or strut or flap their wings and squawk. Let them push each other about, or swim, or sit still and blink in the sun, as they will. Let them otherwise develop their lives—for they sometimes bring us truth and beauty quite beyond what most men call golden.

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Responsible Scientific Choice

Alvin Weinberg's criteria for responsible scientific choice, and his suggestions for improving our system of making choices, are not only sound but inspiring. What prompts me to write, however, is your singling out of one of Weinberg's arguments as "particularly apt" in your editorial of 13 September. This is the idea that the field with most scientific merit is one which contributes "most heavily to and illuminates most brightly its neighboring scientific disciplines."

If this and the other criteria offered by Weinberg are valid, it seems to me that the NASA space program, or at least most of its scientific component, comes off rather well. Space science seems to meet, at least adequately, all the criteria mentioned in your editorial.

I think "space science" measures up quite well mostly because, one could say, so little exists that is "space science" in itself. Earth satellites serve geophysics and its sisters and cousins —upper-atmosphere and ionospheric physics, geomagnetics, and others. Both earth satellites and deep-space probes serve solar physics, astrophysics, and solar-system astronomy—the last having been rather neglected for decades because the earthbound tools we have had could do more in galactic and extragalactic astronomy. Space tools will serve galactic and extragalactic astronomy as well, along with cosmology and (once lunar landings have been made) even geology once again.

Unless its development is throttled, the space program shows promise of determining within a few years whether vital spores of any kind can be found on the moon or in space itself. Within a few years after that, the question of life on Mars will surely be "settled." Certainly "settling" these gross questions will raise many more provocative questions for biology—and probably most of all for molecular biology. The Space Administration seems to be preparing to meet these questions: it was at the NASA Ames Center here in California that ATP was first synthesized.

Certainly the answer is "yes" for both of Weinberg's "internal" criteria: "(1) Is the field ready for exploitation? (2) Are the scientists in the field really competent?" To laymen, the answer might seem to be "no" for the second, because of the early failures in making pre-NASA and NASA hardware work. But the scientists who designed the payloads knew what they were instrumenting for, how to instrument for it, how to retrieve the data, and what to do with the data. This adds up to competence, whatever the engineering difficulties.

Whether or not space activities can be promoted or defended on the three "external" criteria of "technological merit, scientific merit and social merit" depends greatly on the point of view. Some critics seem to begin with an a priori principle that space activities are simply not worth the candle, and it is impossible to show them evidence of merit; they have defined the merit away. At the other extreme are what are best termed "space fans," for whom space activities are a "race"; they are always eager to have *Ourside* do something Bigger, Better, and Firster than *Theirside.*

Space has stimulated interest in science, among laymen generally and among school children (and their teachers) in particular, more than any other scientific development in modern times. To most people, nuclear energy is just bombs, and particle physics is more bombs; chemistry used to be nylon and buffered aspirin. It was the traumatic opening of the space age that brought a real and deep ferment in education; this ferment has not produced much yet, but it is going on at the usual *social* pace—not the pace of science or technology. Space offers mankind an opportunity to channel deep, unconscious, irrational competitive drives into directions other than toward warfare—though the opportunity may be missed. It can be missed if we go on arguing whether we would rather have a lunar landing or a cancer cure (or some other "more worthy" objective); we all know in our hearts that these things are not alternatives. Space also, as Eugene Rabinowitch recently pointed out, offers unprecedented opportunities for international cooperation. Even this much adds up to social merit.

As for scientific merit, "space science" not only serves and illuminates its neighbor sciences but also stimulates science in general and stimulates support for science. Would there be bitter and prolonged disputes today over $10 million for a Hale-Palomar observatory or a preliminary Mohole drilling? The sheer size of the space effort has made "unreasonably" expensive ventures "reasonable." The head of a great oceanographic institute informs me that his budget has tripled in the last few years, and he thinks "space has helped."

The "trouble" with space science is that it requires such frightfully expensive hardware. But this general kind of hardware is being built anyway, for its destructive potential. Without deliberate space efforts it would not serve science directly at all, and it serves society only by providing a deterrent to someone else's destructive use of similar hardware. Or so society hopes. No worthwhile suggestions have been made for getting cheaper hardware or for using the expensive stuff more efficiently; we shall learn how to do these things by using what is available "inefficiently" for a time. Certainly we shall not have cheaper space programs by stretching them out, or waiting indefinitely. Nor would stretchouts or arbitrary waiting periods serve society any better right now when we have idle industrial capacity and people out of work—and while we can still afford unlimited supplies of lipstick and pizza.

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Research Grants—Are They Worth Saving?

The recent recommendations of the Committee on Sponsored Research of the American Council on Education relative to payment of faculty salaries from research grants deserve very serious consideration from the academic community and government agencies. These proposals represent a further step in the direction of approaching all university research support on a strict contractual basis. They also represent a step away from the view that the faculty members of universities have scholarly interests for which they seek financial help and for which they

also receive some help from their university in the form of free time and facilities. Perhaps the time has come when the research grant-in-aid has ceased to have any legitimate place in university life and when the universities are forced to enter the competition for government contracts in order to survive and grow, but this position ought to be reached by decision rather than by default.

It must be recognized that the recommendation that the costs of faculty salaries for time spent in research should be fully recoverable from grants and contracts represents the thinking of a group of experienced and thoughtful administrators. It should be further recognized that administrators' thoughts in recent years have been substantially directed toward problems of paying their faculties and otherwise meeting the rapidly rising costs of research and research training. Administrators have been faced with the development of critical masses in a number of research areas which have resulted in explosions of demands for support as well as scientific results. Faculty members should also not be unmindful of the fact that improvements in salary have been substantially dependent upon partial implementation of the proposed salary policy. Someone has to pay the costs of research as well as that major part of the cost of educational activities which is not met by tuition fees. Funds may come in part from another government agency in the case of state schools, but otherwise must come from our mendicant college and university presidents, and in any case never seem to come in sufficient quantity. No one can argue the fact that educational and research institutions will need much more money to do the job they should, or the fact that these activities are very much in the national interest, or the fact that the federal government is the only single donor with the capability of meeting a major part of the need. Nevertheless, I think there are reasons for inquiring whether the research grant is being asked to provide too much of the required support, whether these demands are converting the research grant to a contract, and whether the research contract is the most effective basis for support of basic research.

There seem to me to be two general types of research activity, and different mechanisms of support may be appropriate to each. In one case a government agency has a problem for which it requires a solution. It seeks out the research capabilities which can deal with this problem. In the case of a university, the agency then in effect asks that faculty and facilities be diverted from their normal functions to work on the problem. This type of purchased research is most characteristically seen during a war or other national emergency, and the contributions of a few major institutions were critical in World War II. Some needs of this kind would still exist in a world completely without tension, and under any circumstances should clearly be supported on a contractual basis which covers the full costs. However, it is also in the national interest to support basic research which has no immediate objective other than a better understanding of ourselves and the universe in which we find ourselves; and this activity is one to which our colleges and universities are already dedicated, or should be. It is an activity which may have constantly shifting goals in the case of any investigator and one for which financial needs may change accordingly. It is, by its nature, not readily constrained in the formality of a contractual relationship, and it is generally so enmeshed in the educational activities of a faculty member that it could only very painfully be dissected out. Consequently, a different basis for financial support is needed in this case.

The grant-in-aid has been recognized as appropriate in the formation of every major research grant program in recent years. Basically, the programs of the Office of Naval Research, National Institutes of Health, and National Science Foundation were all structured to provide the maximum possible latitude in providing funds to assist university and college scientists to conduct those researches which they and the granting agencies could agree were important. In general, the granting agencies have asked other university scientists to help them decide which proposals are most worthy of support, but the approach has been, "tell us what you think is important, and we will try to find a way to help you do it." They have depended upon colleges and universities to pick people who ought to be supported in the sense that they have been more willing to put agency research money where the universities were willing to put theirs. At the same time, colleges and universities have been encouraged to retain their role as partners in the operation and to seek funds from private as well as public sources.

The research grant-in-aid has been a tremendous success. In a way it has been too successful. Over the years, overhead allowances have been added in larger and larger proportions. The universities clearly needed the money, and the grant-in-aid was clearly building universities and faculties so effectively that university administrators could not refuse grants-in-aid. In fact, they could not retain their faculties or recruit new faculty without them. In those institutions which were traditionally on an academic year basis the faculty members got a new lease on their research life, since they could now hope to get salary from a research grant and spend the entire summer in research rather than in teaching summer courses or engaging in some other activity for extra pay. Many institutions which had been on an annual basis converted to an academic year basis since this permitted them, in effect, to give their faculties raises from research grants. More recently, granting agencies have been under increasing pressure to accept the principle that faculty salaries should be fully recoverable from research grants in proportion to time or "effort" spent.

I have already said that I do not think this move is without logic, but it is another step toward conversion of the research grant into a reimbursable contract arrangement, and I do believe that the research contract is not the proper mechanism through which to provide support for basic research. The research contract implies a fairly well-defined objective and the establishment of a fairly rigid budget. It also implies the keeping of more detailed accounting for time and materials devoted to a specific project than is customary in university laboratories. The lack of such rigid controls and inventories does not, of course, mean that the system must be correspondingly wasteful. It is simply a reflection of the fact few investigators will be concerned with only a single problem at a time, and if the centrifuge which was bought for project A is used sometimes on project B, this will generally balance out because the spectrophotometer bought for project B is also used in project A. Perhaps things could be managed on a more rigid basis, but this would be the case only if each investigator had one or two administrative assistants who could keep the necessary inven-

tories and time sheets. The costs of research in relation to accomplishment will certainly not be reduced by the introduction of more rigid fiscal control of basic research grants. It is inevitable, however, that if the universities and colleges hold fast to the view that they must be reimbursed completely for research costs, government agencies will be forced to ask for an equally strict accounting to demonstrate that they are not being asked to pay more than actual costs.

It does not seem necessary to force the research grant out of existence, or to constrain basic research activities in this way. Congress has already recognized one need in a very direct way by providing funds with which to help the universities and colleges build new research laboratories. Support for the maintenance or development of more adequate faculties might be provided in a similarly direct way. The National Institutes of Health have taken steps in this direction with the establishment of Research Career Awards. Accomplishment of the objective may seem more simply reached by again making use of the research grant, but I think we have too much to lose by taking advantage of this apparent simplicity. The universities do not need more help for faculty salaries because the government has asked them to do more research. They need help because government research grant money has made it possible for them to do more of the research they would like to do, and because they are aware of how much more they could do in teaching and research. Why not face the issue, then and ask for help for faculty positions on the basis of a demonstrable need rather than trying to add still another burden which the research grant was never intended to bear?

Finally, there are two practical considerations which should be looked at, both related to the fact that funds for basic research are limited. The first is that the added burden of faculty salaries will considerably reduce the amount of money available for research. If a substantial portion of faculty salaries is transferred to research grants, universities have funds freed for other purposes, but the net investment in the research for which grant money is provided will be reduced correspondingly.

The second consideration is that the result will narrow rather than broaden the base of research support, as Congress and most of the academic community would prefer. Consider the case of an institution which now typically gets a lion's share of federal grant funds. The faculty may spend an average of 20 percent of its time for effort on activities other than research and it will be a rare instance that less than 80 percent can be justified as devoted to "sponsored" research of some kind. The stature of the faculty will generally be such that there will be no question about providing grant support as near the level requested as possible. In general, grants for these institutions can be expected to be funded with maximum support for faculty salaries and without much reduction in other research support. However, for the individual who is a more a nearly average but competent investigator, most of the cream has been skimmed off the milk which the grants programs have to offer. It may be that there are insufficient funds to support his research at all, or that the support given is so limited that charging any substantial portion of his salary to the grant would leave a quite inadequate amount with which to prosecute the research.

The favored institution will now be in an even more favorable position to compete for other outstanding scientists who are consequently also effective competitors for grant funds. I am sure that universities and colleges would not want a change in the present policy by which they determine what salary they will pay their faculty. If, however, they can expect to recover some 80 percent of this salary from grants, they are going to be relatively free to adjust their salaries to whatever competition develops. There is already a rather lively competition of this type, and it seems inevitable that it would become much more severe under the proposed faculty salary arrangement and that the burden of the competition would be increasingly transferred to the research grant and federal funds. Even with the financial benefits which would accrue to a substantial number of faculty members, I'm not sure that most of them would like to see it happen in this way, and I'm certain that many administrators in educational institutions would find some of the consequences unpleasant.

One university administrator with whom I have been associated used to say that there were many times when you had to know how to cut a straight line on the bias. This is one case, however, where we should cut the straight line in the most direct way. The research grant should be preserved with all that is implied in a grant-in-aid, and other needs should be recognized and met on their own merit.

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Code of Ethics

Lawrence Cranberg states [*Science* **141**, 1242 (1963)] that, in contrast to engineers, psychologists, and members of other professions, scientists have no code of ethics, probably because of their remoteness from the marketplace or their slowness to adapt to the great changes which have taken place in recent years. He suggests that we devote our thoughtful attention to this matter.

Very strong in my own scientific upbringing was the principle of "scientific honesty" and the complete realization that this is the very essence of science. I have also seen one or two instances of how rapidly and completely even outstanding scientists disappeared from the scientific community when caught in an overt violation of this ethic. It certainly never occurred to me that this was a matter on which we should vote! I wonder if adopting it formally would make it more effective.

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Cranberg, in his discussion of an ethical code for scientists, seems surprised that no action has been taken in this area. Could it be that the scientific community as a whole feels that such a code is unnecessary? My guess would be "yes"!

From certain points of view a code of ethics is implicit in the word *scientist*. The game of science is played under certain rules—uncodified, yes, but nevertheless present and adhered to by most scientists. Cranberg's examples of codes in certain professions are not applicable to scientists. By and large, the medical profession, lawyers, engineers, psychologists, and so on have codes set up primarily for legal purposes, not for moral purposes.

The mere thought of setting up a code of ethics for scientists is insulting!

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