zymatic hydroxylation are shown in Fig. 10 for the representative case of 4-chlorophenylalanine. The ratio of products is probably determined not only by the point of initial hydroxyl attack but also by the several kinetic factors in each of the possible reactions. The example explains how one enzyme can produce several products from a single substrate. This is of particular significance in drug metabolism, where a single enzyme could account for a great number of urinary products. The diagram also shows that it is possible to have a substitution occur and yet observe no net reaction ("virtual reaction"). The recognition of the "NIH Shift" has shown that hydroxyl group substitution is not limited to positions *ortho*, *meta*, and *para* to a ring substituent but frequently occurs on the same carbon atom as the substituent itself. Finally, the possibility of the reaction of the cationoid intermediates with external nucleophiles could give rise to products such as dihydrodiols (*33*) or mercapturic acids (*34*). Thus, the discovery of the "NIH Shift" has provided new insights into the mechanism of hydroxylation and allowed the development of new tools for enzyme assay. In addition, the findings have opened fascinating new possibilities for metabolic pathways and led to exciting experiments on the relationship of chemical models to enzymatic processes.

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Graduate Student Stipends

Greater reliance on the "traineeship" concept would facilitate a more purposeful and consistent treatment.

Wayne R. Gruner

Human institutions, as all of us know, generally outlive the circumstances which motivated their establishment. Arrangements adopted by the federal government for support of university science are no exception, and this article discusses one case in point. Considerations which originally gave rise to various forms of graduate student support are reviewed and some are found to have diminished in relevance. Currently prevalent attitudes appear to be best reflected in the traineeship approach.

The discussion here deals with students of physics. Conditions of employment, as well as the reasons for these conditions, differ somewhat from one scientific discipline to another. One purpose of this article is to elicit some public discussion of the differences and how they bear upon policies of student support.

The classical form of graduate student support (private fellowships, teaching assistantships, and outside employment) all persist at a significant level in our system today. To these have been added a great diversity of stipends provided by the federal government. Such stipends include: National Science Foundation predoctoral and cooperative fellowships, Atomic Energy Commission fellowships, National Science Foundation traineeships, National Defense Education Act fellowships, research assistantships under research grant and contracts awarded by numerous federal agencies, stipends provided under "University Science Development" grants, and doubtless several others. Each mode of support has its own nominating or selecting procedures and its own reporting or supervisory requirements. These multifarious arrangements impose a burden upon university faculties, federal administrators, and the students themselves. Confusion prevails, and we are learning

The author is head of the physics section of the National Science Foundation. This article is based on portions of a seminar given at the University of Washington in May 1965 and is offered not as a pronouncement but rather as an interesting starting point for community discussion. Opinions or assertions are the private ones of the author, and are not to be construed as official or as representing the views of the National Science Foundation.

only with considerable difficulty the exact number and distribution of graduate student stipends provided by the federal government.

The diversity of programs reflects a diversity of motives and beliefs. Thus, some programs were established upon the supposition that a greater number of talented young people wish to undertake graduate study than are able to find the opportunity. Others were established to improve and reward high scholarship; still others, to increase the overall number of graduate students even at the expense of some diminution of quality. Some arose from the need to get certain technical or pedagogical tasks performed competently and cheaply, and some, recently, from the recognition that able graduate students constitute an indispensable scholarly asset to the university. Each of these motives, probably, has been the relevant one during some period.

However inconsistent the approaches of the federal government may have been, graduate students have certainly found support in ever increasing numbers. Fewer than 10 percent of all full-time physics graduate students are without academically oriented stipends. Even this small minority has been shrinking steadily, despite a rapid increase in the total number of graduate students. The practical situation is quite evidently a "seller's market" for graduate students—one in which opportunities for graduate study in physics exceed the number of very well-qualified, or even properly qualified, young people wishing to undertake graduate work. Stipends take their places, then, along with faculty and institutional prestige, climate, the quality of the local theatre, and the like, in a complex array of incentives held out to the prospective student.

One result is that the ablest students tend to obtain personal fellowships and to concentrate very noticeably, not to say exclusively, in a few of the most prestigious centers.

Again, undergraduate instruction may be adversely affected; graduate students, like their professors, encounter temptations and opportunities to avoid teaching. (Most graduate students would like to get on with their work for the Ph.D. and thus end their period of servitude; teaching appears to them to contribute little toward this end.) Many department chairmen privately report that teaching assistantships are regarded as less attractive than other stipends, and that departmental practice is to extend the graduate student admissions cutoff downward until a sufficient body of recruits is on hand to fill the necessary teaching positions.

In this situation, the graduate students are afforded inhomogeneous training and work experience, and the undergraduates are exposed to a poor selection of graduate students in teaching positions. It is probable, too, that we are admitting to graduate school more students than are truly qualified. Influence of federal actions upon the number, quality, and distribution of students is decisive, but its detailed workings involve complex trade-offs of competing incentives and are somewhat inaccessible to systematic examination. Purposeful adjustment of policy has become very difficult, and we see in operation what I think is probably an important general principle of public administration, namely, that when the government supports the same activity through several parallel channels, the most "permissive" channels set the limits of purposeful control.

Comparison of Support Mechanisms

The central concepts of individual fellowships, such as the National Science Foundation and the Atomic Energy Commission predoctorals, are ability and achievement. Federally supported predoctoral fellowships were established after World War II to guarantee that the ablest students should have an opportunity to attend graduate school if they so desired. These fellowships were intended to confer both a distinction and a practical advantage upon the recipients. The number of fellowships was moderate in relation to the total student population, and the program did not induce a large perturbation in the sociology of graduate students.

Since these fellowships are a form of personal recognition, great pains must be taken by all concerned to see that they are awarded in equitable competition. This means that students must prepare applications and line up recommendations, and that a great deal of professional effort has to be expended in studying and evaluating these applications. Also some responsible person must report at intervals on each individual student's performance.

Federal support of research assistantships, as a feature of federal research grants and contracts, came into vogue shortly after World War II. In fiscal year 1965 such stipends together with associated "indirect cost" accounted for approximately 14 to 18 percent of physics research grant and contract obligations to universities. The assistantships are awarded to graduate students through, and at the discretion of, their research professors. Different professors may use research assistantships according to a wide range of philosophies. On one extreme the research assistantship may amount, in effect, to a predoctoral fellowship with only slight restrictions. On the other, a research assistantship may be regarded as a purchase order for cheap labor. The exact point of balance between these extremes varies greatly from one institution and from one professor to another. It also varies between and within scientific disciplines. One extreme attitude is reflected in an eminent mathematician's aphorism that the research assistant is "a young scientist who is assisted in the conduct of research by his professor."

Traineeships are federally funded fellowships administered by the university; principal examples are traineeships provided by the National Science Foundation and the National Aeronautics and Space Administration, and National Defense Education Act fellowships. I will use the Foundation's traineeship program as an example, although the NDEA program is larger and was established earlier. The National Science Foundation traineeship program was established to increase the fraction of college graduates who continue on with graduate study in the sciences and particularly in engineering. It is not yet clear whether the traineeships effect this end. However, they could effectively control distribution of graduate students among institutions, and some features of their method are exemplary. Indeed they should be considered primarily in terms of method.

Traineeships are allocated by the Foundation to universities. The allocation is subject to liberal specifications concerning seniority of students, approximate distribution over scientific disciplines, and the like. Selection of individual students preferably occurs at the departmental level. Table 1 gives a rough idea of the relative importance of the most common forms of support for physics students.

Recognized Goals

Approximately the existing number of graduate students should be supported, without resort to outside employment, both during their concentration on course work and while they carry out their dissertation research. Of course the support for each student should be contingent throughout his period of study upon maintenance of high scholarship. Teaching is a desirable experience for nearly every graduate student, and many educators recommend that some satisfactory participation in teaching by advanced students be a requirement for the Ph.D.

We also wish to encourage excellence. The present graduate student "market" in physics is such that a truly superior student can be quite sure of obtaining support and, moreover, of being able to choose between several good universities. Since this situation applies for students who do not come into the zone of consideration for NSF predoctoral fellowships, one principal historical motive for establishment of these fellowships has been undermined. Against this, however, we must weigh the consideration that predoctoral fellowships, by conferring personal distinction upon superior students, were intended to buttress respect for achievement and excellence—a matter of some urgency in a society as permissive and egalitarian as ours. As things now stand, the distinction conferred is transient and is one of acknowledgment only. The predoctoral fellow, when he has settled down at a graduate school of his choice, will find that many (perhaps most) of his fellow students receive as much income as he, and some receive more. Even his freedom from obligations may turn out to be in fact a handicap; some observers feel it delays his full involvement in the activity and spirit of the department. To preserve a meaningful "distinction for excellence" it is desirable to continue the predoctoral fellowships but their terms should be made noticeably superior to those of other stipends—without, however, isolating the recipient from his academic environment.

Traineeships

There is increasing national interest in problems of geographical and institutional distribution of students. These problems can best be attacked through traineeships. The predoctoral fellows and the research assistantships have both tended to concentrate heavily in the major research centers. "Cooperative fellowships" were invented in an effort to moderate this effect, and they were equipped with various provisions designed to distribute them more widely among institutions. However, administration of these proved laborious for all concerned, and in consequence the cooperative fellowships have been phased out and replaced by additional traineeships. This is a most promising substitution and should break the trail for more comprehensive reforms.

Table 1. Graduate student support reported by university physics departments.* The total number of full-time physics graduate students in the fall of 1964 was 9172; in the fall of 1965 it was 10,050.

Type of support	Number of students	
	Fall 1964	Fall 1965
NSF predoctoral, and cooperative fellowships	564	513
Total of NSF traineeships, NDEA fellowships, and NASA traineeships	493	1079
Research assistantships	3245	3414
Teaching assistantships	2379	2728

* These are relevant excerpts from much more comprehensive statistics, covering several scientific disciplines, which have been collected and thoroughly analyzed by Dr. R. H. Linnell of the National Science Foundation. His report will be published soon.

The geographical and institutional locations of traineeships and research assistantships are specified by the government agencies. For both types of support, the stipend, once awarded, is under university control. The reporting requirements are reasonable, and administration can be very simple—especially if the requirement that some minimum percentage of trainees be first-year graduate students is relaxed.

In the case of the research assistantships, however, a professor is under some pressure to line up the stipends associated with his various research grants or contracts, and he must look assiduously to their renewal. Thus the research assistant's livelihood becomes hostage—both to the scientific competence and to the "salesmanship" of his professor—and extraneous considerations creep into decisions about the perpetuation of research projects.

The assignment of traineeships involves a sequence of judgments which can be made with a reasonable degree of confidence. Thus, the federal administrators and their advisory panels estimate the approximate numerical capacity of individual academic departments which are judged to provide satisfactory graduate level instruction; this is a fairly easy estimate for an experienced and well-informed person to make. These panels do not have to judge a number of personal applicants strictly on the basis of documentary evidence—as do the panels which evaluate fellowship applications.

At the university, in turn, the person who has to determine which students get traineeship stipends is one who has a considerable stake in these students' satisfactory future performance. Furthermore, in most cases he or his faculty colleagues will have first-hand knowledge of the individual students in question. Availability of traineeships in blocs can provide flexibility badly needed at the departmental level. The student, finally, is dependent neither upon decisions of some remote and abstractly impersonal fellowship award panel nor upon an individual professor's successes in grantsmanship but rather upon the local departmental community as a whole. This situation should be conducive to a more balanced student view of the overall scientific-academic enterprise.

For all of these reasons it would be desirable to gradually substitute traineeships for most of the existing research assistantships. This substitution can be practical only if allocation of traineeships is made to, and selection of individual trainees occurs at, the departmental level—and only if the allocation realistically reflects departmental capacity. Present distribution of NSF traineeships does not suitably exemplify these principles because it is partly motivated to "compensate" for real or supposed deficiencies in distribution of other types of stipends and because the total number of traineeships is small. Even under favorable circumstances, however, it is not to be expected that a nationally balanced scientific program will always result from uncritical accumulation of decisions made independently at individual universities. Research assistantships and the research grants with which they are associated provide a means of adjusting distribution of effort and training among subfields of research when this is necessary. Therefore it seems unwise to abandon research assistantships altogether.

All forms of support should be inte-

grated with the teaching assistance structure in such a way as to afford a consistent educational and work experience to the majority of graduate students and a better quality of instruction to undergraduates.

This unification will be much more easily effected in a system with a large preponderance of traineeships. It should be possible to develop an arrangement under which the university and the government contribute jointly to an overall traineeship stipend budget with the trainees participating in undergraduate instruction and with the university contribution to the budget determined according to the total teaching load carried by all trainees together.

Difficulties

A major practical obstacle to such transformations lies in the fact that the programs involved are administered by perhaps ten different federal agencies, and some of their features are legislatively prescribed. A very high degree of interagency and legislative cooperation is therefore necessary if we are to approach the ideal. However the problem is one for which it seems relatively easy to establish broad areas of agreement, and worthwhile beginnings can be made by administrative accommodation within and between agencies.

Summary

The situation of graduate students in physics is profoundly influenced by federal support, which has been applied with mixed, and occasionally contradictory, purpose.

There are five important goals in the provision of graduate student stipends: (i) maintenance of "distinction for excellence"; (ii) rational distribution over scientific fields and subfields; (iii) constructive involvement of graduate students in undergraduate teaching; (iv) rational geographic and institutional distribution; and (v) administrative simplicity.

These goals may be approached by making several adjustments of the present system.

1) The preeminence of individual predoctoral fellowships should be restored. They should be awarded sparingly to at most five percent of the graduate student population.

2) The great majority of stipends should take the form of traineeships. They should be assigned to departments according to rational criteria.

3) Research assistantships should be continued at a reduced level. Their maintenance will protect research activities of specific public interest when necessary.

4) Teaching should be incorporated into the normal responsibilities of fellows, trainees, and research assistants. Teaching *assistance* should be regarded as a budgeting category and not as an identifying characteristic of a particular group of students.

Changes in these directions could lead to some semblance of a "system" which would duplicate all positive achievements of our present haphazard arrangements, would honor the basic motives, and would realize substantial advantages. The principal advantage, I have argued, would be more purposeful management of the graduate students themselves. Collateral advantages would include both simplified administration and much enhanced economic and demographic awareness on the part of officials responsible for policy decisions. In short, the degree of inadvertence in federal actions affecting graduate education would be lessened.

NEWS AND COMMENT

Scientists and Engineers for L.B.J.: A War and Three Years Later

It appears that the war in Vietnam has sharply diminished support for Lyndon Johnson among the leaders of the American scientific and engineering communities who campaigned for him vigorously in 1964. Results of discussions by *Science* with 30 of the 42 members of the founding committee of Scientists and Engineers for Johnson indicate that the leadership of that remarkable coalition has divided into three camps of nearly equal size—one opposing President Johnson, one supporting him, and one unhappy but uncertain.* The remaining members of the committee could not be reached. Most of those who were contacted requested anonymity as a condition of candor, and *Science* has accordingly withheld names throughout; however, a list of the founders of Scientists and Engineers for Johnson appears on page 1535.

The codification of complex reactions of sophisticated individuals into the simple categories of "pro," "anti," and "uncertain" is obviously not highly precise. Within the categories, feelings and perceptions may overlap even where judgments differ. Nonetheless, the groups do cluster around those simple poles, and a number of observations may be made about each group.

First, the anti-Johnson group includes perhaps the most influential members of the original committee—some of the leading figures in government advisory circles—as well as academic researchers and a miscellany of other denizens of the scientific community. They have kept an increasingly troubled silence because they are still active in the government advisory apparatus or because they play key roles in important public and private institutions and are fearful of the consequences an open break might have. Privately, however, they are full of anguish, depression, and anger. "I burned my Johnson button several months ago," one member of the founding committee remarked.

There is one exception to the pattern of private agony—General James M. Gavin, a former chief of Army research and development who served as Kennedy's ambassador to France and is now the chief executive officer of Arthur D. Little Company in Cambridge. Gavin has made no secret of his dismay over the acceleration of the war—he has testified before the Senate

* For a study of the role of Scientists and Engineers for Johnson in the 1964 campaign, see *Science*, 11 and 18 December 1964.