often higher than those of government agencies) they would raise the quality of research. By contrast, in the project system,

> ...there is really a great range in the degree... and kind of quality criteria that are made. So to be very blunt, a man who couldn't possibly get a grant from the National Science Foundation can go to the Wright Air Development Center and get a grant five times the size. It is very difficult, because of this sort of range in the way that quality judgments are made...for the university to control the situation...[74]

Institutional arguments for broader funding ranged from the objective of strengthening the hand of academic authorities against the power in Washington to promoting

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[73] Ibid.

[74] Ibid.

harmony and a sense of common purpose among faculty members.[75] One government official asserted:

> ...The crux of the matter is...unlike anything else we have done in the nation; we have centralized... scientific decision-making (in the hands of panels, committees, and staff in Washington). Essentially, the root of the decision is national. It is not possible under the present system to...make divergent local decisions and strengthen thereby the truly unusual capability that may be residing in local institutions.[76]

Significant to note here is that although some deans suggested giving the collective faculty more say in dispersal of funds, the individual scientist is known to favor the project system and to resist moves toward broader--particularly, institutional--forms of research support:

> The greatest resistance...comes from the scientists themselves...The science community is apathetic to strong, local institutional support. It does not want controls put upon the scientist by his own institution. On the other hand, if that is not done, we weaken the institution...The scientific community itself does not want strong local institutions...[77]

A simple explanation of the scientists' attitude was offered by a dean: "...They know good and well that a panel of advisers to NSF or NIH or whatever, drawn from among the leaders of their special field, know more about their business and understand them better than their dean or their president"..."And they are absolutely right,"

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[75] Ibid., p. 43.

[76] Ibid.

[77] Ibid., p. 44.

interrupted a government scientist; and the dean readily concurred.[78]

Further System Drawbacks

Some of the most pointed criticisms of the peer review system's ability to promote valid, forward-thinking research have come from Dr. Christian K. Arnold, Associate Director of the National Association of State Universities and Land Grant Colleges. He has cited several drawbacks in the system's operations. For example, he has maintained that some critics claim that the system discriminates in favor of the fluent, established scientist and against the shy, retiring newcomer, who might be a better investigator.[79] He has also expressed a belief that it tends to convert scientists with solid reputations into managers and lobbyists, effectively removing them from their laboratories, and places a premium on the scientist's "visibility" in Washington.[80] Perhaps of even greater importance is the tendency of the system to place emphasis on short-term, specifically defined projects that promise measurable results in a hurry. But of greatest significance, Arnold has defined the sort of relationship the system enforces between the university and the federal establishment, a relationship in which the system erodes the university's

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[78] Ibid.

[79] Arnold, p. 76.

[80] Ibid.

authority while eliminating none of its responsibility. In practice, university approval of federally sponsored projects amounts to little more than veto power, which, if exercised, often results in the scientist taking his project and moving to a different university. Psychologically and actually, then, the scientist is working for the agency and not the university, even though it is the university, and not the agency, that is expected to grant him tenure to guarantee him a career opportunity in his field.[81]

The Dilemma of the Innovator

While many feel that peer review results in the support of high-quality research, there is not much confidence expressed that the system consistently leads to the support of innovative research. Arguments that peer review does not lead predictably to the support of innovative research if it is challenging or risky go as follows. If a proposal challenges the mainstream of scientific thought, the expert peer reviewer who is in the mainstream will tend to see the proposal as wrong on the face of it. The expert reviewer, in particular, is likely to have worked on experiments which either assumed the mainstream hypothesis to be correct or which tested and corroborated the hypothesis. The reviewer's self-esteem and reputation

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[81] Ibid.

in the scientific community may therefore depend upon the correctness of the mainstream of thought. Moreover, the reviewer's laboratory facilities and Foundation grant may be proven useless if the innovative hypothesis is correct. Thus, it may be contrary to the reviewer's interest to find merit in the proposal.[82]

At the NSF oversight hearings there was evidence presented, in the form of personal experience, purporting to show that the Foundation failed to support a correct but challenging innovative theory. This evidence was provided by Drs. Ling,[83] Hazlewood,[84] and Cope.[85] The scientific dispute on which this testimony was based has not yet been resolved in the scientific community.

Rep. Robert Bauman, the forementioned people's advocate, perhaps offers the best closing comment for this section:

> In the correspondence I have received there have been a number of instances of charges from some of NSF's past recipients, at least they identified themselves as such, saying just about what I passed along to you, that new ideas are being stifled by NSF. It may well be that there is a tendency to support the orthodox and to go with the established scientists, whose ideas are favored within the

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[82] NSF Peer Reivew Vol. I, p. 27.

[83] National Science Foundation Peer Review, Special Oversight Hearings, Hearings before the Subcommittee on Science, Research, and Technology, U.S. House of Representatives, July, 1975 (Washington, D.C.: U.S. Government Printing Office), pp. 874-879.

[84] Ibid., pp. 863-866.

[85] Ibid., pp. 873-874.

> councils of NSF. And that, I think, is a very serious question, and one that is going to be very difficult to answer.[86]

NSF Support of Quality Research

Despite the above criticism, however, the witnesses at the Congressional oversight hearings agreed overwhelmingly that some form of peer review should continue to be used to assist in the allocation of federal funds for scientific research. Not a single witness suggested that peer review be abandoned, although several proposed changes were suggested in the decision-making process.

The basic rationale for the use of peer review in decision-making for scientific awards is that the experts in a field of science are better able to judge several important factors than anyone else. These factors include: (1) past performance of the proposer; (2) design of the proposed work; (3) importance of the proposed work to the scientific field.

Most witnesses agreed that the NSF staff could not perform as well without the benefit of peer review as with it. And many stated that, in fact, the potential for staff abuse is greater in systems lacking peer review. Testimony was also in agreement that appropriate peer review procedure would tend to select for funding those projects at the upper end of the quality scale, however high or low the upper end might be. And "the assessment and maintenance

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[86]Ibid., p. 202.

of quality is of fundamental importance to scholarly activities and institutions. Peer review is the principal procedure used for quality control."[87]

THE PEER REVIEW SYSTEM: A FAIR APPROACH?

It is important to note here that, in essence, the second research question formulated for this study--just like the third and fourth questions--is directly related to the issue of the quality of scientific research funded by an agency-to-individual approach. In other words, one cannot have quality research if funding procedures are biased and subject to favoritism, if they are economically unrealistic, if they promote grantsmanship for its own sake.

The whole area of impartiality in the granting of research funds is particularly fraught with pitfalls for quality projects. Several of these pitfalls surfaced during the Congressional oversight hearings; others came to light in interviews and literature review. They include: reviewer bias, "cronyism," undue political influence, geographical/institutional favoritism.

Reviewer Bias and "Cronyism"

Senator William Proxmire, Democrat from Wisconsin, has charged that the peer review panels used by the

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[87]Ibid., p. 460. Statement of Raymond Bowers, Professor of Physics and Director of the Program on Science, Technology and Society, Cornell University.

National Science Foundation are "packed with representatives from those universities that get the grant."[88] Similarly, Rep. Robert H. Michel, Republican from Illinois, has questioned whether the NSF system is "free from cronyism,"[89] while the American Association of Community and Junior Colleges has complained that NSF's peer review process is dominated by scientists from the four-year institutions, a charge that echoes some of the criticisms heard from Congress that an "academic oligarchy" runs the system for its own benefit.[90] John E. Tirrell, the association's vice-president for government affairs, recently testified:

> The NSF peer-review process has been described to me; I approve B's (grant application), B approves C's, and C approves mine. This is fine if you are in the small fraternity of four-year peers--but it is very difficult to break if you are not in the selected fraternity.[91]

This conception of a "select fraternity" of reviewers dominating decisions on research funding is a difficult one to counter. In the mid 1960s the Select Committee on Research (called the Elliott Committee) formed a series of questions relating to the existence of "cronyism" in the peer review system as a whole. For example, it noted

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[88]Philip M. Boffey, "Peer Review Under Attack," The Chronicle of Higher Education (May 1974), 1.

[89]Ibid.

[90]Ibid.

[91]Ibid., 6.

that there had been increasing criticism of advisory methods on two grounds: that in some cases government agencies abdicated their judgment to the panelists, and that a "panel establishment" had grown up, which utilized the same panelists or panelists from the same institutions, over and over. The committee then asked, "Is the repeated use by some agencies of particular panelists (or their protégés) resulting in, or likely to result in, creation of an 'advisory elite' with a vested interest?"[92] And it went on to note that a study of National Institutes of Health panels, covering the past five years, found that "40 percent of the names occur again and again,"[93] an observation which may suggest that the committee tended toward an affirmative reply to its own question.

Also, on the subject of advisory panels the committee produced a survey aimed at examining whether a relationship existed between institutional affluence, institutional excellence, and membership on advisory panels. This is a difficult order, heavily weighted with uncertainties, but the results can at least be described as interesting. The committee safely concluded that there was a "consonance" between federal funding and representation on advisory panels, though it added that "it does not appear...thus

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[92] NSF Peer Review, Special Hearings; see the reference on p. 795 to D.S. Greenberg, "Grant System: Elliott Committee Finds Flaws, Diversity in Study of Practices of Federal Agencies," Science (August 21, 1964).

[93] Ibid.

far, that the allotment of funds has been disproportionate to the indicated capacity of the institutions to perform the research."[94]

Using membership in the National Academy of Sciences and doctorates conferred in 1960-63 as "not infallible guides...(but)...marks of distinction which support an inference of capacity to meet the high standards required for quality research," the committee then tabulated the advisory roles held by members of the ten universities which in 1960-63 received 38 percent of federal research funds. The results demonstrated that the rich insititutions were amply represented in Washington advisory panels, the National Academy of Sciences, and the production of doctorates. But the findings shed no light on the increasingly loud contention of the have-nots--namely, that the rich operate in a closed community of talent, influence, and money.[95]

The issue of "cronyism" and resultant reviewer bias surfaced again in the summer of 1975 during the Congressional oversight hearings for NSF. At that time the principal drawback to the use of peer review in the evaluation of applications for scientific awards was located in the possibility of biased evaluations by the reviewers, a possibility arising from the existence of

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[94]Ibid.

[95]Ibid., p. 796.

"old boys clubs," groups of people in a discipline who know each other. Members of such groups may praise each others' proposals unduly while downgrading outsiders' proposals to an extreme. Motives for such behavior may be intentional self-service or the result of a common view of the discipline held by group members.[96] Witnesses at the hearings also indicated that a reviewer could exhibit bias toward someone known and disliked or disagreed with or could favor personal acquaintances over strangers "simply by virtue of being able to make a better informed judgment."[97]

Three reasons were outlined for difficulty in actually determining the existence of bias:

> 1. Most importantly, talent is concentrated. In most fields of science there are a handful of acknowledged centers of excellence. Talented people frequently move to such centers, and the centers actively recruit talent from wherever they can find it. Not surprisingly, reviewers at these centers tend to rate proposals from other centers highly.
> 2. In any scientific specialty practitioners of the specialty are extremely likely to know one another and have some easily describable relationship such as: "They both went to Stanvard" or "their advisors were roommates at Harford."
> 3. Reviewing scientific proposals is an extremely subjective matter. It is not possible to take a proposal, stick it into a machine, and get a quality rating. If it were possible, peer reviewing would not be necessary.[98]

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[96] NSF Peer Review Vol. I, p. 33.

[97] Ibid.

[98] Ibid.

Yet another question growing out of the above concerns with "cronyism" and bias regards the actual geographical/institutional distribution of reviewers. Does the National Science Foundation use all competent potential reviewers? Though witnesses at the oversight hearings agreed that reviewing should not be concentrated in the hands of a small portion of the qualified scientific community, neither should it be spread so thinly that no scientist has the opportunity, through use of his skills, to become a proficient reviewer.

From the data presented at the hearings by the Foundation concerning the utilization of reviewers, it appears that reviewing is not intensely concentrated, but whether the distribution of reviewing is sufficiently broad is not clear.

> The Foundation's 300 or so program managers used about 30,000 different reviewers in Fiscal Year 1974, who performed about 120,000 reviews altogether. The number of science and engineering doctorate holders in the United States is about 240,000.
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> Roughly speaking, then, each Foundation program manager uses an average of 100 reviewers each year, each of whom performs four reviews, but only one in eight doctorate holders perform reviews for the Foundation each year. These derived figures should not be used or expected to approximate the analagous figures for any given Foundation program; the aggregated numbers blur many unique situations.[99]

Even if "cronyism" and reviewer bias do exist--in NSF or any other federal funding agency--they are difficult

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[99]Ibid., p. 34.

to uncover. In fact, many prominent participants in the peer review system deny their existence or, at the least, minimize it. Thus Dr. John Maccini, Program Manager for Cost (NSF), has said, "I think because of the meritocracy approach we have some interesting projects."[100] And Dr. Raymond Shinn, Director of the Office of Program Integration (NSF), has maintained that the system, as he has experienced it, has not worked in a secretive or manipulative way.[101] While admitting that "cronyism" is possible, Thomas Clements, Chief of the Division of Information Communication Systems at NIE, claimed that it had never occurred to his knowledge and pointed out that it could be avoided if the make-up of peer panels is not too homogeneous.[102]

Additional interesting comments on the issue of "cronyism" surfaced during other personal interviews. Dr. Roy Heath, Dean of the Graduate School and Director of Research Development at Northern Michigan University, said that he sat on a number of review committees at NSF in Washington and saw some of the same faces back many times. But "the fact remains the judgments that we reached are generally reached on the documents and it depends on what it says and how well it says it." If "cronyism"

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[100]Personal Interview, Washington, D.C., January, 1976.

[101]Personal Interview, Washington, D.C., January, 1976.

[102]Personal Interview.

exists, then, he felt that it is due to the fact that a limited number of people are aware that the programs are out and their access to this information enables them to know ahead of time what kind of proposal is needed.[103]

Dr. Charles Haughey said he could easily respond to the statement that "cronyism" may exist in the peer review system:

> I don't think we will ever avoid it short of a kind of jury system where a panel of selectors are chosen from an open listing and when you get that kind of process, you lose the capacity to make professional judgments, so you have the jury. You would have a relatively unexpert jury reporting to a judge who is supposedly technically qualified, which puts the bureaucrat back in position of control.[104]

Finally, according to Dr. Joseph Crosswaite, "cronyism" ism" is difficult to define because a person's "track record" in previous grants does have an influence and there are certainly people who have a history of obtaining grants. "Now whether you attribute that to "cronyism" or the fact that they have a proven track record is a judgment call,"[105] he said. He also noted that proposals were not read "in the blind" without knowledge of the presenter's identity and this could work to the disadvantage of young people who are just getting started. Dr. Crosswaite then gave his definition of "cronyism"

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[103]Personal Interview, Marquette, Michigan, March 1976.

[104]Personal Interview, Washington, D.C., 1976.

[105]Personal Interview.

> as a conscious selection of reviewers but of a non representative subset of the professions. In a sense that you go out and you say, "well, I know that this guy works with this guy and so I will stack the reviews": I don't see any evidence of that since I have been here.[106]

Political Influence

Closely related to the issue of "cronyism" is the question of whether the peer review system should be influenced by "politics," by Congress. Dr. Christian Arnold believes that the awarding of grants should not be part of the political arena.

> I am horrified at the prospect of 500 or so senators and representatives looking over a list of titles and then being able to approve or not to approve the awarding of these grants.[107]

When it was pointed out that the agencies already have this prerogative, he replied, "However, with 500 plus Congressmen looking over the agency's shoulder it is going to affect the kind of grants the agencies award. Whether anything else ever happened at the congressional level or not you can't divorce it."[108]

On the other hand, Dr. Heath said that he believed there is less prejudice in Washington, D.C. nationally than there is locally. And he feels that the channels are open to Congress and that these channels can be employed to

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[106] Ibid.

[107] Personal Interview, Washington, D.C., January 1976.

[108] Ibid.

peer review's benefit:

> Cong. Ruppe is always willing to look at new ideas. From my long experience in Wisconsin, I could say there that even Mr. O'Konski, the so-called "narrow" Rep. from the Superior area, I found him to be most cooperative. He seemed to be willing to accept an idea and try--and even Proxmire who was always yelling "the budget." If you can win the argument with Proxmire that it's something that's needed--he'll go to the floor and fight for it.[109]

And Dr. Dale Stein, Metallurgy Department Head at Michigan Technological University and member of the Advisory Committee on Materials to NSF, felt that the peer review system minimized the politics which would have greater influence in an agency-to-institution system because of pressures on university presidents at the state level.[110]

Geographic Distribution of Grants

One of the strongest charges issued against the agency-to-individual method of fund allocation is that the geographic distribution of such funding is lop-sided and favors certain sections of the country. As early as 1963 Dr. Philip H. Abelson, in a Science editorial, was raising concern over the distribution of research funds and equity of peer review.[111] He pointed out that congressional discontent with federal support of research arises from a number of causes, one of which was the concentration of

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[109] Personal Interview.

[110] Personal Conversation, Houghton, Mich., Sept. 1976.

[111] "Distribution of Research Funds," Science (October 1963).

support at a limited number of universities, ten of which in fiscal 1962 received 38 percent of the total. A compilation of Department of Defense allocations to nonprofit institutions during 1962 indicated that Massachusetts received $117 million while ten states in the South and West collectively obtained only $560,000. Yet these states have a total population more than twice as great as Massachusetts. The National Institutes of Health and the National Science Foundation have distributed their grants more evenly, but they, too, have given a large share of their funds to relatively few institutions. It cannot be denied that scientists have always tended to flock to a few major centers. And the present mode of allocation of funds makes it even easier for the rich to recruit talent from the poor. To quote Dr. Abelson:

> I sat in on a study section at the National Institutes of Health from 1956 throught 1959. As was the rule, our group rated grants on the basis of a scale from 1 to 5. The quality of applications originating from Harvard varied considerably, yet few if any were turned down, and most received a rating between 1 and 2. Proposals from less well known schools received severe scrutiny, were often rejected, and seldom were given a rating better than 2. Members of the study section were not personally prejudiced in favor of the great institutions and, if anything, would have preferred to encourage research at smaller schools. Yet we could not in good conscience produce a different result.[112]

The Select Committee on Research also pinpointed this problem for study in the mid 1960s. In its first progress report, the so-called Elliott Committee (named

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[112] Ibid.

after Congr. Elliott, D-Ala.) observed that there was a growing feeling of concern that more than a generous share of research and development funds was concentrated in a handful of states. The Committee report stated the political problem in this way:

> It is clear that our national security must not be impaired by regional consideration in research and development expenditures. It is equally clear that, to an extent perhaps not yet accurately measurable, these same expenditures have an extraordinarily powerful impact on the education, industrial, and employment sectors of every region's vitality.[113]

The issue of geographic distribution of funds for scientific research was one of the primary emphases during the Congressional oversight hearings on the National Science Foundation in 1975. In fact, the testimony of Dr. Richard C. Atkinson, Deputy Director of NSF, dealt almost explicitly with geographical distribution, which, he maintained, comprises one of the main factors of consideration in the evaluation of a proposal. Those four factors include: (1) the scientific merit of the proposal and its relation to other proposals received by NSF in the same field of science; (2) assessment of the investigator's qualifications for carrying out the research and the availability of facilities and equipment; (3) the distribution of research support among fields of science in NSF's overall program; and (4) the geographical distribution

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[113] "Regional Equity, a New Principle in Distribution of R & D Moneys," International Science and Technology, May 1964, p. 95.

of research supported by NSF.[114]

Then, as part of the material for the hearings, NSF submitted a report entitled, "An Analysis of the Geographic Distribution of NSF Awards as Compared with Selected Indicators."[115] This report examines many aspects of NSF awards on a state-by-state basis and also awards to institutions in each state. Figures 2-9 follow and will be referred to in the analysis of the report's findings.

Figure 2 represents the relationship between the population of a state and the number of dollars in research funds that the state receives from NSF. To clarify Figure 2, consider the point labeled "Massachusetts." Its value on the vertical axis is approximately $30 million and indicates the basic research funds received by Massachusetts from NSF. The value on the horizontal axis for Massachusetts is approximately 5 ½ million and is the state's population. Each of the fifty states and the District of Columbia are represented on the graph. The straight line on the graph indicates how dollars would be distributed if they were given to each state precisely in proportion to its population. Any state that falls above the straight line receives more dollars than is warranted on the basis of population

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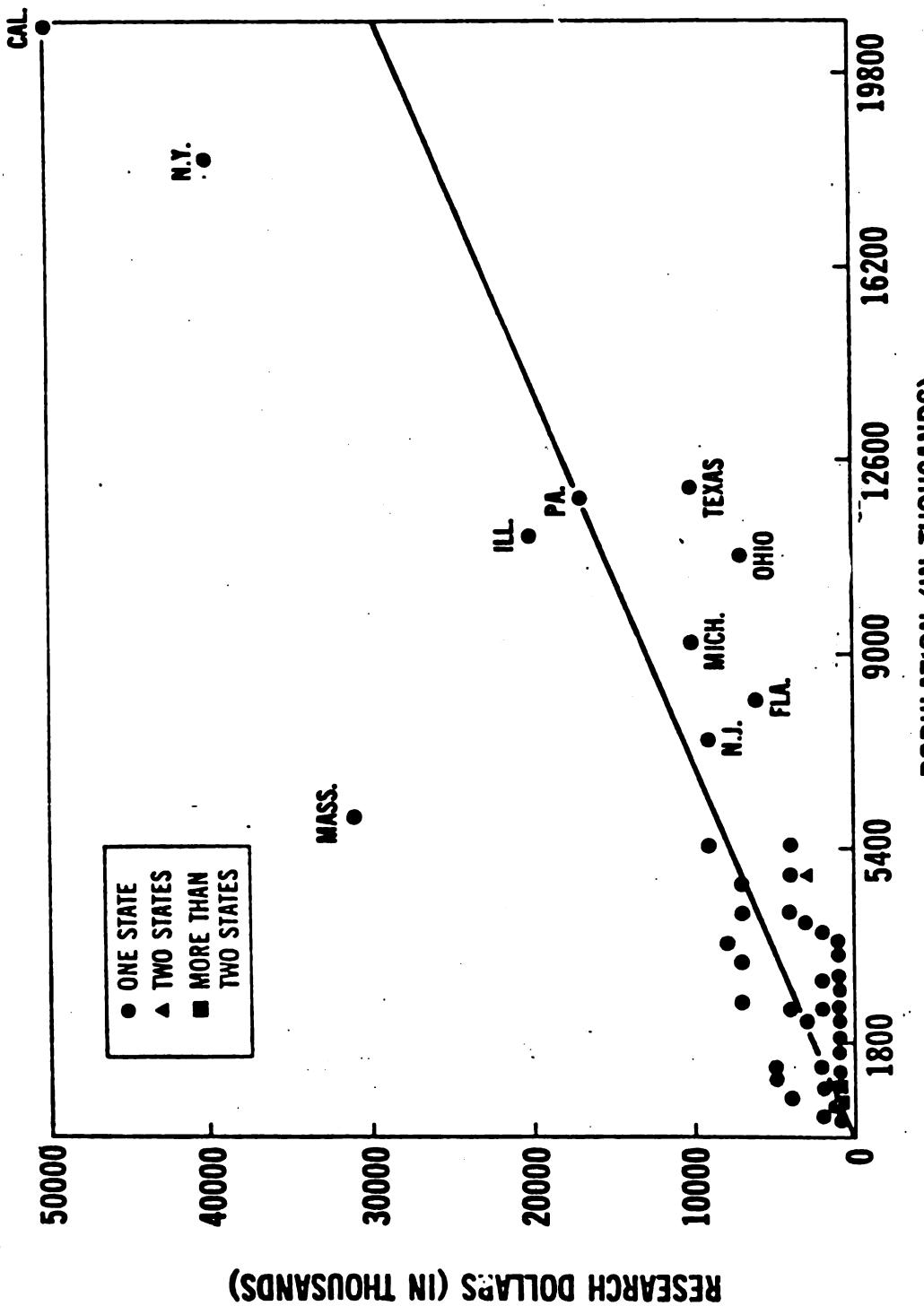
[114] NSF Peer Review, Special Hearings, pp. 249-375.

[115] Ibid.



Source: National Science Foundation Peer Review, Special Oversight Hearings. Hearings before the Subcommittee on Science, Research and Technology, U.S. House of Representatives, July 1975, (Washington, D.C.: U.S. Government Printing Office).

Figure 2. Scientific Research Project Support Dollars for Each State Plotted Against State Population.

alone, and any state that falls below receives too few dollars. As one can see, most of the states cluster about the line, indicating that the distribution of NSF funds is closely correlated with the population of the state. However, there are three special cases--Massachusetts, New York, and California--all falling well above the line. These three states receive proportionately more funds than other states when judged by population.[116]

Atkinson concluded that if NSF's objective was simply to assign its research funds to each state by population, the task would be much easier. NSF's objective, however, is to seek out and support the most innovative and promising research with the only constraint being to avoid undue concentration of funds. In this regard, it is obvious that some states have a greater concentration of scientific talent than others.[117]

Figure 3 presents the distribution of research funds as a function of the number of members of the National Academy of Sciences and the National Academy of Engineering on a state-by-state basis. In this graph Massachusetts has 236 members of the Academies and, as in the previous graph, receives approximately $30 million in research funds. The straight line on the graph is comparable to the one on the preceding graph. If research

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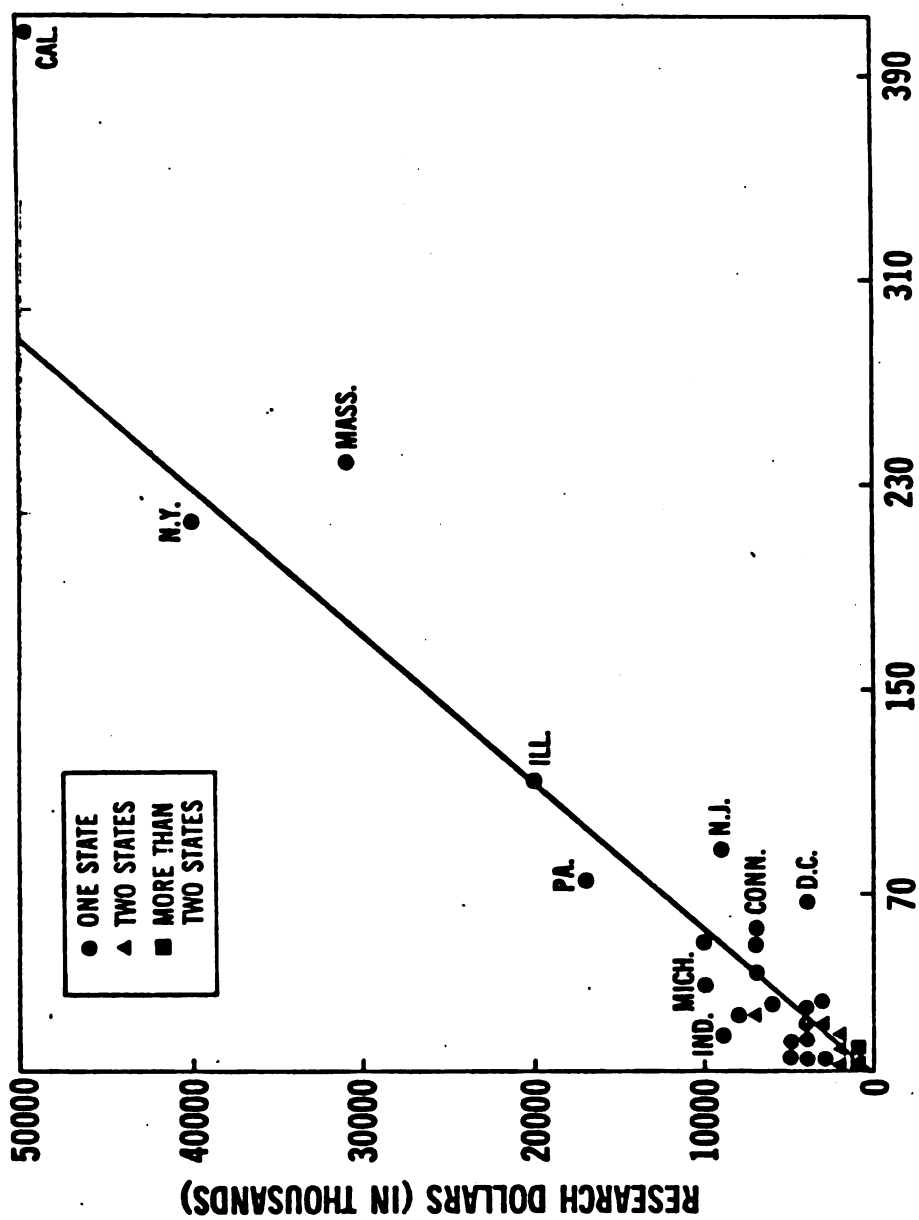
[116] Ibid.

[117] Ibid.



Source: See Figure 2.

Figure 3. Scientific Research Project Support Dollars for each State Plotted against NAS and NAE Members

dollars were assigned to each state proportionate to its number of members in the Academies, then all points would fall on the straight line. Examining this graph, note that most states are fairly close to the line except for Massachusetts and California, which are dramatically below. By this measure, these are states with a great deal of scientific talent which receive far fewer dollars than would be warranted on the basis of Academy members.[118] Atkinson said: "Obviously, we do not want to rely on Academy membership as our only measure of scientific talent."[119]

Figure 4 shows the distribution of research dollars as a function of the number of scientific publications produced in each state. Publications were calculated by counting the number of articles appearing in leading scientific journals over a period of several years; articles were assigned to states in terms of the residence of the authors. In examining Fugure 4, it is evident that New York and California are above the line, indicating that they receive more dollars than expected if funds were distrubuted proportionate to journal publications. Massachusetts, however, falls close to the line as do the other states. This figure suggests that the distribution of NSF funds correlates rather closely with the source of scientific

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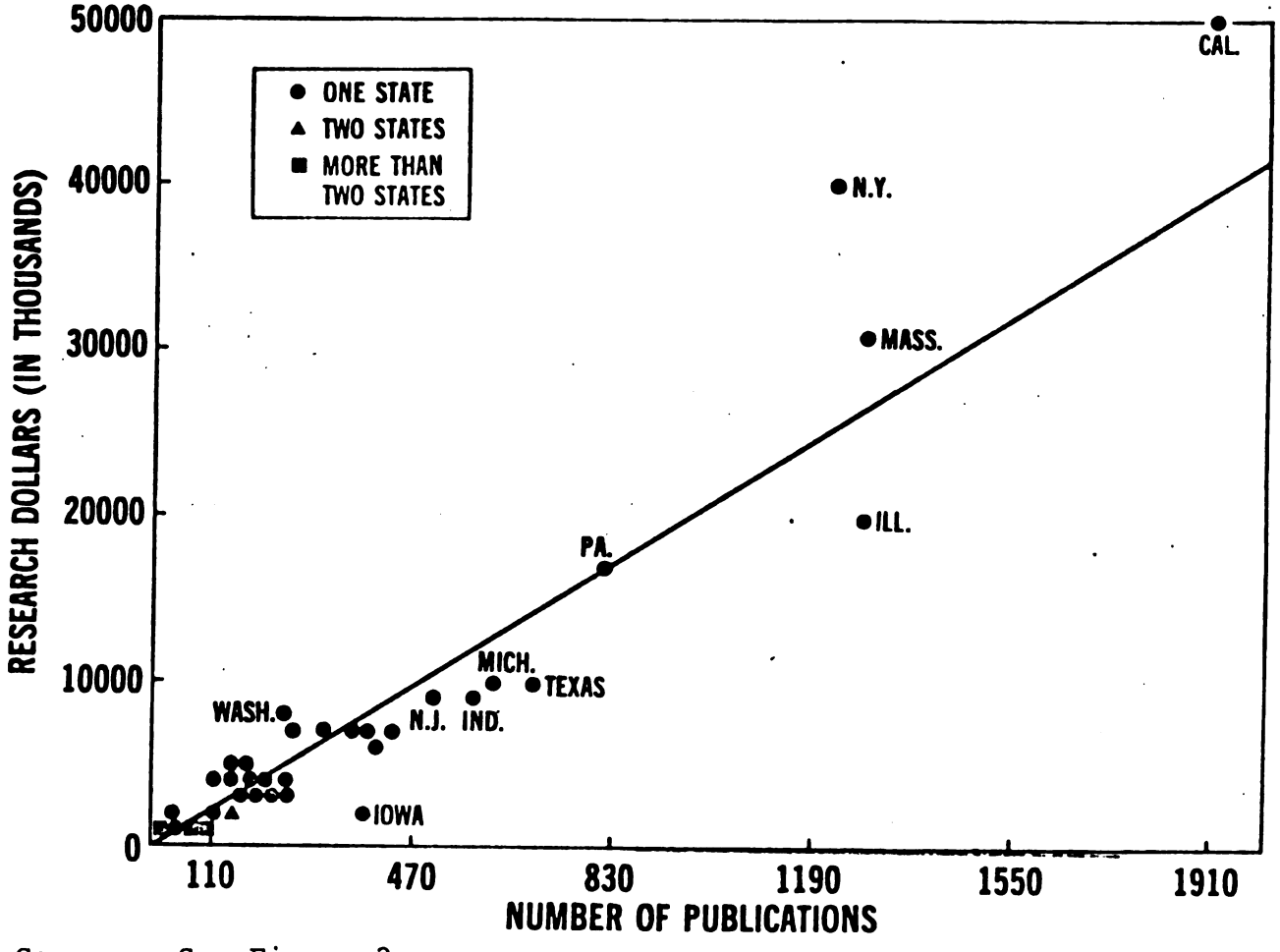
[118] Ibid.

[119] Ibid.



Source: See Figure 2.

Figure 4. Scientific Research Project Support Dollars for each State Plotted against Publications in Leading Scientific Journals

publications.[120]

The horizontal axis on Figure 5 represents the number of individuals receiving NSF fellowships in 1974 who chose to go to universities within each state. California and Massachusetts fall far below the line, indicating that they receive less money than they should based on this measure of scientific excellence. On the other hand, New York falls above the line, which means that it gets a disproportionately large share of research funds when compared to the number of NSF fellows choosing to attend New York universities.[121]

Atkinson concluded that the picture that emerges is fairly clear. In general, the distribution of research funds is closely correlated with state characteristics, such as population, income tax revenues, doctoral scientists in the labor force, and so forth. There are three states--California, Massachusetts, and New York--which receive more NSF dollars than they should based on these criteria. However, when various measures of scientific excellence are examined, it is clear that these states are receiving fewer dollars than they qualify for based on their scientific merit. Obviously, then, NSF's distribution of funds turns out to be something of a compromise between a state's population and its collection

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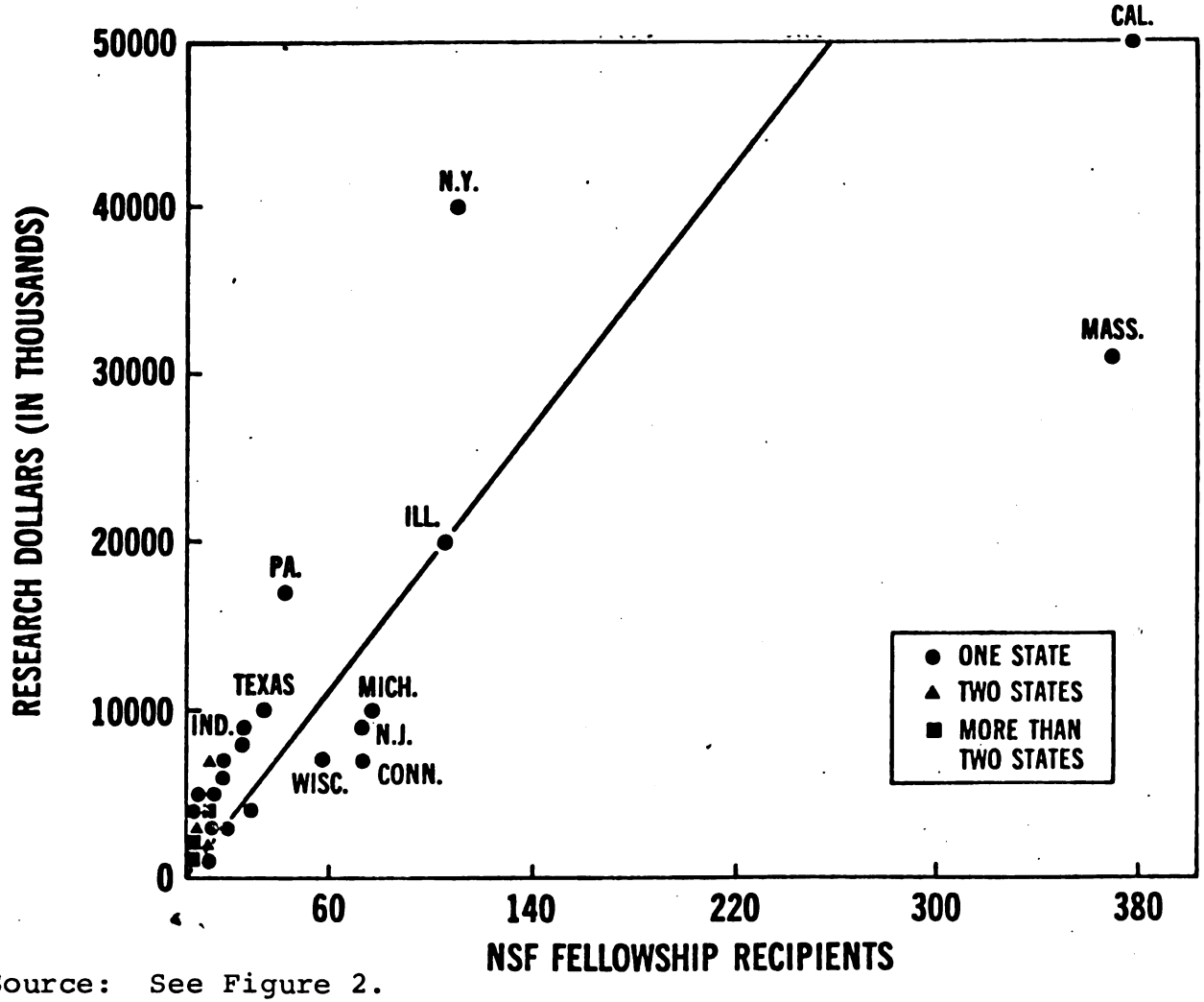
[120] Ibid.

[121] Ibid.



Source: See Figure 2.

Figure 5. Scientific Research Project Support Dollars for each State Plotted against NSF Fellowship Recipients

of scientific talent. NSF has no precise formula for making this compromise; rather the various forces operating on NSF have defined its policy. Whether this policy is correct may well be judged differently by different individuals.[122]

In Figure 6 the number of NSF reviews are plotted on the vertical axis and state population is plotted on the horizontal axis. The straight line on the graph indicates how reviews should be distributed if they were solicited from a state proportionate to that state's population. Except for a few outliers, most of the states cluster closely about the line, indicating that the distribution of NSF reviews is closely correlated with state population. However, the District of Columbia and Maryland provide considerably more reviews than one would expect given their populations. The same observation applies to California and Massachusetts, whereas Ohio is disproportionately low.[123]

Atkinson then said that the question is whether a few select states tend to monopolize the review process. In order to answer this question, it will be useful to consider the source of NSF reviews in relation to the previously mentioned measures of scientific excellence.[124]

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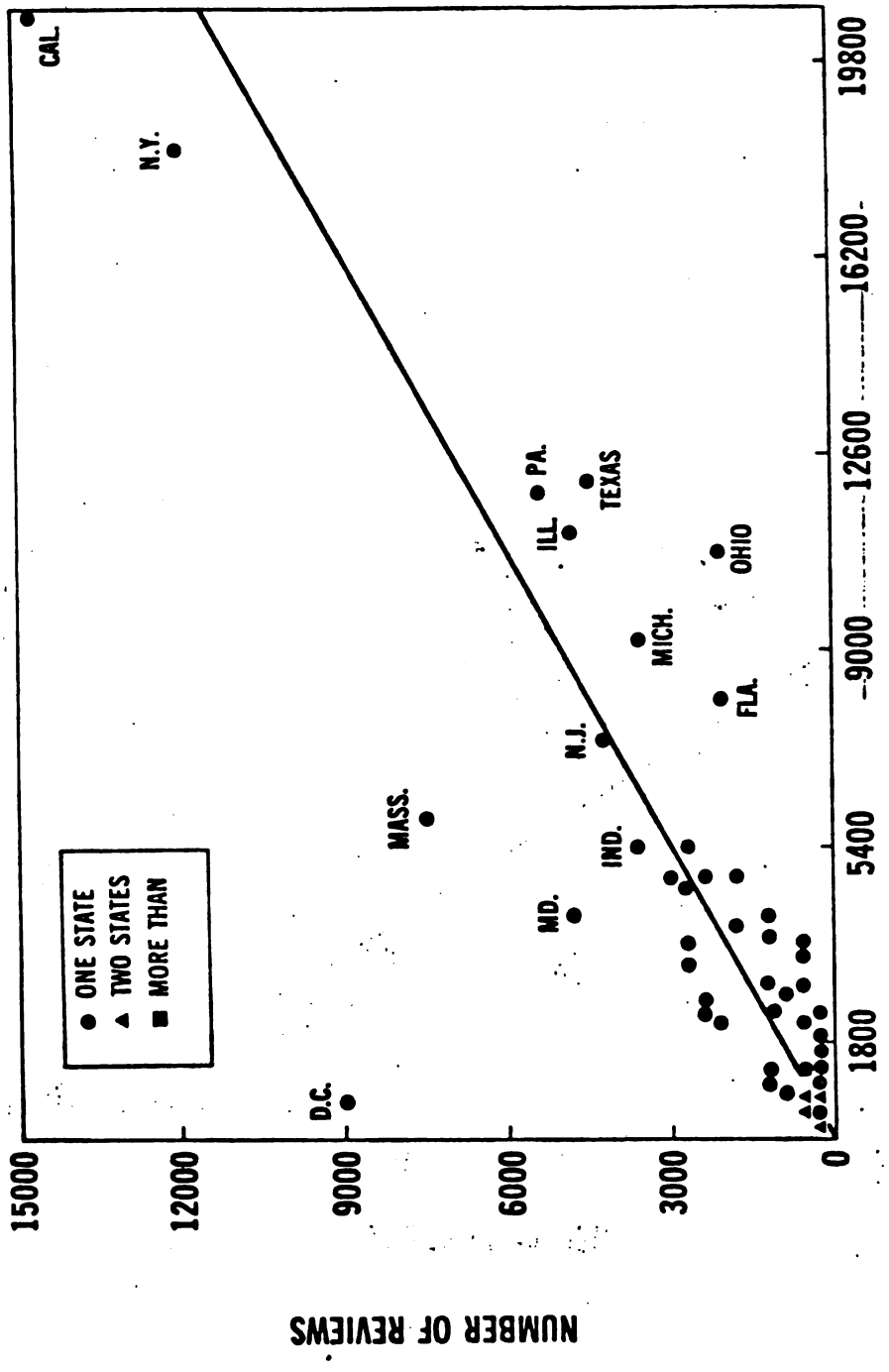
[122] Ibid.

[123] Ibid.

[124] Ibid.



Source: See Figure 2.

Figure 6. NSF Reviews from each State Plotted Against Population

Figure 7 plots NSF reviews as a function of the number of National Academy members in the state. The straight line has the same meaning as in previous graphs. Once again, most states cluster about the straight line, except that the District of Columbia falls well above, whereas California and Massachusetts are dramatically low. By this measure, the District is again overrepresented in the review process, but the opposite is the case for California and Massachusetts.[125]

Figure 8 presents a similar plot for the distribution of NSF reviews as a function of the scientific publications produced in each state; and Figure 9 is a plot for NSF fellowship recipients.

These last four figures indicate that the geographic distribution of NSF reviewers closely approximates both population and various measures of scientific excellence for most states. Those states that fall above the line in one graph fall below the line in another, depending on which measure is considered. There are only three points that are outliers in all four figures. The District of Columbia on all measures provides far more reviews than are to be expected. California and Massachusetts provide too many reviews based on population, but far too few reviews based on any of the measures of scientific excellence. The high concentration of reviews

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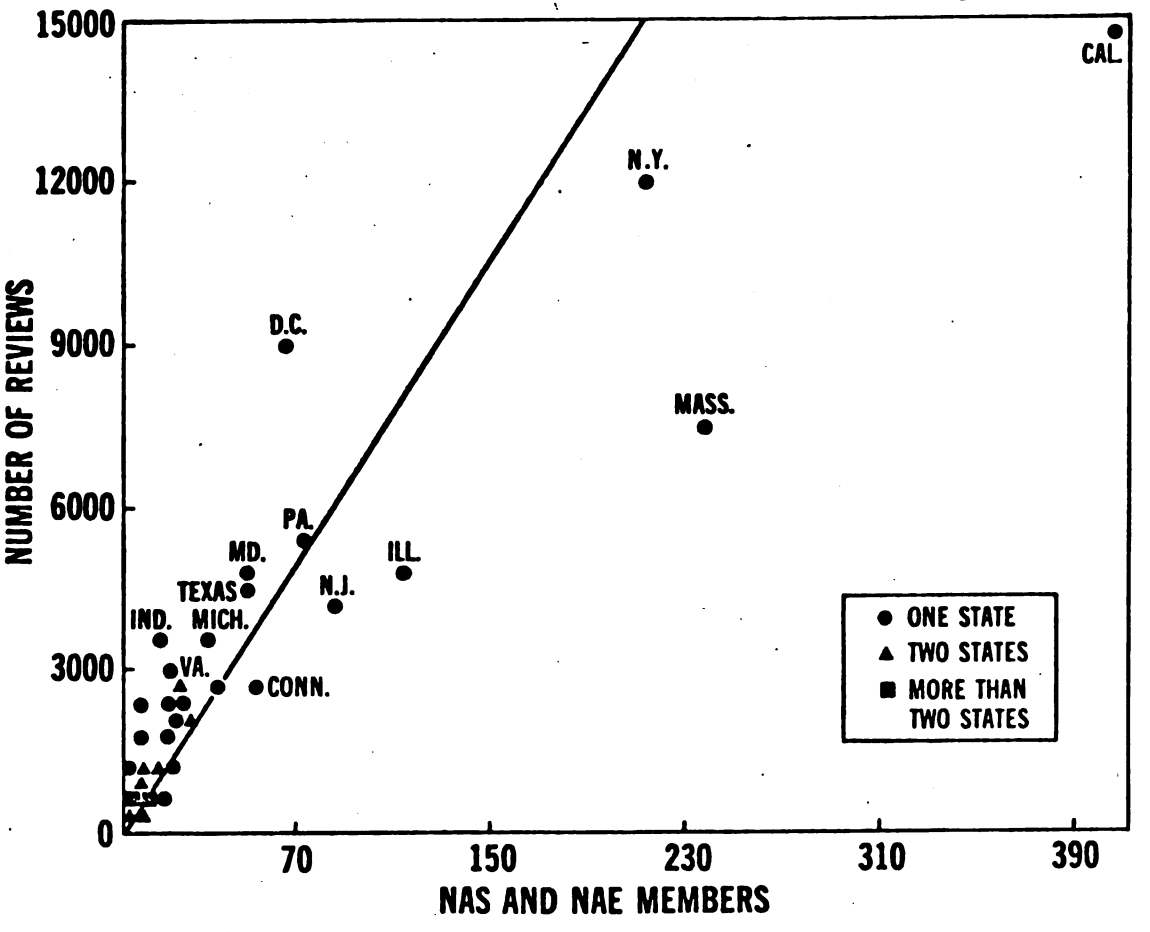
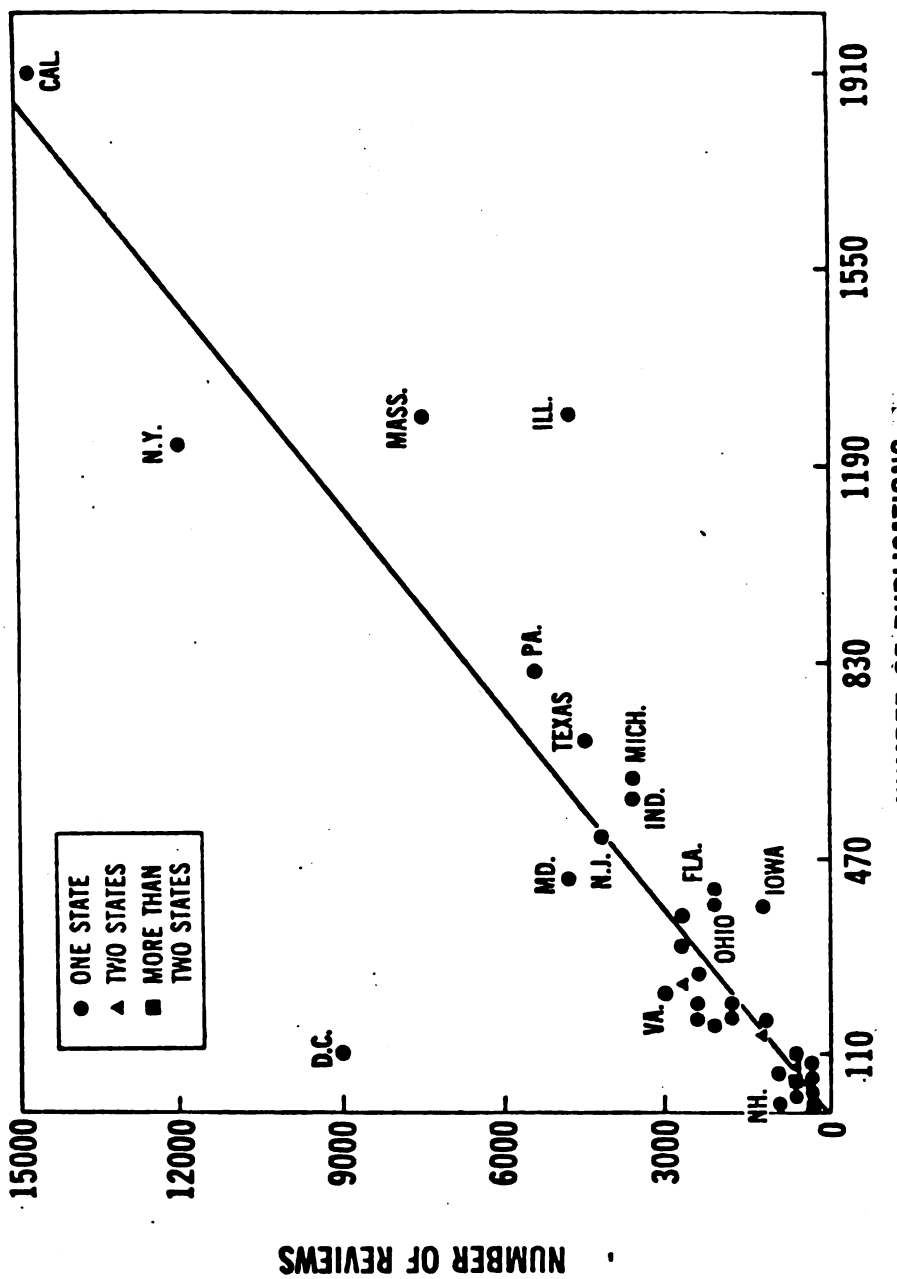
[125] Ibid.



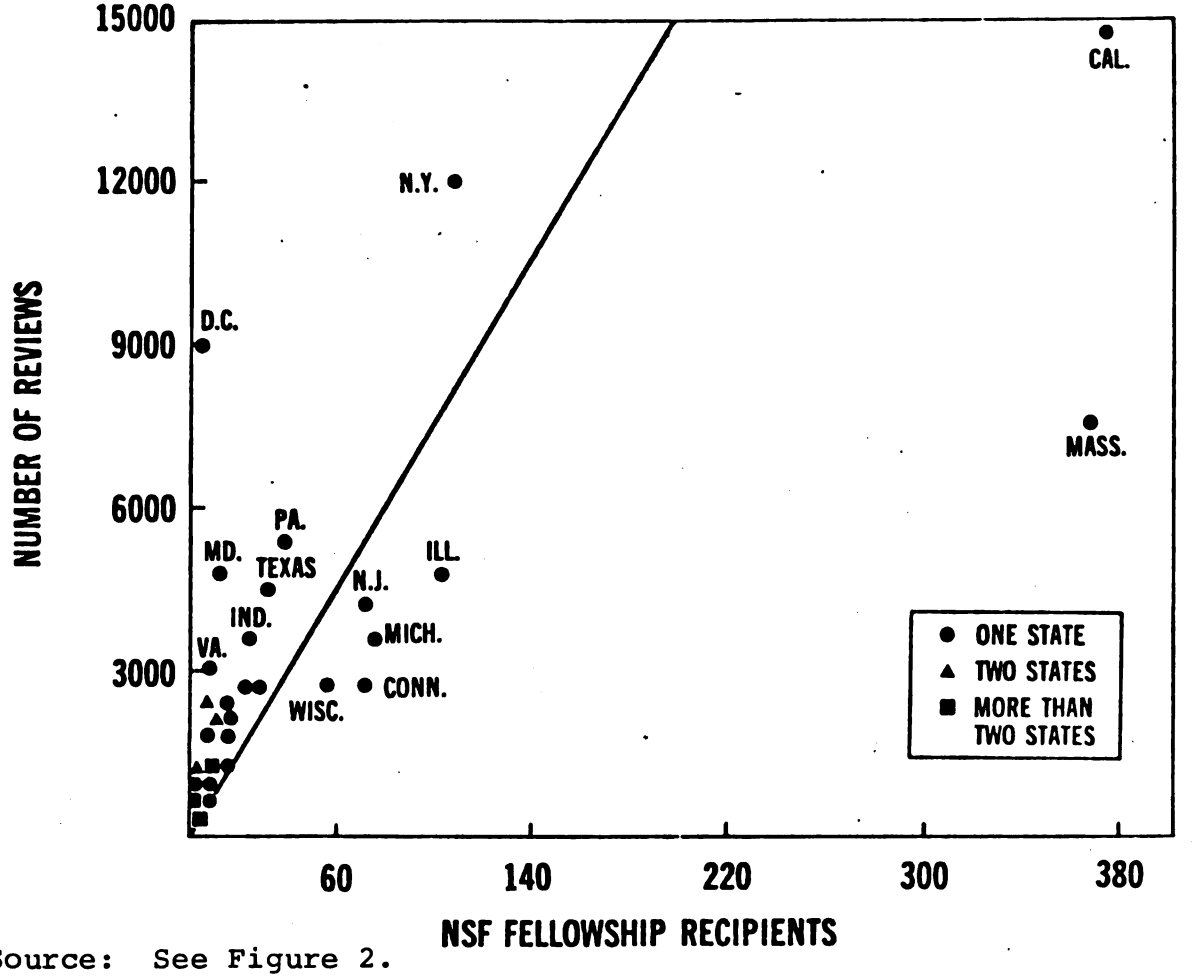
Source: See Figure 2.

Figure 7. NSF Reviews from each State Plotted against NAS and NAE Members



Source: See Figure 2.

Figure 8. NSF Reviews from each State Plotted against Publications in Leading Scientific Journals



Source: See Figure 2.

Figure 9. NSF Reviews from each State Plotted Against NSF Fellowship Recipients

from the District reflects the fact that NSF coordinates with other federal agencies on many proposals; this is particularly the case in the RANN program but is also true in other areas such as in the national programs in oceanography and the atmospheric sciences.[126]

Atkinson said that, nevertheless, the data indicate that

> Washington-based scientists may be overrepresented in the NSF review process. Further analyses need to be undertaken to determine whether this is the state of affairs and should be corrected. The same comments do not apply to California and Massachusetts; in these two cases, NSF procedures strike a balance between selecting reviewers on the basis of a state's population and its scientific expertise. If you favor either side of this balance you will be dissatisfied with NSF procedures, but I know of no way to resolve the issue. The choice is a matter of judgment and the question is whether reasonable people agree with NSF's trade-off between population size and scientific excellence.[127]

A very large segment of the scientific community is involved in the NSF review process. Despite this large involvement, one can ask whether certain universities and certain areas of the country are given a favored status in the competition for research funds. "The Report gives information on this question; we also have additional data that will help you to make a judgment. Unfortunately, I do not have time to review all of the data today; there are, however, a few results that I want to comment on,"

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[126] Ibid.

[127] Ibid.

said Atkinson.[128]

> Consider, first, information comparing university departments ranked in the top 20 by the American Council on Education with departments ranked below the top 20. There is no question that an application from a scientist employed by one of the top 20 departments has a higher probability of NSF funding than an application from some other university.
>
> In the chemistry section, for example, the overall approval rate is 35%. However, the approval rate is 53% for applications from chemistry departments ranked in the top 20, and only 30% for departments below the top 20. This is not an unfair situation; departments are ranked in the top 20 because they have, on the average, a more innovative and distinguished faculty.[129]

The more important question to Atkinson, however, concerns possible relationships between the scientist who submits a proposal and the scientists who review that proposal. The NSF data clearly indicate that proposals submitted by scientists from the top 20 departments have the same distribution of reviewers as proposals from other schools; the assignment of reviewers in terms of the eminence of the university with which they are affiliated is not statistically correlated with the eminence of the school from which the proposal originates. A closely allied issue concerns the correlations between the geographic locations of reviewers and the scientist submitting the proposal. But when data is analyzed on a regional basis, again there is no statistically

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[128] Ibid.

[129] Ibid.

significant relation between the location of the applicant and the locations of reviewers. Atkinson maintained that these two observations are particularly important and mean that the review process is not biased by the distinction of the institution submitting the proposal or by the region of the country in which the institution is located.[130]

Despite Atkinson's testimony, however, Dr. Doris Wilsdorf, University of Virginia, claimed that her data showed that: "clearly, indications are that geographical concentration of funding rather than dispersal of funding has taken place."[131] She based this claim on the Citation Index in which the names of all people whose work has been referenced in thousands of journals worldwide are given, together with the names of the people that have cited them and the journals in which they have been cited. Thus, one can make a count of how often the use of the research output of any one author was made.[132]

Dr. Wilsdorf further maintained that a person who is largely engaged in teaching rather than research is handicapped in seeking funds from NSF and that there is a direct relationship between the number of references in publications and the success of an individual or group

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[130] Ibid.

[131] NSF Peer Review, Special Hearings, p. 730.

[132] Ibid., p. 706.

receiving positive or affirmative peer review comments that lead to successful applications.[133]

Industrial Research Opinion Poll

As a pertinent conclusion to the findings regarding the second research question on the fairness of the peer review system, an opinion poll of scientists themselves and their perceptions of the peer review process provides some valuable insights. Such a poll was conducted in 1975 by Industrial Research Magazine.

According to Robert R. Jones,[134] the editor,

> a major control feature in this nation's research efforts is failing to do its job, and the world is poorer for this breakdown. The control feature is peer review, a profession-guiding procedure that promises to apply the vest of disinterested wisdom to research project funding and, ergo, to individual scientists' tenure, promotions, and salary increases.
>
> [Yet] while there are strong indications that four out of every five scientists who have knowledge of the peer review system favor it in principle only one in eleven believes that the system as it operates today is fair and reasonable. The other 91% believe that this important cog in our research machine has broken down, and they have called for modifications to make it acceptable to them.[135]

In order to obtain specific opinions of scientists regarding peer review, Industrial Research Magazine, via an opinion poll, surveyed and received responses from 1,093 persons who work as scientists or engineers in the research and development industry. Almost 900 of these

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[133] Ibid., p. 708.

[134] "Much of U.S. Research Controlled by Faulty Mechanism," Industrial Research (September 1975), pp. 87-91.

[135] Ibid., p. 87.

respondents indicated that they believe peer review fails if its goal is to assure equitable distribution of research funds.[136] Another interesting finding relates to this paper's earlier consideration of peer review's promotion of scientific advancement in terms of the system's encouragement of innovation: 87 percent of those responding answered "yes" to the question: "Are funds denied individuals challenging reviewers?"[137]

It is important to note here that although the opinion poll results provide interesting correlations with some of the findings of this study, the polls themselves can be viewed as suspect because of relatively small response rates and because the criterion for selection of potential respondents (that the respondent received the free magazine Industrial Research) was not scientifically oriented toward obtaining a true cross-section of the scientific community.

A copy of the IR questionnaire including response results can be found in Appendix B.

THE ECONOMIC ASPECTS OF PEER REVIEW

The question of economics surfaced again and again in the interviews conducted for this study of peer review. Although there seemed to be no denial that the agency-to-individual approach to federal funding entails greater

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[136] Ibid.

[137] NSF Peer Review, Special Hearings, p. 234.

expense than the agency-to-institution approach, there was disagreement regarding the necessity of such expense. Detractors of the system claimed that additional costs were exhorbitant and unnecessary, while the system's backers justified the costs as necessary for the operation of an open and fair system which involves the public sector in the person of the scientific expert serving as a reviewer of grant applications and the scientific researcher applying for the grant.

Economic Arguments Against

Perhaps one of the strongest economic arguments against the peer review system, or the agency-to-individual approach, is the high cost factor: peer review is an expensive system to operate. Indeed, the costs of maintaining the system mount steadily with the multiplication of bureau and agency staffs and interlocking advisory boards, increasing treks to Washington by increasing numbers of university staff members, overlapping agency and university administrative and accounting services, the development of large (but still inadequate) mailing lists in order to announce an ever increasing number of separate programs, and even the establishment of permanent university liaison offices within the nations' capitol--costs absent or greatly reduced with the older agency-to institution approach.[138]

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[138]Dr. Christian Arnold, Personal Interview.

Dr. Christian Arnold presented the hypothetical situation of the young scientist who acquires a research grant and six weeks into his research discovers that it has no chance of success. Note that there are many positive points which have motivated his application for a grant in addition to a belief in his own research aims, points such as more prestige for his university, promotional possibilities, monetary reward, etc. Can those motivational aspects be put aside when the research which has been funded "turns sour." Dr. Arnold said no:

> There is no incentive for him to stop his work. Neither the scientist nor the university would have anything to gain from stopping that two-year project or whatever short of its termination. However, if this was the university's money there would be all sorts of incentives to stop the project when it was found that it was no longer going to be productive and let the scientist get on with what he thinks is more productive.[139]

He then went on to maintain that, in comparison with institutional funding, it is perhaps twenty to fifty times as expensive to operate a national project grant review system.

> In the first place you cut down with an institutional support program. You have practically no administrative overhead at the national level. Your awards to an institutional program would have to be settled on some kind of a formula basis. All you need really to do is to have some control to make certain the funds are spent for what they are designed to be spent for, fund accountability. At the local level then you would necessarily have some PR too, but you wouldn't have travel expenses you have at the national level. You wouldn't need

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[139] Ibid.

> as many copies of the proposal for one thing. It would be just less paperwork, fewer people involved, less travel involved.[140]

Economic Arguments In Favor

Dr. Emerson Elliott from the National Institute of Education counters arguments like those of Arnold's by insisting that the cost of operating the peer review system can be justified on the basis that involving the public sector in the process does lead to additional expected expenses. Many people don't realize, he claimed "that you do have a lot of requirements in the government for notification, publication, announcements in the federal register, comment and review periods, open review system, open meetings, the Federal Advisory panel approvals..."[141] And all these requirements cost money to fulfill.

Dr. Charles Haughey agreed with Dr. Elliott. "It seemed to me that that kind of thing is the price we have to pay for opening creative research possibilities to everyone in the U.S. The notion really is that we are opening the coffers in support of any good idea coming from anywhere, the university or elsewhere."[142] He agreed that, under contracted research, compliance reporting could be required and termination could be

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[140] Ibid.

[141] Personal Interview, Washington, D.C., January 1976.

[142] Personal Interview.

arranged for given certain contingencies met or not met; thus, the system could be managed more efficiently. However, such an approach would limit the spontaneity of the research sponsored through a grant-in-aid. Furthermore, he insisted, "we are trying to buy the interest of that total person [applying for the grant] so that his teaching and his service as well as his scholarship are to some extent affected by that grant-in-aid."[143] The university contract approach, though perhaps more economically efficient, does not permit the same type of access to the individual scientist applying for the research grant. Dr. Heath supported this notion when he claimed that if a person was a true researcher and if he "survived" the panel review process and won a grant, then he would have the expertise to be flexible enough in his research approach to avoid the type of pitfall to which Arnold refers when he charges that a scientist on a grant could deliberately continue a dead-end project for the sake of maintaining funding and obligations.[144]

GRANTSMANSHIP AND THE ISSUE OF OPENNESS

During the Congressional Oversight Hearings on the National Science Foundation's peer review system two of the most significant issues to be considered were those of grantsmanship (a funding award made on the basis of

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[143] Ibid.

[144] Personal Interview.

proposal writing rather than proposal content) and the actual openness of the system's operation. Congressmen wanted to know what kinds of grants were being made by NSF, what research emphases were being supported. And how were these emphases affected by the system's insistence on the confidentiality of peer review results and on the necessity for the proposer to be able to "write well"?

Grantsmanship

Rep. Robert Bauman expressed a strong interest in the oversight committee exercising its obligation to look closely at NSF activities, especially at the research projects it was supporting. He then went on to cite a case which indicated a reason for concern.

> This information was gleaned from the daily NSF notices sent to our congressional offices: $9,600 in March of this year, for a biography of Isaac Newton, given to Indiana University.
>
> Would you believe there are 145 biographies of Isaac Newton in the Library of Congress at this very moment?
>
> Now, I am sure Isaac Newton was a very great man. I am sure he was greater than the gentleman from Maryland; perhaps he even approached the greatness of the distinguished chairman of the subcommittee (Mr. Boland) who has been so able in presenting this bill today.
>
> But how many times does the apple have to fall?[145]

Bauman went on to cite yet another case of questionable research: NSF's grant of $36,500 to the

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[145] Congressional Record, June 24, 1975, p. H6015.

University of Michigan for a study of the "Evolution of Song Learning of Parasitic Finches."

> I have a lot of finches in my district. I am sure they would be interested in this type of spending. At a dollar a finch they could all benefit...
>
> I suggest there is a need for revision of the basic system by which these research grants are made. They are handed out in an unregulated and secretive manner known as the "peer review system." This system allows cronies to get together and finance their pet projects, where grant application writing has become an art and where many people are not devoting themselves to basic research needs but, rather, to feathering their own nests, just as the finches whose songbird qualities are being studied under one of these grants.[146]

Bauman's charges are serious ones. Indeed, if the emphasis is on grantsmanship as an art rather than the significance of an applicant's research objectives, how can the public expect that worthwhile projects are being funded, that the best scientific ideas are being utilized? According to Dr. Rustum Roy:

> Today [that] the total proposal-aim--peer review system is approaching a dangerous level of inefficiency. We waste more time using up the best brains of the country in writing their own proposals. That is the major part of the inefficiency of the process: the writing and review of dozens of proposals--which is a totally nonproductive, bureaucratic process. This is an enormous drain on American scientific manpower. Meanwhile, the great American invention, of the multiple sources of funding, which was the truly American innovation, that, I think, is endangered. Most of the money, especially for new work, tends to end up in a smaller and smaller number of agencies, principally ERDA and NSF.[147]

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[146] Ibid.

[147] NSF Peer Review, Special Hearings, pp. 754, 755.

Are some people getting funded on the skill of the presentation of the idea rather than on the merit of the idea itself? Dr. Heath from NMU admits that there has to be skill in presentation for an applicant to be considered for a grant, but he argues that merit of the idea is the over-riding concern. Yet when asked if he believed a Columbus or a Kepler idea would get funded today, he indicated that, yes, it would. "I think if somebody got a really good idea and if he can write--but if he can't write, he can't get it funded."[148] Does the wild idea, the really wild idea, out there get a chance? He responded:

> I think so. I've worked on the atom bomb. That was a wild idea and that certainly was funded. Now it may have been an administrative decision at the time but Bush, Einstein, etc., were really the peers in that instance. As a matter of fact, while I was in it I was wondering how they dared reach the decision. But really we were looking for new knowledge--we had an inkling on the way to go and we went there successfully.[149]

NIE's Dr. Thomas Clements acknowledged the existence of grantsmanship in the peer review system when he admitted that it is always possible that someone is more eloquent and rhetorically skillful than another, that some people write better or know more about the federal game than others. But he qualified his admission:

> I suppose their batting average would be somewhat higher. I do not think, and maybe I am not the

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[148]Personal Interview.

[149]Ibid.

> best source on this because afterall, I am a Fed, but I really do not think that anybody is going to con my staff with unalloyed grantsmanship because my people do have substantive competence, in the area of their working, and they are not going to be conned by a bunch of glittering generalities.[150]

When NSF's Dr. John Maccini was asked what his organization was doing about the existence of grantsmanship, he referred to the seven criteria used by reviewers in evaluating an application, as listed in NSF's Guide for Preparation of Proposals. And the very use of such criteria would seem to prevent a proposal from being accepted based only on its written quality, though Maccini added, "Now this doesn't negate the problem that you have got to write a good proposal...you have got to say it well."[151]

System Openness

The issue of whether or not the peer review system is working to the disadvantage of worthwhile research by funding "well written project proposals" rather than substantive research efforts bears directly on the concern regarding the openness of the system. Do secrecy and confidentiality promote bias, favoritism, insubstantial research? Many of peer review's critics say yes. The first witness to testify before the oversight hearings committee, Rep. John B. Conlan from Oregon, levelled a harsh attack on the system:

> Here is an amazing system, gentlemen, where individual program managers are given carte blanche

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[150]Personal Interview.

[151]Personal Interview.

> authority to select peer reviewers who will be used to evaluate proposals.
>
> ...Unfortunately, under NSF's current management practices, they have a completely arbitrary system that is closed and unaccountable to the scientific community and to the Congress.
>
> It is common knowledge in the science community that NSF program managers can get whatever answer they want out of the peer review system to justify their decision to reject or fund a particular proposal.
>
> ...I know from studying material provided to me by NSF that this is an "Old Boy's System," where program managers rely on trusted friends in the academic community to review their proposals. These friends recommend their friends as reviewers.
>
> ...It is an incestuous "buddy system" that frequently stifles new ideas and scientific breakthroughs, while carving up the multimillion dollar Federal research and education pie in a monopoly game of grantsmanship.[152]

Conlan then went on to cite as an example of the system's weaknesses with regards to grantsmanship and openness the NSF funding, with more than $3.3 million, of the Individualized Science Instructional System--ISIS--a curriculum project at Florida State University.[153] He indicated that the program includes several explicit sex education courses and referred to one of the courses as being "so hot that it is unavailable for public or congressional review."[154]

> I say this because one of the sex mini-courses now being pilot tested called "Human Reproduction," itself achieves a new height in science porno

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[152] NSF Peer Review, Special Hearings, pp. 4, 5.

[153] Ibid., p. 6.

[154] Ibid., p. 7.

> literature. There is some material, including prurient questions aimed at mixed classes of 10th grade boys and girls, that I cannot bring myself to quote here in this public hearing.
>
> I will simply provide a typical "True-False" question here in my text so that you can see my point. This question in the Teacher's Guide for "Human Reproduction" is asked following one of the mini-courses many how-it's-done sex lessons:
>
> > True or False. A man with a large, flaccid penis will have the same size erection as a man with a small penis.[155]

In favor of a public policy which would make reviews' and reviewers' names available to principal investigators and to the Congress, Conlan concluded by accusing NSF of being arrogant in its refusal to be more open in its process. "The examples I have cited, are therefore, part of an overall pattern which, when taken together, constitute an indictment of a sick system that cries out for reform. The answer, gentlemen, is total openness in the system."[156]

The "sickness" to which Conlan referred gains new dimensions in an article by Edward Roeder entitled "The Consulting Con Game:

> There are reportedly a lot of honest consultants, and this writer knows a few. But most, who operate behind the scenes outside the bureaucratic safeguards and delays of the system, receive too little public scrutiny. They can turn out to be someone like E. Howard Hunt, a former White House consultant and $100-a-day project director for an Office of Education contract at the time he

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[155] Ibid.

[156] Ibid., p. 11.

> engineered the Watergate break-in. They can be beneficiaries of absurd wastes of the taxpayers' money, such as the $23,000 HEW research study entitled, "An Evaluation and Parameterization of Stability and Safety Performance of Two and Three-wheeled Vehicular Toys for Riding." (The study's chief conclusions? Tikes fall off trikes because they either (a) lose their balance, or (b) collide with objects.)
>
> Or they can simply be clever men who invent fraudulent schemes for their own profit.
>
> What follows is one such case, the con game of a trio of consultants who latched onto the Emergency School Assistance Program (ESAP), part of HEW's Office of Education. Aside from collecting fat consulting fees from ESAP, these men were able to award sizable contracts to phony grantees created by themselves or their friends, and to require legitimate grantees--usually small, black, Southern universities--to kick back a portion of their federal funds to bogus consulting firms in which they had an interest.[157]

When one acknowledges the legitimacy of these complaints, one must then confront a new question: How far can openness in the decision-making process co-exist with effective evaluation of award applications? With regards to NSF at the oversight hearings, the agreement was overwhelming that increased openness per se is desirable. To what extent was hotly debated with choices ranging from the most secret to the most open, though no one ascribed to the extreme position that applicants should know nothing about who reviewers were or what they said.[158] But there were four distinct positions on the degree of openness which should exist:

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[157] New Times (November 1974), p. 26.

[158] NSF Peer Review, Special Hearings, p. 22.

(1) The NSF policy for many years, up to June 1975, was that applicants should receive paraphrased reviewer comments on request but should not know the identity of reviewers.[159]

(2) On January 1, 1976 the NSF Policy became: applicants should receive verbatim reviewers' comments on request but should not know the identity of reviewers.

(3) Applicants should receive signed verbatim peer reviews on request (Rep. Conlan and Heinz Walsdorf believed this would be best).

(4) Applicants and the public at large should have access to signed verbatim peer reviews (rejected by all).

As indicated above, NSF had itself arrived at a new proposal in June 1975 regarding openness of the peer review system. At the oversight hearings Dr. Donald B. Rice, National Science Board member, presented the arguments considered in arriving at that proposal:

> One: Reviewers will be more candid on all aspects of the proposal, and the qualifications of the proposer to accomplish the work, if their identity and/or verbatim comments are kept confidential and not passed on to the proposer. Thus, confidentially, in this view, contributes to the quality of reviews.
>
> Two: Providing names of peer reviewers to principal investigators is likely to encourage personality clashes between the proposer and the reviewer, leading to unnecessary ill will and hard feelings among all parties concerned.
>
> Three: Program managers might have to take on the role of arbitrators between proposers and

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[159] Ibid. Resolution adopted by the National Science Board at its 174th meeting on June 20, 1975, on Peer Review information.

> reviewers, and would also find themselves spending more and more of their time defending their decisions orally and in writing. This would add measurably to their workload, and make it more difficult to come to the decisions they have to reach.
>
> Four: Many potential reviewers would refuse to participate in a system that required them to be identified with their comments to the authors of the proposals they have reviewed.
>
> Five: Unless their identity was protected, reviewers would be reluctant to comment critically on proposals by others who could adversely affect the career path of the reviewers.
>
> Six: The identification of reviewers would increase the opportunity for political pressures to intrude on the system.[160]

The resolution regarding confidentiality and peer review information was actually adopted by the National Science Board at its 174th Meeting on June 20, 1975. It had four resolves:

1. The Foundation will publish annually a list of all reviewers used by each Division;

2. Program officers should seek broadly representative participation of qualified individuals as reviewers;

3. Verbatim copies of reviews requested by the Foundation after January 1, 1976, not including the identity of the reviewer, will be made available to the principal investigator-project director upon request. The question of including the identity of the reviewer will be considered further by the National Science Board.

4. The Foundation, upon request, will inform the principal investigator-project director of the reasons

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[160] Ibid., pp. 767-768.

for its decision on the proposal.[161]

All reviews requested prior to January 1, 1976 were to continue to be governed by earlier policies since those reviews would have been solicited with a commitment on the part of the National Science Foundation to the confidentiality established by that earlier policy. At the hearings Board representatives evinced the belief that the new policy will serve to improve information exchange with the scientific community and allow it to better understand the reasons behind National Science Foundation decisions.[162]

But there are dangers, too, when openness becomes a policy, especially when Congress can exercise control over the review procedure. In the hearings several witnesses voiced this concern, among them Rep. Tom Harkin who pointed out that "the 'old boys' club is well in place right here in Congress"[163] and further indicated that when he took his bar examination that the names of those lawyers that did the review were kept secret.[164] Dr. Norman Hackerman, Chairman, National Science Board, also later made the point that editors of many scientific and technological journals were among the first to use the peer review process to judge the quality of original research

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[161] Ibid., p. 60.

[162] Ibid.

[163] Ibid., p. 34.

[164] Ibid, pp. 34,35.

articles submitted for publication, and he attributed the high quality of the majority of scientific journals to this process.[165] Rep. Tom Harkin warned of the dangers of political pressures if the names of reviewers were released: "You are going to have the worst kind of pressure. You are going to have political pressure, sudden political pressure."[166] Later he said:

> I feel whenever inquiry and freedom of thought is placed beyond the realm of the politician, then that country acquires a spiritual strength that makes it, in fact, a beacon of liberty in the world. That is what I want to protect. I don't want to become another Soviet Union or China, where people are channelized into their programs.
>
> I want freedom of--whatever nature, social sciences, hard sciences--freedom to inquire, and to challenge, the freedom to challenge the most deeply rooted beliefs that people hold. Only by doing that can people really change and grow.
>
> I think this prior approval would take away that freedom of inquiry.[167]

And the chairman, Rep. James Symington added:

> I think whatever kind of a frying pan we may be in now with respect to oversight might turn into a fire of old boyism if Congress became the court of last resort on all of these grants. For a while there would be few intrepid members who would question the grants. Little by little, it seems to me, a form of congressional courtesy would take over which might even turn into an active club on the NSF to go forward with grants which it may have had some suspicion about. I do not, in my own mind, know what grant applications are pending from any state.

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[165] Ibid., p. 76.

[166] Ibid., p. 36.

[167] Ibid., p. 240.

> If I were to know that I might be inclined to make some friendly intercession.[168]

Perhaps as a conclusion to this section on openness it would be interesting to ponder the results of a survey submitted to the committee by Dr. Vincent S. Haneman, Jr., First Vice President of the American Society for Engineering Education. The survey involved the Engineering Research Council whose members were polled on July 29, 1975. Of the seventy-six responses from 172 engineers, Dr. Haneman reported the following:

Question 1 - Concerning whether the faculty of an institution prefer to have their names placed upon the technical portion of the proposal--33 of 76 said yes, 39 said no, and 4 abstained or did not give an indication which could be placed in either the yes or no category.

Question 2 - Would the faculty prefer to have their names identified on the second part or the evaluation of the individual?--11 out of 76 said yes; 64, an overwhelming majority, said no; and one was in question.

Question 3 - If it were the will of the Congress that public identity of the reviewers be published along with their reviews, would the faculty still be available to provide this service?--27 out of 76 said yes; 46 said no; and 3 abstained.

Question 4 - Under the conditions of three, that is, the will of the Congress, did the respondents feel that

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[168]Ibid., p. 241.

more candid, honest, evaluations would result from those who did volunteer? Only 8 said yes; 64 indicated that evaluations would be less candid, less honest; 4 abstained.[169]

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[169] Ibid, pp. 630-631.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

It was the purpose of this researcher to present a spectrum of criticism regarding the peer review system employed by the agency-to-individual approach to federal funding of scientific research. That presentation, it was hoped, could then lead to a more knowledgeable and realistic evaluation of the system's workings. The National Science Foundation became the model in this case study approach because it utilizes peer review and because that utilization was made so visible in a series of Congressional oversight hearings in July 1975. But it is important to note with regard to the conclusions to be now offered that statements made about NSF can be applied in some cases to other federal agencies (such as the National Institutes of Health and the National Institute of Education) which also utilize peer review in some form. Indeed, according to Thane Gustafson,

> In practice, peer review procedures and patterns of proposal vary widely from one government body to another and even within a single agency. In some agencies peer review is elaborate, proposals are largely unsolicited, and the influence of advisory committees is great; in others peer review is cursory, the influence of agency staff outweighs that of outside advisers, and research proposals originate in response to requests from the agency.[170]

Regardless of its mode of operation, however--a mode whose variances Gustafson outlines, the agency-to-individual approach to federal funding has the same weaknesses and limitations as well as strengths.

CONCLUSIONS

Peer Review and Scientific Excellence

The most important single consideration with regards to the peer review system is whether or not it promotes scientific excellence, quality research, effective scientific advancement, innovation and change. The findings on the National Science Foundation by the Congressional oversight committee are interesting on this point.

Witnesses at the hearings agreed overwhelmingly that some form of peer review should continue to be used in the allocation of federal funds for scientific research. Further, not a single witness suggested that peer review be abandoned. Personal interviews conducted by this author revealed the same attitudes, even from severe critics.

With specific regard to NSF, most hearing witnesses agreed that Foundation staff could not perform as well without the peer review system intact, and several argued that the potential for staff abuse is greater in systems lacking peer review. Bases for this latter argument

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[170]"The Controversy Over Peer Review," Science (December 12, 1975), p. 1060.

include the belief that peer review acts as a restraining influence on the staff in that outsiders (reviewers) act as checks against any agency biases and that the decision-making process is strengthened by the provision of knowledge and expertise from these scientists working in the forefront in the field.

Thus, it can be concluded that no method superior to peer review has been found for judging the scientific competence of proposals. Hence, the argument is not whether the system should be replaced, but how it should be modified to enhance its positive aspects.

There was not a great deal of testimony at the oversight hearings directly addressing the issue of the quality of projects supported by NSF. What testimony there was, however, reached consensus on the opinion that an appropriately functioning peer review system would select for funding those projects at the upper end of the quality scale. Representatives from colleges and universities see the insurance of such quality to be tied to the peer review method of decision-making with regard to federal grants. In fact, they expressed opposition to an alternative system wherein decisions by full-time federal officials would be made without advice from "outside" scientists whose expertise guarantees the support of worthwhile research. For modification of the system as it exists they did indicate that a sum equal to 15 percent of the total amount of federal research grants and contracts

received by each university be made directly available to the university itself rather than individual project researchers so as to avoid the rigidity that occurs when all research funds are ear-marked for narrowly specific purposes.

Most testimony on quality research focused on NSF's support of innovation, and there was not much confidence expressed in peer reviewers' willingness to support innovative research if it challenged the mainstream of scientific thought or if it seemed unlikely to succeed. Personal interviews revealed mixed feelings. Dr. Thomas Clements admitted that he thought that there would be "lots of people who feel they don't get a fair shake in the peer review system to the extent that it does reward orthodoxy."[171]

Arguments that the system does support innovation followed the reasoning that "nobody wants to turn down the next Nobel prizewinner." In addition, while admitting that many innovative ideas might be rejected, authorities such as Philip Handler, President of the National Academy of Sciences claimed that all types of research were being turned back due to lack of funding. According to Handler, "A growing fraction of all worthwhile research proposals is rejected annually for lack of funds rather than lack

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[171]Personal Interview.

of scientific merit."[172]

Thus, it would appear that the peer review system could do more in the way of seeking out and supporting innovative research. And to insure that the National Science Foundation play a role in this effort, the congressional committee recommended that the National Science Board study the support of innovative research and report to Congress. The study is to include: a detailed analysis of the issues covered in the report of the Subcommittee on Science, Research, and Technology dealing with NSF Peer Review; a look at major scientific innovations with regard to how they were funded and how they came to be accepted; and an examination of how adequate the decision-making procedure used by NSF programs is for finding and funding innovative research and recommendations. The Congress also made a major decision when it charged the National Science Board, and not Congress, with primary responsibility for the establishment of policies governing peer review at NSF.

Peer Review and the Question of Fairness

Whatever the success of the main mission of such a system (promoting scientific excellence), the question remains as to how fair that system is in the realization of its mission. Is it equitable, impartial in its decision-making? Can it be accused of favoritism? As indicated

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[172] NSF Peer Review, Special Hearings, p. 992.

in the previous chapter, the opinions on this matter vary.

Several witnesses at the NSF oversight hearings cited the principle drawback to the use of peer review in the agency-to-individual approach as the potential which exists for biased evaluations by reviewers. This potential is based in the tendency for groups of reviewers to be composed of individuals from a common discipline who may praise each other's proposals too highly while giving lower ratings to "outsiders." To peer review's critics such favoritism becomes possible when one considers NSF data on reviewer selection. Thus, the New England, Pacific and Mid-Atlantic states together, which employ about 50 percent of the nation's doctoral scientists and engineers, account for nearly two thirds of NSF advisers.[173] And for fiscal year 1974 data reveal that California, Massachusetts, Maryland, and Washington, D.C. were represented, in terms of NSF reviewers, more than proportionately in relation to their population of scientists.[174] Another charge that advisory panels are dominated by members of prestigious universities is confirmed by NSF statistics that show that within NSF the top eighteen institutions which employed 9 percent of the nation's academic doctorate-holding scientists in 1971 contributed

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[173]Statement by Dr. R.C. Atkinson, Deputy Director, National Science Foundation in NSF Peer Review, Special Hearings.

[174]Ibid.

more than one third of the advisers.[175]

Thus, one could conclude that there is some truth to the charge that a certain amount of geographical/ institutional "favoritism" does exist with regards to participant selection for peer review. Yet whether this disproportionate emphasis on certain regions and schools leads to "cronyism" and unfairness in the actual awarding of grants is another issue. Personal interviews conducted by this researcher revealed that no one doubted that such situations could exist, but none had personally witnessed any. Indeed, all indicated that biased reviews would be rare since the reviewer is putting his professional reputation at stake every time he conducts a review.

Still, there are data which reveal that patterns of funding within NSF give strong advantage to prestige institutions. Thus, in 1974 research grant awards to the top twenty institutions represented one third of total NSF obligations for all programs.[176] But there is other evidence that concentration does not always work to the advantage of the prestige institutions. A study of the allocation of NSF project grants in metallurgy and materials research shows that they are clustered among the

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[175]Preliminary results of a study of the NSF advisory system by N.C. Mullins, Social Science Studies (July 1, 1975).

[176]Gustafson, p. 1062.

middle ranked institutions rather than the top ones.[177]

Therefore, the issue of concentration in funding and reviewer choice is more complicated than imagined by many. The meaning of any information must be measured against the question of whether an award is unfair or uneven. Are we seeking equity over scientific merit? It is obvious that those who say the peer review system is unfair are seeking equity, while those who are looking for scientific merit are asking whether the distribution of awards is really out of line with the distribution of scientific quality in the country's research institutions.

The findings of Congress at the NSF oversight hearings reflect the feelings of two camps of opinion with regard to the question of fairness: the camp represented by Rep. John Conlan which believed that a "defensive" system should be devised to cut down on the number of dishonest participants in the peer review system (by defensive Conlan meant a system containing a mechanism for continual oversight of the review process, a mechanism which could include Congressional review), and the camp led by Rep. Charles Mosher which assumed the honesty of peer review participants and urged an adoption of trust in the system.

Congress found that the NSF staff was dedicated, competent, and honest and established that the operation

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[177] NSF Peer Review, Special Hearings, p. 747.

of the system should be based on trust of the staff and reviewers, combined with vigilance to ensure that trust is warranted. The rationale for such an approach is that a system based on trust allows more latitude for staff discretion and results in better performance than those systems based on highly structured procedure. Also a staff member or reviewer who is not trusted will either perform badly or withdraw from the system. Adoption of peer panels, like those used by the National Institutes of Health, was also suggested. These are study sections (convened advisory panels) organized for the review of those research proposals to be supported by grants, an organization which may minimize the possibility of undue influence or bias by program managers or individual reviewers. In addition, the Subcommittee recommended that the National Science Board conduct a study on how much NSF should rely on peer panel review and report to Congress since it felt it did not have sufficient information on peer review systems to come to a definite conclusion at the time. Yet whatever the final judgment, it is doubtful if blind reviewing, peer panel review, or Congressional review will ever satisfy the extreme critics or their deep suspicions.

In addition to the above, Congress determined that NSF should devise systematic methods which would ensure that competent reviewers be used regardless of institutional affiliation or geographic location. Further, the

committee recommended that in order to monitor the progress--or failure--of fairness in the peer review system, NSF conduct random audits of the decision processes used for the awarding of grants.

Peer Review and the Cost Factor

The economic costs of peer review in initiating and supporting research efforts in science were not directly addressed at the NSF oversight hearings. Dr. Christian Arnold charged that the system had to be the most costly one ever devised by man to generate research in science and that such a cost factor should not be dismissed without solid investigation. On the other hand, many within the agencies and universities saw no such problem or perhaps would not admit to such. But it is an area of conflicting opinion.

Conversations with graduate students presented insights quite contrary to the attitudes of agency officals and university professors and administrators. For example, two graduate students revealed that they were among ten students within the same university department who received $8,000 each in a research grant for study in a specific scientific area. But only one of the ten was actually engaged and qualified in the field designated; the other nine were doing department related research <u>but not research for which the grant was awarded</u>.

Such evidence as the above leads one to conclude

that the issue of research expenditures by federal agencies might bear further investigation. Though peer review's supporters maintain the high cost of the system is justified by the type of research it encourages, one must also confront the dilemma posed by the divergence which may exist between the purpose of a grant being awarded and the actual research carried out.

Peer Review and Confidentiality

With regards to openness in the peer review system, one can conclude from the hearings' testimony and personal interviews that people engaged in the review process would be less candid if their identity were made public. Indeed, many individuals would refuse to be reviewers if such publicity became established practice or if signed verbatim reviews were made available to applicants and even the public.

It is this researcher's belief that much could be lost by insistence on a totally open system in terms of quality reviews and people willing to participate in the process. And it seems that the National Science Board's change in policy from "applicants should receive paraphrased reviewer comments on request but should not know the identity of reviewers" to "applicants should receive verbatim reviewers' comments on request but should not know the identity of reviewers" (an NSF policy since January 1, 1976) is a step in the direction of avoiding this loss.

There is no doubt that any degree of confidentiality makes a system difficult to defend from charges and criticisms such as those which have surfaced in this study. But the detriments that total openness could bring to the peer review system far outweigh the advantages to be gained. The problems of poor quality reviews, personality clashes, refusals by experts to particiapte, threats to future careers, and increased opportunity for the intrusion of political pressure are powerful reasons for opposing total system openness.

In fact, it would seem that Congress itself is unwilling to move precipitously towards rejection of confidentiality. At the NSF hearings it urged caution in dealing with the issue and recommended further study by the National Science Board (via information collection of quantitative data on the review process and opinions from the scientific community) of the effect of confidentiality on the operation of peer review. Specifically with regards to NSF's policy change (referred to above), the subcommittee expressed approval and suggested that "further changes in the level of confidentiality of the Foundation's peer review system should be made slowly if at all."[178]

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[178] NSF Peer Review Vol I, p. 59.

Summary

Evidence of professional and political attacks on peer review without proper data evaluation and discussion was apparent in many cases. Particularly the articles appearing in professional journals and statements by some politicians are "lopsided" and could easily encourage distorted views on the part of other non-involved professionals that the whole peer review system is a disaster contrived and run by persons with less than honorable intentions, that it is a system protecting self-seekers without the interests of research as a primary goal.

This researcher's investigation did not lead to such conclusions. Yet such attacks have had positive effects in that they have sensitized Congress and the academic community to the issues involved in the workings of the peer review system. The results of such sensitization have been meetings and studies (such as those convened and carried out by the Elliott Committee and the Brookings Institute) and congressional oversight hearings for an agency such as NSF. And it is to the credit of the professional practitioners in the field, the NSF staff, and especially the members of Congress that a superb sense of balance was maintained in discussions and decisions at the NSF hearings. Confidence in peer review was clearly expressed. And what emerged was not the claim to perfection of a system, for such a claim should surely mean the end of all growth, but rather a belief that this

system has within itself the capabilities for change and improvement making radical departure unnecessary. Rationality and balance prevailed as reflected in the basic recommendations of Congress and the opinions of the majority of those interviewed.

RECOMMENDATIONS FOR FUTURE RESEARCH

This investigation led to the acquiring of much information via documents, written opinions, and personal interviews that did not deal directly with the specific topic under investigation and was not used. Such information, however, did generate contemplation of areas for future study.

One of these areas bears indirectly on one of the research questions posed for this study, that question which has to do with whether or not the peer review system provides for the advance of science in the most effective way possible. In arriving at a thorough answer to such a query, one must take into consideration the effect of competition on the system. In other words, does the decentralized, competitive grant award process, currently promoted by peer review within the agency-to-individual approach to federal funding, encourage solid and innovative research along with an academic and public atmosphere supportive of scientific excellence? Or does the competition which accompanies such a decentralized funding effort result in negative outcomes such as collusion, mutual isolation, and a one-sided

professional emphasis on research at the expense of instructional performance and goals?

In light of these questions, one possible area which merits serious future study is the effect of competition promoted by peer review on academic institutions themselves, their faculties, and students. Let us suppose, then, that a faculty member may be in a university department that generates great pressure upon him to acquire research grants (or his pressure may be self-induced) because attainment of a grant brings the possiblity of publication, extra money, promotion, equipment, prestige or tenure. In other words, what percent of university policies, especially those dealing with promotion and tenure, induce such an orientation for faculty? Further, what consequence does such a competitive system have for the faculty person and his relationship to his teaching profession and ability? Is it positive or negative? And perhaps most important, what effect does the drive for the research grant have on the students? Are professors sacrificing their students, graduate and undergraduate, to satisfy administrative pressures or personal aims to "publish or perish," to carry out original research?

If the answer to the latter question is yes, then perhaps a viable solution would be the hiring of university faculty in a track system. Thus, when being employed, a professor could be given a choice of being hired and evaluated in Track A or Track B. Track A would be primarily teaching, i.e., eighteen contact hours per week with the

expectation of one publication per year. Track B's, primary mission would be research; for example, then, three contact hours of teaching per week might be required but concentration would be on research.

The Track A employee would be evaluated on teaching ability and effectiveness, while the Track B person would be evaluated on his ability to conduct and generate research. All evaluations of ability, regardless of Track, would determine salary, promotion, and tenure.

The advantages in such a Track system might include the following:

1. More professional pride and ability could be generated in the teaching field as a profession.
2. Students, undergraduate or graduate, would be less likely to suffer since professors' prime responsibility would be fixed.
3. Greater faculty-student ratio would occur increasing production which would result in obvious economic implications.
4. Individuals would be more content due to their placement in roles fulfilling their needs and capabilities; production from both Tracks would thus increase.
5. Greater flexibility would exist within departments of a university; for example, a department could program the areas it wants to improve or emphasize by calling for a Track A or B person when filling vacancies or expanding. Such a system could also permit in-place flexibility by setting up criteria by which

professors could shift from Track to Track for periods of time.

In suggesting the study of such a model for change within the university structure, this researcher is acknowledging the tremendous competitive effect the research grant system directed by the federal government has on the academic community. Indeed, an examination of this effect has not yet been forthcoming from either the critics or the supporters of the peer review system. Yet it is necessary to look at this subject because the viability of the system cannot be maintained if the university community suffers more than it benefits from the system's pressure for scientific excellence.

And it would certainly seem at this point in history that the system and its pressures are here to stay. Indeed, according to Thane Gustafson:

> For most types of fundamental research the traditional project grant, selected by peer review, with overall priority among fields and subfields determined at least in part by proposal pressure, appears to provide the best available guarantee of scientific merit and accurate information. It is important, however, to extend existing safeguards: to choose advisors and agency staff who are representatives of the best science; to limit their terms of service; to separate as much as possible the evaluation of scientific merit from that of funding so as to reduce the dependence of researchers on the priorities or biases of any one agency or congressional committee; and finally to subject the entire system to periodic review and criticism. Given the present--admittedly tentative--state of our knowledge about the impact of the traditional peer review system, there is not a convincing case that the system's defects warrant the risk of sacrificing its virtues.[179]

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[179] p. 1065.

APPENDICES

APPENDIX A

COMPLETE LISTING OF INTERVIEWEES

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Dr. Allen Shinn, Deputy Assistant Director, Science Education, National Science Foundation. Interviewed in his office, Washington, D.C., January 29, 1976.

Dr. Roy Heath, Director of Research Development, Northern Michigan University. Interviewed in his office, Marquette, Michigan, March 1976.

Dr. Ward Mason, Chief of the R & D System Support Division, National Institute of Education, Washington, D.C. Interviewed in his office, January 30, 1976.

Dr. Emerson Elliott, Deputy Director, National Institute of Education. Interviewed in his office, Washington, D.C., January 30, 1976.

Dr. Charles Haughey, Chief, Communications and Linkage Branch, National Institute of Education. Interviwed in his office, Washington, D.C., January 1976.

Dr. Thos. Clements, Chief of the Information Communications Systems Division, National Institute of Education. Interviewed in his office, Washington, D.C., January 30, 1976.

Dr. Christian Arnold, Associate Director, National Association of State Universities and Land Grant Colleges. Interviewed in his office, Washington, D.C., January 29, 1976.

Dr. John Maccini, Program Manager Coordinator for Cost, National Science Foundation. Interviewed in his office, Washington, D.C., January 30, 1976.

Dr. Richard Worksman, Advisor for Administrative Policy, National Institute of Education. Interviewed in his office, Washington, D.C., January 29, 1976.

Dr. Joseph Crosswaite, Rotator, National Science Foundation. Interviewed in his office, Washington, D.C., January 30, 1976.

Dr. Raymond L. Smith, President, Michigan Technological University. Interviewed in his office, Houghton, Michigan, August 1976.

Dr. Dale Stein, Department Head, Metallurgical Engineering, Michigan Technological University. Interviewed in his office, Houghton, Michigan, August 1976.

Dr. Alfred Hendrickson, Professor, Metallurgical Engineering, Michigan Technological University. Interviewed in his office, Houghton, Michigan, July 1976.

Mr. Hunter Mormon, Senior National Institute of Education Associate, Office of Planning, Budget, and Program Analysis. Interviewed in his office, Washington, D.C., January 1976.

Dr. Lloyd Heldt, Professor, Metallurgical Engineering, Michigan Technological University. Interviewed in his office, Houghton, Michigan, September 1976.

Dr. Richard Heckel, Professor, Metallurgical Engineering, Michigan Technological University. Interviewed in his office, Houghton, Michigan, September 1976.

APPENDIX B

INDUSTRIAL RESEARCH OPINION POLL

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INDUSTRIAL RESEARCH OPINION POLL

Field of Research (Q 9)

Physics	141 returns
Biomedical and/or biological	298 returns
Chemical	393 returns
Other	261 returns

1. Do you agree with the principle of Peer Review?

	Phys	Biomed	Chem	Other	Total
Yes	82%	86%	79%	74%	80%
No	18	14	21	25	20

2. Do you believe that the various Peer Review Procedures as they operate in practice are

in need of drastic change	34	40	44	46	42
in need of slight change	55	49	47	48	49
fair and reasonable	11	11	9	6	9

The following comments and criticisms have been made about the operation of the Peer Review System, Please react.

3. It encourages unorthodox ideas.

definitely agree	3	5	4	7	5
agree somewhat	14	17	17	18	17
disagree somewhat	35	36	32	31	33
definitely disagree	48	42	47	44	45

4. It promotes conflicts of interest, "croneyism," and favoritism.

definitely agree	37	48	43	45	44
agree somewhat	45	36	44	43	42
disagree somewhat	9	9	10	8	9
definitely disagree	9	7	3	4	5

5. During the decision-making process, the applicant has no adequate means to defend his proposal.

	Phys	Biomed	Chem	Other	Total
definitely agree	49%	55%	48%	47%	50%
agree somewhat	32	30	37	38	35
disagree somewhat	13	10	10	10	10
definitely disagree	6	5	5	5	5

6. The decision-making process is open and well understood.

definitely agree	9	8	5	4	6
agree somewhat	21	15	16	17	17
disagree somewhat	36	37	40	39	38
definitely disagree	34	40	39	40	39

7. Following an adverse decision, the applicant can easily appeal.

definitely agree	5	5	2	2	3
agree somewhat	15	11	9	12	11
disagree somewhat	36	30	42	39	37
disagree definitely	44	54	47	47	49

8. Funds are equitably distributed between young and established investigators.

definitely agree	3	6	3	2	4
agree somewhat	14	9	10	10	10
disagree somewhat	33	27	33	35	32
definitely disagree	50	58	54	53	54

9. How many years of experience in research have you had?

less than 5	9	13	15	18	15
5 to 10	23	31	30	22	27
11 to 20	38	33	30	34	33
more than 20	30	23	25	26	25

10. How many times have you served as a member of a study section, council, or committee directly related to Peer Review decisions?

none	57	70	72	57	66
once	7	8	8	10	8
2 to 5	25	14	15	19	17
more than 5	11	8	5	14	9

Given the approximate numbers of grant applications submitted throughout your career:

	Phys	Biomed	Chem	Other	Total
11. To NIH, approved and funded					
None	84%	45%	81%	90%	73%
One	5	13	7	3	7
Two	1	9	4	3	7
3 to 5	9	18	5	3	9
6 to 10	1	10	1	-	3
11 to 15	-	2	1	-	1
16 to 20	-	1	-	1	1
More than 20	-	2	1	-	1
12. To NIH, approved and not funded or not approved					
None	81	46	82	93	74
One	13	20	11	3	12
Two	3	14	3	2	6
3 to 5	2	14	3	1	6
6 to 10	1	3	1	1	2
11 or more	-	3	-	-	-
13. To NSF, approved and funded					
None	67	76	75	76	75
One	12	9	9	11	10
Two	6	9	8	5	7
3 to 5	11	5	5	6	6
6 to 10	2	1	2	2	1
11 or more	2	-	1	-	1
14. To NSF, approved and not funded or not approved					
None	59	74	72	74	71
One	18	14	12	11	13
Two	11	5	9	6	8
3 to 5	9	6	5	6	6
6 to 10	2	1	2	2	2
11 or more	1	-	-	-	-
15. To AEC, approved and funded					
None	79	92	88	84	87
One	7	3	5	6	5
Two	5	1	1	3	2
3 to 5	6	1	4	3	3
6 to 10	1	2	1	4	2
11 or more	2	1	1	-	1

	Phys	Biomed	Chem	Other	Total
16. To DOD, approved and funded					
None	55%	90%	86%	68%	79%
One	11	1	5	4	4
Two	8	4	1	8	4
3 to 5	15	3	4	10	6
6 to 10	4	2	2	4	3
11 to 15	3	-	1	2	1
16 to 20	2	-	-	1	1
More than 20	2	1	1	3	2
17. To DOD, approved and not funded or not approved					
None	57	92	84	73	80
One	13	2	7	5	6
Two	13	3	4	5	5
3 to 5	13	3	4	5	5
6 to 10	7	5	1	4	2
11 to 15	1	5	1	2	1
16 to 20	1	5	-	-	1
More than 20	2	5	-	3	1
18. To other federal agency, approved and funded					
None	67	72	81	69	74
One	12	11	6	10	9
Two	6	6	6	3	5
3 to 5	6	9	4	9	7
6 to 10	6	2	2	4	3
11 to 15	1	-	-	2	1
16 to 20	1	-	-	1	-
More than 20	1	-	1	2	1
19. To other federal agency, approved and not funded or not approved					
None	73	79	81	73	78
One	9	6	8	7	7
Two	8	6	4	4	5
3 to 5	5	5	6	9	6
6 to 10	3	2	1	2	2
11 to 15	-	1	-	2	1
16 to 20	1	-	-	1	-
More than 20	1	1	-	2	1

	Phys	Biomed	Chem	Other	Total
20. To private or other foundations, approved and funded					
None	76%	52%	58%	80%	67%
One	8	17	12	9	12
Two	5	11	6	4	7
3 to 5	8	14	11	2	9
6 to 10	2	4	2	3	3
11 to 15	1	-	1	1	1
16 to 20	0	1	-	1	5
More than 20	-	1	-	-	5
21. To private or other foundations, approved and not funded or not approved					
None	75	60	73	79	71
One	10	14	13	10	12
Two	7	10	6	3	7
3 to 5	3	12	6	5	7
6 to 10	2	4	1	1	2
11 to 15	-	-	1	-	-
16 to 20	1	-	-	-	-
More than 20	2	-	-	2	1

SELECTED BIBLIOGRAPHY

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BOOKS

Bailey, S.K. Congress Makes a Law. New York: Columbia University Press, 1950.

Bert, John W. Research in Education. New Jersey: Prentice Hall, Inc. 1970.

Bush, Vannevar. Science - The Endless Frontier. Washington, D.C.: National Science Foundation, 1945.

Gottschaulk, L. Understanding History. New York: Alfred A. Knopf, 1963.

Johnson, S.W. On the Relations that Exist Between Science and Agriculture. New York: State Agricultural Society Trans., 1855.

Kahn, R.L. and Connell, C.F. The Dynamics of Interviewing. New York: John Wiley and Sons, 1957.

Knoblauch, H.C., Law, E.M. and Meyer, W.P. State Agricultural Experiment Stations. Washington, D.C.: U.S. Department of Agriculture, 1962.

Orlans, Harold. Science Policy and the University. Washington, D.C.: The Brookings Institute, 1968.

Ross, E.D. The U.S. Department of Agriculture During the Commissionership. Washington, D.C.: Agricultural History, 1946.

Thomas, Lawrence C. Philosophical Redirection of Educational Research. Chicago: University of Chicago Press, 1972.

Weyl, F. Joachim. Research in the Service of the National Purpose. Washington, D.C.: U.S. Government Printing Office, 1966.

PUBLICATIONS OF THE GOVERNMENT, THE NATIONAL SCIENCE FOUNDATION AND OTHER ORGANIZATIONS

National Academy of Sciences, Committee on Science and Public Policy. "Federal Support of Basic Research in Institutions of Higher Learning." Washington, D.C., 1964.

The National Institute of Education: A Brief Outline of its History, Status, and Tentative Plans. Washington, D.C.: Library of Congress, Congressional Research Service, April 2, 1973.

National Institute of Education. The Status of Educational Research and Development in the United States (1975 Databook). Washington, D.C., May 1975.

National Patterns of R & D Resources. Washington, D.C.: U.S. Government Printing Office, 1967.

National Science Board. "Resolution on Peer Review Information." Adopted at the 174th Meeting, June 20, 1975.

National Science Foundation. 17th Annual Report. Washington, D.C., 1968.

_____. Federal Funds for Research and Development and Other Scientific Activities. Washington, D.C., Fiscal years 1973, 1974, 1975.

_____. Grants and Contracts Awarded Fiscal Year 1975. Washington, D.C., 1975.

_____. Grants for Scientific Research. Washington, D.C., 1973.

_____. Minority Institutions Science Improvement. Washington, D.C., October 1974.

_____. Mosaic. Washington, D.C., November/December 1975.

_____. Research and Development and Economic Growth/Productivity. Washington, D.C., 1971.

_____. Research Initiation and Support. Washington, D.C., 1976.

_____. Science and Engineering Technician Education Program. Washington, D.C., 1976.

Sponsored University Programs for Research and Education. East Lansing: Michigan State University Press, Office of Research and Development, Publication 12, 1971.

United States Congress. House Committee on Government Operations. The Administration of Research Grants in Public Health Service. 90th Cong., 1st sess., 1968.

_____. Congressional Record. June 24, 1975.

_____. House Subcommittee on Science, Research, and Development, Committee on Science and Astronautics. A Bill to Amend the NSF Act of 1950. 89th Cong., 1st sess., 1965.

_____. Federal R & D. Programs--The Decision-Making Process. 84th Cong., 2nd sess., H.R. 1664, June 27, 1966.

_____. Subcommittee on Research and Technology Programs. Federal R & D Programs--The Democratic Process. 59th Cong., 2nd sess., January 7-11, 1966.

_____. Government and Science Hearings. 88th Cong., 1st sess., October 15 - November 20, 1963.

_____. Government and Science Hearings. 89th Cong., 1st sess., June 23 - August 1965.

_____. Select Committee on Government Research. Hearings on Federal R & D. Programs, Pts. 1-3. 88th Cong., 1st and 2nd sess., November 18, 1963 - January 22, 1964.

_____. Hearings Before the House Subcommittee on Appropriations. Washington, D.C.: U.S. Government Printing Office, 1963, 1964.

_____. Subcommittee of the House Committee on Appropriations. Hearings on U.S. Departments of Labor and Health, Education, and Welfare Appropriations 1968. 90th Cong., 1st sess., 1967.

_____. Subcommittee on Executive Reorganization and Government Research. An Inventory of Congressional Concern with R & D. 91st Cong., 2nd sess., 1971.

_____. House Committee on Science and Astronautics. Leadership in Science Policy: The National Science Foundation--Its Present and Future. 89th Cong., 1st sess., 1965.

_____. NSF: A General Review. 89th Cong., 1st sess., H.R. 1219, 1965.

_____. National Science Foundation Peer Review. Special Oversight Hearings, Hearings Before the House Subcommittee on Science, Research, and Technology, July 1975.

_____. National Science Foundation Peer Review, Vol. I: A Report of the Subcommittee on Science, Research, and Technology, U.S. House of Representatives. 94th Cong., 2nd sess. Washington, D.C.: U.S. Government Printing Office, January 1976.

United States Department of Navy. 1967 Annual Report - Naval Research Laboratory. Washington, D.C., 1967.

_____. Office of Naval Research - Contract Research Program. Washington, D.C.: ONR-1, June 1962.

United States Office of Naval Research. A Decade of Basic and Applied Science in the Navy. Washington, D.C., March 1957.

The White House. Scientific Progress: The Universities and the Federal Government. November 15, 1960.

PERIODICALS

Abelson, Philip H. "Chemistry in the Universities." Science 144, April 17, 1964.

_____. "Congress and Research." Paper delivered at The Second Radioisotope Conference, Gatlinburg, Tennessee, April 20, 1964.

_____. "Departure of the President's Adviser." Science 179, January 1973.

_____. "Distribution of Federal Research Funds." Science 144, May 1, 1964.

_____. "Distribution of Research Funds." Science 142, October 1963.

_____. "New Centers of Excellence." Science 150, October 1965.

_____. "Only One Side of the Question." Science 145, July 1964.

_____. "The President's Science Adviser." Science 142, November 1963.

_____. "Proliferation of Bureaucracy." Science 163, February 1969.

_____. "The Research and Development Pork Barrel." Science 149, July 1965.

_____. "Science Dropouts." Science 144, June 1964.

"Air Force: More Funds to Outside Labs." Industrial Research, 1975.

Allott, Gordon. "Massivity in Financing Research." Science, January 1965.

"AEC Asks President to Urge Full $460 Million in Grants for Undergraduate Facilities." Science, May 1964.

Arnold, Christian K. "Higher Education: Fourth Branch of Government?" Saturday Review, January 1964.

"Australia's Famed Hall Institute is Hit Hard by U.S. Budget Cuts." Scientific Research, December 1968.

Ben-David, Joseph. "Scientific Productivity and Academic Organization in Nineteenth Century Medicine." American Sociological Review 25 December 1960, 6.

"Better Administration of R & D Grants Urged." Chemical and Engineering News, August 1964.

"Bleak Future Seen for Scientific Research." Machine Design, November 1970, p. 8.

Boffey, Philip M. "Mansfield Amendment Curb on Basic Research May Spread." Science 167, March 1970.

_____. "Peer Review Under Attack." The Chronicle of Higher Education, May 1975.

_____. "Science and the White House." The Chronicle of Higher Education, July 1974.

Bross, Irwin D.J. "NIH Career Awards." Physics Today, March 1965.

Bush, V. "Vannevar Bush Speaks." Science 142, December 27, 1963.

"Career Training: The New Realism." U.S. News and World Report, September 1, 1975, pp. 48-50.

Carey, William D. "Peer Review Revisited." Science 189, August 1, 1975.

"Circular Letter No. 33, National Association of State Universities and Land Grant Colleges," September 1965.

"Congress May Investigate NAS." Science 179, January 1973.

"Congress Pressed on Research Cost." The New York Times, May 22, 1964.

"Congress vs. NSF." The Chronicle of Higher Education, July 7, 1975.

Cowen, Robert C. "Cost of Research Draws U.S. Probe." The Christian Science Monitor, May 4, 1964.

Craig, May. "A Woman Writer Takes a Critical Look at America." U.S. News and World Report, February 1964.

"Creutz Sees a Gradual Increase in NSF Support of Applied Science." Physics Today, November 1970.

Culliton, Barbara J. "NSF Defense of Closed Peer Review System Not Persuasive." Science, August 1975.

David, Edward E., Jr. "Directions for R & D." Research Development, September 1975, pp. 18-26.

Davis, Harold L. "Peer Review on Trial." Physics Today, September 1975, p. 96.

"Defense Department Will Cut Back Foreign Research 60 Percent by Fiscal 1970." Scientific Research, September 1968, p. 17.

"Dr. Abelson Scores JFK's Science Staff." Houston Press, November 20, 1963.

Dupree, A. Hunter. "New Policy for the Government-University Partnership." Science 169, July 1970.

"$500 Million Asked for Converting Engineers." Machine Design, August 1971.

"Glum Physicists Eye Their Dwindling Funds." Business Week, May 1968, pp. 87-89.

Goudsmit, S.A. "Editorial: A Drastic Change in Policy." Physical Review Letters 13, No. 3, July 1964.

Greenberg, Daniel S. "Congress and Science: NSF Hearings Provide Some Illuminating Insights on the Deteriorating Relationship." Science 142, October 1963, pp. 368-370.

_____. "Daddario Committee: Hearings to be Held on Overhead Support and Geographical Distribution." Science 144, April 17, 1964.

_____. "Grant System: Elliott Committee Finds Flaws, Diversity in Study of Practices of Federal Agencies." Science 145, August 1964.

_____. "LBJ Directive: He Says Spread the Research Money." Science, September 1965.

_____. "When Pure Science Meets Pure Politics." The Reporter, March 12, 1964, pp. 39-41.

Gustafson, Thane. "The Controversy Over Peer Review." Science 190, December 12, 1975, pp. 1060-1065.

"Hands Across the Sea." Scientific Research, August 1968.

Hotz, Robert. "A Hard-Nosed Budget." Aviation Week and Space Technology, February 1973.

_____. "Toward a Technological Appalachia." Aviation Week and Space Technology, March 1971.

"How Things Look in a Big New U.S. Industry." U.S. News and World Report, October 19, 1964.

Hudkins, Lonnie. "U.S. Has No Research Policy." Houston Press, November 19, 1963.

"In 1972: 8% More Money for R & D." Machine Design, January 1972.

"IRRPOS (Interdisciplinary Research Relevant to Problems of our Society) Looks for Relevance to Society's Problems." Physics Today, November 1970.

"Italy: Political Turmoil Kills Plan for First Doctoral Program." Science, May 1970.

Jones, Robert. "Much of U.S. Research Controlled by Faulty Mechanism." Industrial Research, September 1976, pp. 87-92.

"Kennedy Asks More for NSF." Science 168, April 1970.

Kerr, Clark. "Society and the Status Quo: The Individual and the Innovative Society." Science 144, April 1964.

Lahey, Edwin A. "Research Bias at Midwest." The Kansas City Star, July 15, 1965.

Levin, Louis. "Grants and University Authority." Science 146, November 1964.

"Massive U.S. Research Cuts Poleax Jobs of Scientists." The Houston Chronicle, November 1970.

"MOHOLE: The Project That Went Awry." Research and Development, January 1964, p. 115.

"NIH: End of an Era for Foreign Support." Scientific Research, August 1968.

"NSF's Appropriation Has Been Cut by the House Appropriations Committee." Chemical and Engineering News, May 1964.

"NSF Budget: House Group Reacts to Data on Plight of Science." Science 168, April 1970.

"NSF Undergraduate Education in Science, Project Director's Meeting." Educational Newsletter, March 1970.

Naughton, James. "Nixon's Science Aid Unseen: Is He Heard?" The Milwaukee Journal, March 8, 1972.

"The Needs of Chemistry." The New York Times, May 1964.

Nelson, Bryce. "A Surplus of Scientists? The Job Market is Tightening." Science 166, October 1969, p. 582.

"New Centers of Excellence." Industrial Research, May 1964.

"New Role for NASA Research Center." Science 168, April 1970.

"Nixon Sets Shift in Science Job." The Milwaukee Journal, January 1973.

"Ohio's Old Laissez-Faire Attitude on Linking Education, Research, and Industry Undergoing Change." Science 145, July 1964.

Osmundsen, John A. "Hostility Toward Science is Detected." The New York Times, December 29, 1963.

Parrish, John B. "Growth and Dispersion of Industrial Research Manpower." Research and Development, May 1964.

"Peer Review and Grants." Industrial Research, June 1975.

"Pentagon Cheats, Rickover Charges." The Detroit Free Press, February 19, 1970.

"Perspectives in Federal Physics Support - an Interview with Chalmers Sherwin." Physics Today, September 1967, pp. 73-74.

"Physics Fads and Finance." New Scientist, August 1974, p. 462.

"Poverty Pays--Federal Way." The Daily Mining Gazette, Houghton, Michigan , February 23, 1970.

"Preparing for Change in Defense Spending." Stanford Research Institute, March-April 1964.

"Regional Equity, a New Principle in Distribution of R & D Moneys." International Science and Technology, May 1964.

"R & D Seeks a New Strategy for the Seventies." Industrial Research, March 1970.

"R & D to Top $30 Billion in '73." Machine Design, August 1973.

"Research Grants by U.S. Criticized." The Kansas City Star, December 11, 1964.

"Research-Poor Areas Must Help Themselves." Chemical and Engineering News, May 1964.

"Returns are Poor from R & D Spending." Machine Design, June 1970.

Roeder, Edward. "The Consulting Con Game." New York Times, November 15, 1974, pp. 26-32.

Rowsey, Luther. "Meet the Man Who Splits the Atoms of U.S. Research Policy." Houston Press, Nobember 19, 1963.

Satchell, Michael. "The Riley Affair." The Washington Star, February 1973.

"Science Structure Criticized." Industrial Research, May 1969, pp. 42-46.

"Scientists Gloomy on Science's Future." Scientific Research, May 1968, p. 12.

Shapely, Deborah. "NSF: A 'Populist' Pattern in Metallurgy Materials Research." Science, August 1975.

_____. "Surprise Appointments Restore Science to White House Favor." Science, November 28, 1975, p. 859.

"Shift of NSF Funds." Science 167, March 1970, p. 1672.

"Shrinking Funds Mean Bleak Outlook for Italian Biomedical Research." Scientific Research, March 1968.

Spilhaus, Athelstan F. "Man in the Sea." Science 145, September 1964.

"Teaching vs. Research on the Campus." The Kansas City Star, June 27, 1965.

"U.S. Science Endangered, Board Feels." The Milwaukee Journal, February 29, 1970.

Wade, Nicholas. "Agriculture: NAS Panel Charges Inept Management, Poor Research." Science 179, January 1973.

Walsh, John. "NSF and Its Critics in Congress. New Pressure on Peer Review." Science 188, June, 1975.

_____. "NSF to Make More Peer Review Information Available." Science 189, July 1975, p. 123.

_____. "NSF Peer Review Hearings: House Panel Starts with Critics." Science 189, August 8, 1975, pp. 435-537.

"Washington Concentrates: NSF's Appropriation Has Been Cut by the House." The Chemical World This Week, January 1964.

"Washington Ramble: News in Brief on Investigations, Accelerators, Anger in NSF, and Other Matters." Science 142, November 1963.

Wolfle, Dael. "Geographic Distribution of R & D Funds." Science 147, January 1965.

"Woolridge Report: Study of NIH Producing Conflicting Reactions among Congressional Figures." Science 148, Arpil 16, 1965, pp. 351-352.