and 6000°K—depending upon how much allowance was made for overlapping by the CN band near 3825 A!

3) On 17 August 1961 the first *time-resolved* spectra of lightning were obtained in Tucson, with a drum camera attached to the spectrograph described in this article. Spectra of the brighter components of multistroked flashes are separated, rather than superimposed. Some of these spectra are superior in detail to any obtained heretofore. In certain cases the spectrum of the afterglow has been separated from that of the principal discharge.

References and Notes

1. In slitless spectroscopy a line-like source acts as its own slit and collimator when placed at a considerable distance from a camera equipped with an objective prism or grating. The resulting spectrum is really a series of monochromatic images of the entire *source* (rather than of a slit, as in conventional spectroscopy). By noting the relative widths and intensities of selected "lines" at various positions in the source, one often can infer a good deal about the distribution of temperature, pressure, and ionization.
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Federal Support of Research Careers

Government joins universities to increase the number of career appointments in research.

James A. Shannon and Charles V. Kidd

For some years it has been evident to qualified observers that the absence of adequate numbers of stable career opportunities for scientists has been an increasingly important barrier to the establishment of a sound research structure for the nation as a whole.

During and since World War II, university research in the United States has been heavily dependent for support upon federal grants and contracts. This support is often, although not always, provided for long periods of time. In many fields of science, support for research has grown at a pace exceeding the capacity of universities to staff the programs from their regular sources of income. The staffing problem has been solved in various ways. Large research organizations have been set up outside universities. Government laboratories have been expanded. Finally, universities have adopted practices enabling them to undertake larger research programs without committing a correspondingly larger proportion of university funds. These practices have included such steps as payment of the salaries of faculty members and other professional people from research grant and contract funds.

Increasing numbers of investigators, particularly at the assistant and associate professor levels, receive all or a large part of their income from research grants and contracts. This situation arises not from reluctance to pay staffs from stable funds, or from misgivings as to the quality of the group whose salaries are derived from grants and contracts. The research programs of the nation have simply expanded more rapidly than the financial base of stable funds available to universities. This development has been necessary to expansion of research in universities, but it has had some unfortunate consequences. First, the number of investigators whose salaries are dependent upon renewable research grant or contract support has now become so large as to create an unhealthy degree of uncertainty as a built-in characteristic of the system. Second, many of the individuals concerned, and their families, lead a sort of hand-to-mouth—or grant-to-grant—existence. This is not conducive to the best work, nor is it an equitable arrangement. Third, the salary arrangements have tended in academic institutions to be a devisive force, by creating a group of scientists who have few—and in many cases no—teaching responsibilities. Finally, the system does not provide an adequate investment in the future research capacity of the nation by strengthening the teaching process to the optimum degree.

The Public Health Service, with the approval of the Congress, is in the process of initiating a program aimed directly at the solution of these problems in the fields of medical and related research. This article deals with the development of this program for increasing the stability of research careers in medical research through the grant program of the National Institutes of Health. In this presentation, in addition to defining the principles of the operation of this new program, we discuss some of the problems which have arisen during the early stages of its implementation. Most of these stem from new relations that are emerging between the federal research support programs and institutions of higher learning.

In essence, this is a case study of the problems which arise when the federal government supports research in universities which have responsibilities extending beyond research to teaching. If the federal government looks to the research capacity of the nation 10 or 20 years in the future, as well as its current research capacity, it must be concerned with the ability of the people who will be investigators in the coming

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decade and beyond. Those people are now students, and they are being taught in universities. Accordingly, if the federal government's concern for medical and related research is to be a continuing concern, it must take into account the training of investigators for the future, as well as the support of scientists who are now fully trained. This transition from support of medical research in a narrow sense to support of the full structure and range of activities necessary to provide a sound scientific program in medicine and the related sciences for the indefinite future is the central problem of federal research policy in this area of research support. The problems involved in establishing a sound program for supporting careers in research are a specific aspect of the more general problem.

The Committee of Consultants on Medical Research to the Committee on Appropriations of the United States Senate issued in May 1960 a report, "Federal Support of Medical Research," which recommended that: "Funds should be provided through the National Institutes of Health in fiscal year 1961 to support the establishment of 200 research professorships in medical and dental schools and the basic science departments of colleges and universities at a salary level of $20,000 a year, the funds to be made available to, and administered by, the respective institutions."

Subsequently, $2 million was appropriated for this purpose, and an announcement of the plan to establish a "research professorship award" was made. The guides for administering this program, although issued at that time, were subsequently withdrawn and revised. The original guides were as follows.

1) Schools could nominate full professors (with provision for nomination of associate professors in unusual circumstances.)

2) Awards would be competitive, and selection would be based upon the distinction of the nominee. In the words of the brochure announcing the program, "Career Research Professors will be selected for support on the basis of demonstrated capacity to pursue with distinction a professorial career in independent research and teaching," in the fields of medicine, dentistry, public health, and related sciences.

3) Schools could nominate persons with tenure, and with income derived from stable sources, provided they agreed to use the released money for other professional positions in the school.

4) Awards would be for 5 years and would be renewable.

These guides were discussed with a large number of individuals from universities and with representatives of professional organizations. At that time, questions raised by these individuals related chiefly to such matters as the eligibility of faculty members with administrative duties, the firmness of the federal commitment to provide stable support, the fate of the award if the awardee changed schools, and other matters largely of an administrative nature.

Problems with the Original Program

Over the ensuing months, as institutions selected candidates under these initial guidelines, some more fundamental questions arose in the minds of persons in the institutions and in the federal government. These were as follows.

1) Some institutions had begun to have misgivings over the terms of a program which involved the federal government, even indirectly, in the selection of professors.

2) Some institutions were reluctant to make nominations because they did not wish to place full professors in national competition with each other or with professors from other institutions.

3) Other institutions were reluctant to make nominations because they felt that the award would not be stable, basing this view upon the words of the guide indicating that the awards would be initially for 5 years with a promise of support for the additional years, contingent upon annual appropriations.

4) On the part of the federal government, it was realized, as applications were received, that there had not been an adequate understanding with the universities as to the nature of the commitments that both they and the federal government should assume if a program for career support were to be fully acceptable and productive, and of the qualifications of candidates.

5) When the applications were reviewed *as a group*, it was found that a high proportion of the applicants were full professors of high distinction who were approaching, or who had entered, the final stages of their careers. Each institution acted in good faith within the terms of the guides, but the group as a whole did not possess characteristics in accord with the intent of Congress.

6) It was also found that a high proportion of the nominees were full professors with tenure. The effect of the program would have been largely to release the university funds formerly used for the payment of the salaries of full professors for the appointment of junior faculty. This was not the intended major effect of the program, as described to and accepted by the Congress. Thus, the desired objective of providing greater opportunities for stable career support for individuals paid from grant funds would have become a secondary and purely fortuitous result of the program.

No one of these reservations was conclusive. Some of them were mutually exclusive, and they were given various weights by those concerned with the program. But in total, they constituted substantial reason to review with care both the fundamentals and the operating guides for the program. Such considerations led the National Advisory Health Council, a group of citizens advisory to the Public Health Service, to pass a resolution on 15 March 1961 which recommended "That the Career Research Professorship Program, in its present form, be abandoned before implementation in the form of specific awards."

In the light of this resolution and of further consideration of the applications and the guides, a Committee on Career Research Professorships, which had been convened to make recommendations on applications, was asked to consider the basic elements of the program and to advise on its future.

On the basis of the considerations brought forward by this group, and of further deliberation, it was decided (i) not to make awards under the existing guides; (ii) to return the appropriated $2 million to the Treasury; (iii) to revise and issue new guides as quickly as possible; (iv) to return all applications with a request that institutions review them in the light of new guides and make new nominations; and (v) to make awards in the second half of calendar year 1961.

Policy Questions Clarified

Experience with the original guides sharpened some points of policy which had hitherto not been clearly stated.

1) A program designed to provide stable career opportunities for the large group of capable investigators receiving support from unstable sources—largely grants and contracts—could not simul-

taneously serve effectively to provide awards to career research professors who would be selected for support on the basis of demonstrated capacity to pursue with distinction a professorial career. The program had to be designed to do one or the other.

2) A program designed to increase the number of scientists supported from stable funds could not be based on standards encouraging nomination of persons with assured positions and assured income. The program would have to be designed primarily for those whose incomes were derived from unstable sources.

3) There should be no possibility that the inference might be drawn from the program guides that the federal government was selecting professors.

4) If the program were to provide a source of income more stable than that provided by research grants, the federal government would have to make awards with the firm intention of continuing them for the productive careers of those selected. Awards in segments of 5 years, renewable upon review at the end of each 5-year period, would not provide the necessary stability.

5) Whether the program was designed solely for persons engaged full time in research and teaching, or whether those engaged in research and teaching on a part-time basis would be eligible, was a question to be decided. Furthermore, if only full-time persons were to be eligible, "full time" would have to be defined. The original guides were silent on this point.

6) A federal program designed to provide stable career opportunities in academic and other research environments involves a long-term relationship between the institution and the federal government. The institutions, as well as the federal government, must assume appropriate responsibilities for the career stability of those given federal awards. This question was not dealt with in the earlier guides.

The points enumerated above seem in retrospect to be the kind of conclusion that one would reach by quiet and fairly brief reflection. The fact that many experienced people from universities, foundations, independent research organizations, and the federal government did not reach these conclusions in the initial discussions bespeaks the complexity of the problems that arise when a new policy affecting long-range government-university relations is adopted by a federal agency, and particularly when answers must be stated quickly.

New Guides

The re-examination of the premises underlying the original program, and of the specific guides for the program, led to the development of a new program concept and a new set of guides. The program has been designated the "NIH Research Career Award Program." In summary, the revised program, which will go into effect during the federal fiscal year that began 1 July 1961, has the following characteristics.

1) The primacy of the intent to increase the number of stably financed academic and other research positions is established. Accordingly, candidates whose salaries are derived primarily from research grants or contracts and from similar sources of relatively short assured duration will be given preference.

2) Conversely, the objective of providing awards designed to recognize outstanding scientific excellence, and to provide status and prestige to the individual and his institution, is subordinate. The awards will be competitive, and the standards for awards will be high, but the area of competition will be primarily among those whose incomes are from sources of relatively short assured duration.

3) To provide a system for support of research careers, it is necessary to distinguish between various levels of career development, because the needs of individuals and institutions vary at different levels. Accordingly, two groups of awards have been established. "Research career development awards" are designed for those who are in the early years of research careers. To be eligible, candidates must have had at least 3 years of relevant research or professional experience after receiving the doctorate. Awards are for 5 years, renewable, upon adequate justification, for 5 additional years. "Research career awards" are designed for those with substantial experience who are already launched upon research careers; these awards will provide support for the full career of the individuals who are selected.

4) An important objective of the program is to strengthen research institutions, while providing support to individuals. To provide a continuing link between the individuals selected and their institutions, a number of ties to the institution are preserved under the program. Awardees are expected to participate in the general activities of the institution, including teaching. Awards are not made to individuals but are made to institutions on behalf of individuals. The NIH award will be consistent with the salary scale of the institution for persons with comparable experience and accomplishments. Finally, the institution is asked to nominate for "career awards" only those whom it would wish to have as permanent staff. Taken together, these provisions should link the institution and the awardees effectively under a program which provides salaries from a federal agency.

5) The awards are intended to provide sufficient compensation to permit those who are selected to devote their careers to research and teaching. Consistent with the principle that awardees are intended to be integral members of faculties, or of research staffs of nonacademic institutions, the award will correspond to the salary paid by the institution to other persons with comparable attainments. Since the object of the program is to free people for careers in research and teaching, those who receive awards will be expected to devote themselves full time to these activities. However, the award recipients will be expected to engage in the usual ancillary activities of faculty members, such as writing, delivering occasional outside lectures, and serving on advisory groups, and they may receive the usual compensation for such work. Awardees will also be expected to practice their professions, as may be indicated, in connection with their teaching and research duties, and in order to maintain their professional skills. However, they may not retain personal income from practice.

Scope of the Program and Its Future

The program has been devised to meet very clearly defined and limited objectives. Accordingly, many individuals of high competence will not be eligible, and many institutions may find that they either cannot or do not wish to nominate persons for awards. For example, some medical schools which permit their faculty members to retain substantial sums from the practice of medicine may feel that they prefer their present system and do not wish to make the changes required to make faculty members eligible.

The fact that candidates with unstable incomes will be given preference, and the concurrent administrative intent to sustain high standards of excellence, will

tend to concentrate awards below the senior academic levels. This is the case because the prevailing practice is to give first priority in the use of firm institutional funds to the payment of salaries to the most able senior faculty members. If the needs for firm funds for payment of salaries to outstanding persons progressing to senior positions expand more rapidly than the firm institutional funds available for salaries, the federal funds for career support will become progressively more important at the senior levels.

In terms of money, $4 million is available in the year that began 1 July 1961 for the Research Career Award Program. It is anticipated that this will finance about 275 awards.

As a long-range possibility, amalgamation of parts or all of this program with the new General Research Support Grant program will be considered. The General Research Support Grant provides broad aid for medical and related research, not support in the form of aid to specified projects or programs. The General Research Support Grant is a single grant to an institution, allowing it to meet those direct costs of research not covered by other forms of research support which are, in the judgment of the institution, most urgent. For these grants, $20 million will be available in calendar year 1962 to schools of medicine, dentistry, osteopathy, and public health. The grant will be increased and extended to other institutions engaged in medical and related research in subsequent years.

To view federal support for research in universities in perspective, the Research Career Award Program represents a shift towards emphasis upon the long-term support of highly qualified people for research and teaching, as constrasted with support of current research. The General Research Support Grant represents a trend, evident in the actions of a number of federal agencies and most explicitly in the institutional grant of the National Science Foundation, toward aid to research and education on a broad basis, detailed determinations being left to the institutions. Accordingly, the long-range relationships between the programs must be taken into account in considering the evolution of the grant programs of the National Institutes of Health.

Biochemistry of Aging

The mechanism of aging presents a challenge to modern biochemistry and biology.

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The present development of biochemistry and biology suggests that the question, "Why do we get old?" may be answered in the foreseeable future. There are now several ways of investigating the mechanisms of aging in the laboratory, and new insights are bound to come from work in associated areas. I shall attempt to review in this article some trends in research on the biochemistry of aging.

Mortality data provide one approach to the aging problem. Gompertz (*1*) observed that a plot of the logarithm of the death rate in the surviving human population against age is a straight line after maturity. A similar relationship has been found in other captive populations, such as rodents and *Drosophila* (*2*). In human beings, the death rate doubles every 7 to 8.5 years (*3*). This implies that there is a 100-fold increase in the probability of death between ages 35 and 85 (*4*).

If separate physiological variables are measured, such as maximal breathing capacity, renal plasma flow (*5*), integration of complex mental skills, and speed of voluntary responses (*6*), there is a definite decrease with age, although this decrease seldom exceeds 30 to 50 percent (*4, 5, 7*).

When an explanation of this impaired function is sought in tissue pathology, a number of changes are observed. In certain areas of the brain there is a decrease in total numbers of viable cells, amounting in some areas to 25 to 30 percent, together with a decrease in the total amount of brain tissue—a decrease which may be of the order of 9 to 17 percent. At the same time, aberrations appear in the cytoplasm and nucleus of nerve cells (*6*).

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Decrease in strength may result from a decrease in the functioning mass of muscle as well as from an impairment in innervation. Evidence for the replacement of muscle fibers by connective and adipose tissue in older animals has been reviewed by Andrew (*8*), who attempts the difficult task of correlating what is known of the changes with age in skeletal, smooth, and cardiac muscle.

The age decrement in discrete renal functions can be attributed to a loss of functioning nephrons. The relationship between number of functioning units and functional capacity in kidney and other tissues is reviewed by Shock in the AAAS publication on aging (*7*).

In spite of the great current interest in hormones and the aging process, the exact relationships between endocrine function and aging is not well understood. Pincus (*9*) has reviewed much of the literature on this subject and attaches particular importance to the function of the pituitary.

Enzymes

To the biochemist the subject of enzymatic activity of aging tissue is of great interest. It is not always easy to distinguish between the amount of an enzyme present in a tissue and the activity of the enzyme. It is particularly difficult to measure the amount of inactivated enzyme which might be present in tissue as a consequence of