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Science and Social Purpose

Proposed fundamental changes in the national science effort are discussed in terms of biomedical research.

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Discussions of contemporary science too often focus on the painful and disruptive effects of a reduction in federal support—an inevitable consequence of general constraints on federal expenditures. They are less than helpful in the broad analysis of the general support system itself.

It would be well to acknowledge that there are fundamental imperfections in present federal mechanisms for the support of science, and that the ultimate patrons of science, the public, have not been given an understanding of science that can serve as a base for its continued support and evolution. A simple return to larger funding of research would mitigate some of the immediately urgent problems, but this alone would not adequately serve the long-term needs of science. Here I explore the basis for this conviction, as well as its implications for evolution of science policy.

The urgent tasks that now confront the scientific community, though not simple, are quite clear.

1) The scientific community must adjust itself to less than optimum funding, at least for the present, while retaining the essential strength of the scientific enterprise.

2) It must seek out the imperfections of the present support systems, and propose modifications that are corrective and, in addition, rationally based and generally applicable to the diverse fields of science.

3) Finally, the scientific community must devise means of fostering a broader understanding of the revolutionary technological forces that can be unleashed by a vigorous science for the betterment of society.

All three of these tasks are feasible, each is urgent, and each will require a high degree of scientific statesmanship.

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General Considerations

Science has flourished remarkably in the United States since the end of World War II, largely as the result of intelligent use of the vast sums of public money available for a wide diversity of scientific and technological activities. The government policies which fostered this development emphasized the promise of science for the attainment of major public objectives. These policies were pursued even though only a few of the individuals directly involved in the political process truly understood the difficulties inherent in the problems that scientists were asked to solve, or the character, complexity, and *modus operandi* of science. Further, as diverse fields of science rapidly evolved under these circumstances, the scientific community made little attempt to increase public understanding of these characteristics of science, or to establish the necessary coupling between the satisfaction of social needs and aspirations on the one hand and broad support of research on the other.

For a time, science seemed to be isolated from the real world and its problems. The public attitudes which fostered the outpouring of support were a popular expression of faith in the ultimate power of science to benefit mankind. Many scientists, on the other hand, viewed activities in their own fields as a type of pure intellectualism —an expression of what is best in our society, not necessarily connected with public needs and problems or social purposes. Such a view is reasonable for the individual scientist but does not provide an adequate base for broad public support of a more general enterprise.

It is true that much of science was defended before the public by hardheaded and sophisticated administrators. They were convinced that science could, if properly supported, make broad contributions to society, and their plans, approaches, and public attitudes reflected a high degree of realism. These attitudes prevailed in the programs for the exploitation of nuclear energy, in those for the development of new weapons, and, to a large extent, in those aimed at alleviating disease and disability.

The coupling of research with broad social issues was less well articulated in the development of support programs for basic research, or for the "fundamental research" essential in scientifically based missions. This latter type of activity, frequently called "mission-oriented basic or fundamental research," was deemed essential to an agency's mission when this was viewed broadly and with a concern for the future. However, too often the activity was buried within a complex agency budget and not presented as an essential part of a rationally evolving program. The opportunity was missed

to couple fundamental research with applications and developmental activities, particularly as these related to the general social purposes of the agency.

For many areas of science (medicine, perhaps, is an exception), the major impetus for expansion was external to science as such. It was a response to deficiencies in U.S. programs perceived when other nations made striking technological advances that had implications for the defense of this nation, or that generated urgent, but poorly defined, concern for national prestige. An example is the sizable influence that Sputnik I and the subsequent evolution of the Russian space program had on federal spending for research and development. This event did more than change the order of magnitude of U.S. R & D expenditures for defense and space; it had an influence on all areas of R & D. In fact, by precipitating the Office of Education into the mainstream of higher education through enactment of the National Defense Education Act, it may well have changed the course of higher education in this country. In any case, the burgeoning economy of the United States, with its already broad technological base, imposed few serious budgetary restrictions on science-program development during the late 1950's and early 1960's.

This set of circumstances permitted science in the United States to grow more or less in accordance with its own internal logic, being guided more by considerations of excellence, productivity, and freedom of individual effort than by consideration of the extent to which it might satisfy definable social needs. It seems likely that the period 1945–1965, particularly the last decade, will be viewed in retrospect as the time when U.S. science reached the summit of broad uncritical public support—what might be called the "Augustan era" of American science. But this was not a planned "happening"; it was more an accident, or spin-off from an affluent society's making bountiful contributions to science for diverse and often vague purposes. Fortunately, these contributions were, in the main, managed intelligently.

Such a situation, anomalous as it appears, in retrospect, to have been, led to the evolution of programs that were a mix of basic, applied, and developmental activities. As the broad program evolved, its continued support and growth depended directly on obvious concurrent benefits as well as on expectations for the future. These benefits were derived largely from the applied and developmental portions of the activity, rather than from the basic science involved. Such practical benefits dominated most presentations of accomplishments in all areas of science. Meanwhile, the public comprehension of research and development was shaped by mass-media information techniques which presented the progress of science as a stochastic series of exciting science spectaculars, without giving any sense of the fabric of scientific continuity and of its underlying warp and woof.

One wonders what the public attitudes toward science would be today if more attention had been devoted, during the past two decades, to education of the public in the internal complexities of science, and in the relationship between scientific discovery and technological advance. One should not lightly dismiss the role that presentation of the adventure of scientific discovery can play in motivating the public to support science. But it is important for scientists to understand that the motivating forces that captured public interest a decade ago have little relevance today. If science is to remain healthy and vigorous and is to continue to advance, a more rational basis for development of the national science effort must be found.

Despite the anomalies, the nation has acquired a broad and vigorous base in most general areas of science. During the present period of fiscal constraints, this base can provide a sound point of departure for the next stage in the exploitation of the nation's intellectual resources in science and technology. In the meantime, we must correct the fundamental weaknesses in the support structure, weaknesess that can place our long-term scientific prospects in jeopardy.

I am firmly convinced that it is possible to improve our present support mechanism for science, and to provide for a more rational distribution of supports without hampering the productive activity now in being. I am also convinced that such action must be accompanied by a coupling of activities aimed at the acquisition of new knowledge and activities aimed at applying that knowledge for the attainment of social objectives.

Because the changes required will involve a sharp departure from the past, such a development will require very thoughtful planning. Much is at stake, and there is no precedent or established design to guide us.

Before considering how our national science effort can be made more effective, one must clearly understand the distribution and magnitude of our current scientific effort and the critical strengths and deficiencies of present support mechanisms, and have some perception of the social needs that will provide the ultimate gauge of relevance and progress. Such a mix of substantive, policy, and procedural considerations is not amenable to simple treatment—certainly not if one attempts to consider science and its usefulness as a whole. However, it is possible to examine a major segment of science in these terms and later review the results for their relevance to all fields of science. Such considerations could then provide a basis for designing overall national policies.

The discussion of the biomedical sciences which follows is not such a definitive analysis. It is, rather, a series of reflections on some of the more important issues. Furthermore, I have selected the biomedical-science area for comment more because of my acquaintance with that area than because of a judgment on its relative importance.

Biomedical Research—1968

The striking World War II advances in medicine, a progressive public understanding of the socioeconomic burden of chronic illness, and our ignorance in relevant areas of science led to a general acceptance of the view that the ultimate resolution of major disease problems was possible only through research and the acquisition of wholly new knowledge—fundamental as well as applied. These views led to the enactment, during the late 1940's, of the landmark legislation which was the basis for the development of the modern NIH programs for the support of biomedical research. However, during these initial stages of the organic growth of NIH and other federal programs, the complexity of the biomedical problems and the proper scale of an effort that would satisfy the needs were matters not seriously considered or generally discussed.

The longer-term aspects of furthering medical capability were first pre-

sented formally by NIH to the Department of Health, Education, and Welfare in the summer of 1955, in a series of discussions with the then Secretary, Marion Folsom. This resulted in general agreement on the need to expand broadly the research support programs of NIH, the pace to be determined by the availability of scientific resources rather than by any specific limitation on dollars. It was also agreed that the existing science base was inadequate for the major effort to be applied and for developmental programs directly targeted on the clearly visible great medical problems. It was also apparent that the available manpower and facilities were insufficient for exploiting the scientific opportunities or for mounting an attack commensurate with the seriousness of the problems posed by disease.

Major expansion of fellowship and graduate education programs, designed to produce scientists rather than medical specialists, was proposed and approved. A precedent-breaking program of federal assistance for the construction of medical educational and research facilities was presented, but this program fell afoul of the then strong congressional opposition to federal entry into education, and the lack of broad support from the academic sector. When finally enacted, in 1956, this legislation decoupled, for support purposes, science from professional education and provided for the construction of research facilities only.

Secretary Folsom was responsible for another action of far-reaching consequence. He commissioned a committee to inquire into many of the important issues confronting biomedical research. This gave rise to a report, commonly called the "Bayne-Jones Report" (*1*), which, together with a later report commissioned by the Senate Appropriations Committee, the so-called "Jones Report" (*2*), provided much of the basis for the vigorous but rational support of the biomedical sciences by congressional leaders. These two reports also provided the philosophical and practical basis for an attempt by Folsom's successor, Secretary Flemming, to redress some of the imbalances, within institutions, being generated by the "project grant" as the sole instrument of federal support in the expansion of biomedical research and related training. Secretary Flemming was successful in obtaining from Congress an amendment to the Public Health Service act authorizing the award of "grants for the general support of research and research training programs" (*3*) of institutions. This was the origin of the institutional support programs of NIH, represented by NIH general research support grants, biomedical science support grants, and health science advancement awards.

The events of the late 1950's are of special interest as we search out the origins of deficiencies in the present project-grant system of research support. It was proposed initially that a substantial portion of the total federal support of research should be general support. In the first year, 5 percent of the total budgeted research grants to be made would be in the form of general research and training grants. This was to increase to 10 percent in the second year and 15 percent in the third year. An additional 2 to 3 years, it was believed, would be needed for a definitive study of the effectiveness of the program. This study would provide the basis for determining what proportion of total grant funds should be made available through project grants and what proportion through general grants. The latter, it was suggested, might well constitute 25 to 30 percent of the total. Unfortunately these proposals found little merit in the eyes of the individual scientist and his immediate supporters, since it appeared that they would diminish the share of resources available to him and his field.

Furthermore, attitudes toward such concepts of funding were affected by the trend toward focusing of popular interest and attention on specific achievements. For example, in the field of cardiovascular medicine it has been more convenient to view research progress in terms of the progression from "blue-baby" operations, through complex vascular surgery and open-heart surgery, to, finally, heart transplantation than to consider the vast scope of the interrelated basic scientific effort that necessarily preceded each of these achievements. And it has been in the past, and indeed still is, simpler to raise funds for quite explicit programs which tend to be short-term, such as the testing of a specific drug, than for longer-range and more complex studies that are more general in nature but are necessary if substantial advance is to be achieved. The project system tends to foster continued emphasis on short-term prospects and on individual science spectaculars. These circumstances lead to an environment within which the scientist can expect to be asked, much to his consternation, "What have you done for me lately?"

In such an environment, and in light of the traditional distaste for federal intervention in the educational process, it is not surprising that medical schools delayed asserting even a modest need for federal support for their basic educational programs until the early 1960's. It is only during the past year that the medical schools and the medical profession have agreed that massive support is essential for both current and expected educational programs if these institutions are to meet the broad social objectives that society has placed before them. Similarly, only recently has serious attention been given to the general needs of university-based science and education. The translation of these needs into fully realistic federal programs and appropriations has yet to be achieved. These perceptions of need come, unfortunately, at a time of heavy demands on the federal budget, associated with broad social turmoil, rapidly mounting federal costs for education and R & D in general, and enervating international commitments.

I should emphasize at this point that there is indeed an imbalance between support of research and support of education in our professional and graduate schools, and that there are broad deficiencies in both the educational and the socially oriented service functions of these institutions. The genesis of the problems, however, is not the development of a massive federally supported research activity, as is frequently alleged, but, rather, the long delay in recognizing, and in gaining consensus on, the parallel role the federal establishment should play in the progressive evolution of broad educational programs and socially oriented service programs. This role has not yet been comprehensively defined.

But for all these deficiencies of the support system, a highly diversified biomedical research activity has been developed. This is widely dispersed across the nation and is generally characterized by excellence. Its major weaknesses stem from the support of research alone in a situation in which research, education, and service are intimately mixed, and from the almost exclusive use of project systems of support by all agencies. These two

characteristics of the support system have resulted in a fundamental instability of institutions of higher education at the very time that new and broad educational and social functions are being imposed upon them.

Remedial Action

I turn now to consideration of what I believe must be done to provide a solid base for the further development of the biomedical sciences. Clearly, whatever is planned must be planned in relation to the general problems of education and institutional development. Note must also be taken of the pressing service-related activities of many of the institutions involved.

I do not present any detailed arguments, only a few broad generalizations. I trust these will be viewed by some as informed judgments, since I know they will be taken by many as a statement of personal prejudices.

Institutional support. To meet the needs and correct the deficiencies of the complex programs I am discussing, substantial funds must be made available directly to institutions of higher education for general support of their basic graduate and professional educational functions. These funds must be adequate, and must be made available by mechanisms which permit the institution as a whole to grow and to attain general educational competence as well as the greatest possible degree of excellence. Further, these objectives must be attained within a system of support that gives the federal sponsor assurance that the broad public objectives for which the funds are made available are indeed being well served.

If the federal establishment provides this type of funding, the amounts will be substantial. This in turn will impose on the university, in the areas of graduate and medical education, wholly new obligations. The universities and medical schools will have to indicate the size and scope of the central educational function, upon which their educational achievement will be judged. Further, methods will have to be developed for assessing the quality of the central educational enterprise that is supported. For example, medical schools that receive general support funds because of an urgent financial crisis in their funding must realize that this is possible for a year or two in an acute emergency but is not a normal or indeed an adequate base for long-term support, and certainly is not a rational basis for long-term development.

Given a more adequate and more stable financial base, institutions of higher education could plan their overall development in the light of the broad educational and social responsibilities they have recently acquired. Beyond this central core of support, the project system of grants and contracts can continue to provide the principal means for extension of mission-oriented research programs.

Support of mission-oriented research. Once the institutional integrity of institutions of higher education has been secured by general support programs, the mission-oriented agencies of the federal establishment can move more directly toward accomplishment of their special missions. They can be more free in selecting the institutions that are to receive support for research and development. Also, the terms and conditions of their awards can directly reflect the program needs of the agencies' objectives rather than a compromise between the mission needs of an agency and the sometimes overriding needs of higher education, as is now the case. With institutional integrity assured, the way begins to open for an enlarged and more sharply focused research activity, accompanied in many cases by a much greater measure of national organization than now exists (*4*).

Elements of such organized research, when it is performed within an academic environment, can enrich the academic environment. However, such activity will, I believe, be increasingly performed in research environments peculiarly devised for such complex but coherently related research undertakings, be these in universities, medical centers, research institutions, national laboratories, or industry. In this case, the further development of the undifferentiated base of the biomedical sciences will proceed in academic environments devised to provide the essential coupling of research and education, and will be supported as an objective apart from, but complementary to, mission programs.

Allocation of resources. Other requirements must be met if the mix of undertakings noted above is to be productive. The first requirement is a better information system, one capable of providing an ongoing analysis of the nature and extent of scientific effort in areas of direct relevance to broad problems in medicine and health. What is needed is not a system that provides for the simple storage and retrieval of documents or indeed of the data and other information they contain. Rather, the system must be capable of providing analyses and arrays of information specifically relevant to broad sets of problems perceived from an overall point of view (*5*).

The present informational systems of federal agencies may satisfy agency purposes, but they do not satisfy the broader national need. For example, NIH supports only about 40 percent of all biomedical research and about 55 percent of all biomedical research supported by the federal establishment. The rest is derived from other agencies—the Atomic Energy Commission, the Department of Defense, NASA, the National Science Foundation, the Veterans Administration, the Department of Agriculture, and other portions of the Public Health Service. There is not now any simple mechanism for analyzing all these activities insofar as they relate to the generalities of biomedical research. The analysis envisaged would not be a simple consideration of the biomedical sciences as such but, rather, would be an analysis of research and training in relation to the broader national objectives in the field of health. In this fashion science would assume its proper place as a competitor for the federal dollar.

Viewed in this light, research activity can be classified in very broad categories for central consideration of priorities in terms of social objectives. The allocation of resources then becomes manageable. One must accept the condition that such allocations must reflect a number of value judgments and are not amenable to simple linear scaling.

Central consideration of the use of science and technology in the promotion of health would be paralleled by central consideration of their use in relation to defense; space; resources, including energy and minerals; food; civil needs, including environment, housing, transportation, and many problems of our cities; and, finally, the knowledge base and general education.

One cannot hold a brief for any high degree of specificity or precision at this stage of development of a central program analysis and planning activity. One must recognize that our political system now makes resource allocations for science that are quite

explicit, but does so by a series of judgments made in relative isolation from each other. It does not seem very bold to say that this decision process can be improved, and that allocations can be made among science areas, with some consideration given to the probable value of science to society. Since allocations to individual areas of science can never be absolute in the absence of unlimited resources, the allocation process must permit comparative assessment of competing fields. Finally, for broad acceptance by the public, the allocation process must provide input not only from science, the generator of new knowledge, but also from technology, the applier of new knowledge, and from the consumer, the user of technological applications.

Such a proposal is tantamount to suggesting the designation of a series of cognizant agencies for information assembly and analysis. These would not reflect departmental or agency operational structure.

Some central apparatus. However, for effective utilization of the organized flow of information produced by such cognizant agencies, such information would have to be collated at a high point in the Executive Branch, a point at which the critical policy and allocation decisions that would influence program development in science and education, and in the use of science for other social purposes, would be made. These decisions are so important that the level for collation of information could be no lower than that at which the National Security Council and the Council of Economic Advisors operate.

With a suitable central apparatus it might be possible to diminish the present chaotic competition for research and development funds among the major areas of scientific endeavor—the competition between the needs of research and education—and to consider these needs in relation to broad social needs and national purposes. The evolution of an increasingly firm sense of national capabilities and priorities would permit clearer expression of our national purposes in the pursuit and utilization of new knowledge.

I fully realize that we now have many central mechanisms for program review and policy advice, but, without considering each one in detail, I would hold that no one of them, nor indeed a combination of all, is adequate for our future needs and purposes.

General Prospects and Problems

But to return to the future of the biomedical sciences, the sequence of thoughts that I would like to leave with you is as follows.

1) The socioeconomic burden of disease is inordinate.

2) The economic cost, the most direct indicator of which is the unit cost of medical care, continues to rise geometrically with time.

3) The conquest of serious disease and attainment of the essentials for a better quality of life are not visionary goals. They will, however, require a substantial expansion of research under circumstances that provide comparably well-developed support for educational and service programs.

4) A prime essential for such accomplishments is the development of central analysis and planning functions that are adequate to the task of ordering national priorities and serve as a basis for the allocation of resources among broad fields of science and within the biomedical field.

5) There must be developed, in parallel with the expansion of research and the development of central analysis and planning functions, an adequate public information program that portrays not only achievement but also prospects and problems.

I would emphasize that each area of science has its own special problems. Biochemical science is no exception. It shares some of its problems with medical education and medical service.

These problems stem from a public awareness of our deficiencies in knowledge. The public has immediate experience of disease, disability, and death. Moreover, it has become exquisitely sensitive to certain deficiencies in our system of medical education. Such public knowledge, even though only partial, is too frequently the basis of emotional outpourings that result from nonavailability of physicians at times of medical need, or from individual failures of diagnosis and therapy.

Furthermore, members of the general community have reason to be dissatisfied with the results of scientific "tours de force" presented as scientific spectaculars but having little relevance to their own problems. They have seen new drugs produce defective children, and they have been told that the triumphs of molecular biology can lead to a social evil as well as to social good. They rightly care less about the niceties of bureaucratic structure than about the productivity of the total enterprise, and they have a right to have the fields of science, education, and service, as these relate to medicine, presented to them in a more unified and understandable fashion. They have a right to a more realistic presentation of the goals that members of the scientific community have set for themselves, and of the prospects of success, as well as a right to some conception of the mechanics of the process, including some appreciation of the projected time base. While they may not need to know more about the distribution of these activities within the academic and federal structures, they have a right to demand that bureaucratic considerations of departmental autonomy, institutional individuality, and freedom of the individual scientists will not, in themselves, impose barriers to the development of a sound science and the rapid translation of new knowledge into a readily available medical capability.

I am convinced that the trend of research, education, and service, as these relate to medicine, will, even more in the future than today, be the concern of the people who are consumers of the final product, and that this concern will increasingly be reflected in congressional attitudes. If this view is generally correct, then I would judge that, although there will be no riots in the streets, there could be generated high public pressures for change, which could be misguided.

I would hope that we can accomplish the necessary organizational and bureaucratic changes through rational processes within the scientific community and the branches of government rather than at the hands of a disenchanted public.

References

1. *Advancement of Medical Research and Education, through the Department of Health, Education, and Welfare; Final Report of the Secretary's Consultants on Medical Research and Education: DHEW* (Bayne-Jones Report) (Government Printing Office, Washington, D.C., 1958).
2. *Federal Support of Medical Research: Report of the Committee of Consultants on Medical Research to the Subcommittee on Departments of Labor and Health, Education, and Welfare of the Committee on Appropriations, United States Senate, 86th Congress, 2d Session* (Boisfeuillet Jones Report) (Government Printing Office, Washington, D.C., 1960).
3. Public Law 86–798, 15 September 1960.
4. *The Advancement of Knowledge for the Nation's Health: A Report to the President on the Research Programs of the National Institutes of Health, Office of Program Planning, NIH* (Government Printing Office, Washington, D.C., 1967).
5. *Science, Government, and Information* (Government Printing Office, Washington, D.C., 1963); A. Weinberg, *Reflections on Big Science* (M.I.T. Press, Cambridge, Mass., 1967).