Commission, the National Aeronautics and Space Administration, and other fund-granting federal agencies, the effect upon the universities is to produce much of the chaotic state which I tried briefly to describe.

The solution to this kind of haphazard administration appears to me to be obvious: Grant to each of the universities directly, by means of a well-monitored system of dispensation, enough money to meet adequately all of its legitimate needs, and hold the university officials responsible for a proper internal administration of these funds.

In case DuBridge and other readers of *Science* may suspect that the views expressed in the paper under discussion are merely the "half-baked" and ill-considered views of a single individual, and are not representative of the scientific community at large, it is worthy of note that this paper has evoked an avalanche of mail consisting overwhelmingly of expressions of enthusiastic approval. Already 166 such communications have been received from a cross section of scientists ranging from nuclear physicists to psychologists—both in the United States and abroad. To the members of Congress, the administrators of agencies disbursing government funds for scientific and educational uses, and others who should be mindful of such matters, this unintentional poll of scientific opinion should be of more than passing interest.

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Reference

1. *Bulletin of California Institute of Technology*, vol. 69, No. 4 (Pasadena, Calif., Nov. 1960).

More on Paper Work

The editorial "More paper work, less research" [*Science* **139**, 725 (22 Feb. 1963)] is much to the point. However, it does not mention what seems to me the most disturbing feature in the new regulations of the grant program of the National Institutes of Health. This is the requirement that the investigator must notify the granting agency if he has altered the objectives of his research, as he stated them in his application. How this rule is to operate in practice I do not know. No criteria are given to indicate just what constitutes a change of objective, but in any case the requirement appears to impair the fundamental distinction

between a research grant and a contract. A contract is given to a man who agrees in advance to do a specified job in applied research or development; the fundamental scientific evidence is already available to show that the job can be done, and general specifications can be laid out in advance. A research grant, on the other hand, is given to permit the investigator to explore unknown territory; he may state in his application some of the things that he thinks he may find and will indicate how he may start to go about finding them. However, in any fundamental research new and unexpected leads will turn up, and the whole point of the research is to find out things that could not be foreseen at the time when the application was written. The research grant program of NIH, as hitherto administered, has shown profound appreciation of these fundamental facts. It is regrettable that pressure from congressional committees is leading to a more rigid attitude, and to diminished freedom of research.

Of course, investigators who have already achieved high distinction can generally write their research applications in such broad terms as to include almost any new development that may occur in the course of the research. Relatively unknown young investigators are generally under pressure, in writing research grant applications, to specify in considerable detail what they intend to do and how they plan to do it. If they are conscientious they may feel considerably worried by the requirement that they must report to the granting agency any new turn that their research takes. Moreover there may be a future tendency, if present trends continue, to require *all* investigators, when they apply for grants, to write out a description of the intended research in great detail and to stick to that prearranged line unless they get specific permission to change it. This would be contrary to sound policy.

When, for instance, Roentgen made the initial observation that led to the discovery of x-rays he changed the objective of his research immediately. Would the progress of science have been promoted by requiring him to get permission from a government agency to do so?

Very likely permission would have been granted after some delay, but any delay would have retarded the pursuit of a great discovery. No administrator, and no advisory scientific panel, is in a position to tell the investigator what he ought to do under such circumstances. It is easy enough to miss the opportunity for major new discoveries; the inertia of the human mind is great. Several investigators before Roentgen had observed fogging of photographic plates near cathode ray machines, but had failed to see the great discovery implicit in this simple observation. If we set up rules that make it harder for investigators to change the objective of their research we shall make such discoveries less likely in the future.

To grant government money with such freedom in its use may appear to place the scientist in a position of special privilege. In fact, scientific research is probably the most profitable form of investment known, but it yields its best returns only when competent investigators, recognized as such by qualified experts in a panel or study section, are given adequate research grants and plenty of discretion in following the lines of research that look most promising to them. This is a justifiable way to spend the taxpayer's money, because experience has shown that, in the long run, it yields the best results. The dividends to the public are far greater if the scientist has a good deal of latitude in trying out his ideas, within the limits of his approved budget, than if he is held more tightly on the leash. To ask this is not to ask for special privilege, but for the opportunity to carry on the work so as to secure the best results.

It seems likely that the new regulations will not save money for the government. Rather they will increase the costs of research by requiring a new army of accountants and administrative officials to handle the elaborate bookkeeping and paper work. The cost of all this is likely to be much more than the amount saved by imposing stricter regulations on the scientists, quite apart from the serious loss to science, which your editorial mentions, because the scientists themselves will be spending more time on paperwork and less on research.

Nevertheless, scientists cannot dismiss lightly the problem of fiscal responsibility. If even one grant in a thousand is handled wastefully or dishonestly, such irresponsibility endangers the whole scientific community and the community at large. It is harmful to the national interest to cripple

the development of fundamental science, as the new NIH regulations probably will; but it is also harmful to allow irresponsible people to waste or misappropriate government money. The wastefulness of a few demoralizes many and must be held in check. This is the serious problem that justly concerns those members of Congress who are critical of the administration of research grant programs. It is a genuine problem, and we cannot ignore it, while at the same time we must urge the maintenance of liberal policies in administering research grants, for the advancement of science and of our society.

Some of the great private foundations set a pattern of free and flexible support for research in the earlier decades of this century. Their example profoundly influenced government agencies, such as NIH and NSF, when they began to support research on a very large scale, and in a manner that has nourished such a magnificent growth of science in the United States during the last 15 years. Government support has been so great, and its administration so well designed to permit the scientist to proceed freely with his work that the private foundations have largely withdrawn from this field and have devoted themselves to other problems and needs. In view of these new developments it is perhaps in the public interest that more money from private sources should again flow into the support of research in the natural sciences. Private foundations can choose carefully among the people they wish to support and grant them funds with a maximum of freedom and a minimum of administrative regulation. Such funds, even though limited, will be worth far more to the people who receive them than the same amount of money from NIH, with its present encumbrances.

It is one of the most effective features of our social system that the sources of power and influence are widely distributed. Large-scale government support is essential today for the development of scientific research, but the maintenance of some support from sources outside of government is vital to preserve the balance and to minimize the potential danger that science might be stifled by bureaucratic regulation.

JOHN T. EDSALL
Biological Laboratories, Harvard University, Cambridge, Massachusetts

Your editorial properly calls attention to an abuse of confidence which may lead to inconveniences for those who contribute to the progress of science.

Calling the attention of the scientific fraternity as a whole to this situation serves notice that scientists, as a group, must adhere to ethical as well as legal standards in their dealings with government.

The professions have found that the best way of dealing with the "small minority who betray their trust" is to subject them to pitiless publicity, rather than to anonymity in referring to their act, which, without revealing their identity, casts a reflection on the entire group. Congressional demand for better policing of situations such as you have described merely reflects the public demand for such action and there is no greater deterrent of unethical conduct than the knowledge that the discovery of such conduct will be made public.

ROBERT P. FISCHELIS
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In view of inaccuracies contained in your 22 February editorial and at the urging of scientists who feel that your statements should not go unanswered, I feel obliged to make further comment on this matter.

I believe the editor has greatly exaggerated the increase in paper work required for yearly grant continuations under the new NIH policies and the additional reporting requirements in general. In this connection, our studies revealed that NIH has not made the most effective use for grant management purposes of report data already in its possession. In any event, the Committee on Government Operations has performed its proper function in demonstrating the inadequacy of policies for the guidance of grantees and the need for more effective procedures to prevent the misuse and the inefficient use of public funds. The specific manner by which NIH chooses to implement the recommendations of the Committee with which it has expressed agreement is the agency's responsibility.

I cannot avoid the conclusion that the editor of *Science* has not studied the Committee's reports and hearing record when he speaks of an "unfortunate slip" and "one instance of mismanagement." The fact is that the Committee has demonstrated a pattern of administrative weakness in the NIH

grant programs. The case referred to was illustrative of the kinds of undesirable spending practices that have resulted in the absence of clear-cut grant policies and under the agency's management procedures. Moreover, one should not ignore the fact that NIH officials testified that management improvements were desirable and overdue in these programs.

Perhaps the editor is too close to NIH to be a disinterested observer. It is noteworthy that he has been a consultant to the agency for many years.

L. H. FOUNTAIN
Chairman, Intergovernmental Relations Subcommittee, Committee on Government Operations, U.S. House of Representatives

As one who has participated in the flourishing growth of American science during the last two decades, I wish to endorse the editorials in *Science* of 1 and 22 February. I consider that the thoughtful dispensation of public funds has moved American science into world leadership.

The National Institutes of Health and the National Science Foundation, led by their scientific administrators, developed a granting policy that guaranteed a fair but stern judgment. This resulted in a distribution of funds which benefited the gifted and promising young men and women as well as those who had already shown ability. In particular, the availability of funds and decent salaries for young people not only attracted gifted people to scientific fields at home but also drew scientific talent from all over the world to this country. In contrast to most other countries, here there was an opportunity to get a place in the scientific community and obtain the means to do independent research work which, because of the structure of many scientific communities outside this country, was obtainable by only a very few.

It is difficult to understand that this almost miraculously successful government expenditure should be challenged as an imprudent distribution of public funds. Although such slips as there have been should not be brushed off lightly, the magnitude of the success shows how small the waste has been. It is witnessed by the increase in the flow of Nobel prizes in chemistry, physics and medicine to this country in recent years. We find that 40 went to United States scientists in the years 1946–1962 as against 16 in the period 1927–1945.

FRITZ LIPMANN
Rockefeller Institute, New York

Your excellent editorial pointed out some of the inevitable consequences of the new budgetary rules propounded by the NIH in the wake of congressional inquiry. Perhaps these are indeed the sorts of rules that congressmen deem necessary, perhaps not. Certainly some congressmen, like Fogarty of Rhode Island, who have specialized in matters concerning health research, should be able to understand how wasteful of precious research and teaching time these procedures are; the cure for cancer or even the common cold will not be found in double-entry accounting books.

Needless to say, no one is condoning the few examples of actual misuse of funds, which have received an undue amount of publicity. But apparently this phrase, "misuse of funds," has a different meaning for the accountant and the investigator—and we cannot agree with the implication of your news writer D. S. Greenberg (1 March, pp. 814–15) that this connotes a lack of moral fiber among scientists. To cite one possible example, is it truly a misuse of funds to transfer monies from the category for technical help to the purchase of a $4000 photomicrographic apparatus that came on the market after the grant was made? Previously such shifts were encouraged, on the assumption that the investigator might know best what use of funds would yield the most in the long run. Now, apparently, one must wait months for an uncertain permission from Washington.

It is in this light that the recent furor over the American Institute of Biological Sciences augurs badly for the future. The scant information on the alleged "misuse" of funds that has reached us in newspaperless New York City as part of appeals for financial support has failed to clarify the nature of the actual crime. What does appear is that the NSF saw fit suddenly to require the return of funds. Certainly to use money to make a series of teaching films, even if not covered in the original grant, should not be termed "misusing public money," as one sees in many summaries, including those in *Science*. Is it not possible that AIBS gave the public a great deal for its money? Certainly the spasticity of the NSF in this matter gives one cause for apprehension. Does this action imply that each of us who has transferred funds might now be summarily required to return them? Can we look forward to receiving appeals from individual scientists for the same kind of financial support the AIBS

has required in the last month or so? Is it in fact true that science and scientists have been shown to be "guilty" and must clear themselves in the public eye?

If it becomes necessary that, to do investigative work, one must spend weeks each year fussing over the assignment of funds and worrying about foreseeing future needs, many may consider the excitement of the actual research not worth the trouble. One problem that worries many of us in academic medicine, for example, is that the pool of talented people interested in pursuing these lines is steadily shrinking because other exciting areas are opening up. A major factor that has helped our particular group in maintaining its competitive position has been the availability of funds for doing exploratory (basic) rather than applied research. If the chore of seeking and administering such funds becomes increasingly unpleasant and if the threat of being held personally accountable for alleged "misuse of funds" becomes routine, the attraction of this field will dim rapidly. Will this turn of events aid the opening of still more medical schools to produce the needed physicians?

In this connection, it seems pertinent to quote the Nobel laureate Otto Loewi on the conditions before World War I in the German universities [*Perspectives Biol. Med.* **4**, 3 (1960)]:

"The conditions in Germany at that time were most favorable to the development of scientists. . . . The universities were government owned, but the government hardly ever interfered with their far-reaching autonomy. As a rule, it contented itself with accepting the debts of the departments. If the debts were excessive, the department got a warning—and a little later the payment. Because of these enlightened policies, there was no need to rush work and publication."

We are deeply disturbed and wish to benefit from wide discussion of the problems facing our particular community. These problems must be considered within the larger framework of the adjustment of the United States to the problem of recruiting personnel for all of the current needs. But we doubt that the direction recently taken by the NIH and NSF is going to aid in the ultimate solution of our dilemma, or even to improve the ethics of the scientific community, if such improvement is indeed required.

ERNST A. SCHARRER
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The development of a broad program of research related to health under the auspices of the National Institutes of Health during the past two decades represents one of the highlights of scientific achievement in the United States. Moreover the administration of this program until now has been conducted with commendable attention to the dual objectives of freedom of scientific inquiry and proper accountability for the use of public funds.

Recently, administrative procedures of the National Institutes of Health have been revised and distributed to universities and research institutes.

While recognizing the continuing need for scrupulous stewardship, we are deeply concerned about the introduction of measures that are fundamentally in conflict with the fact that research, which in its very essence is a creative process, must be evaluated in terms of its productivity, not in terms of its pro-

cedural components. Research productivity is principally determined by the incisiveness and originality of the ideas on which it is based. The generation of good research ideas is an unpredictable process which is at least as dependent on the stimulation provided by the study of disease processes and by contacts with fellow scientists and students as it is related to time spent in the mechanics of experimentation in the laboratory. Therefore it is manifestly inappropriate and unrealistic to measure a scientist's effort and contribution in terms implicit in one of the new procedures, which draws an artificial distinction between these components.

Furthermore, scientific progress is impeded when competent scientists are denied sufficient latitude to alter their direction of inquiry as indicated by the course of their observations or by the unfolding of their ideas. Progress is also impeded when scientists are unable to exploit new leads promptly for lack of essential equipment. The requirement that scientists stipulate equipment needs as much as one year in advance is clearly impractical, as is the requirement that unforeseeable changes in research direction or in equipment must have the prior written approval of nonscientific personnel.

The threat to future progress of the research programs related to health in the United States is so grave that the procedures should be altered, if necessary by revision of the law, to meet the special needs of the scientific community.

WALTER J. BURDETTE
R. LEE CLARK, JR.
GEORGE B. COOPER, SIDNEY FARBER
PAUL M. GROSS, A. MCGEHEE HARVEY
HENRY S. KAPLAN, JOHN G. KIDD
MARY W. LASKER, LYNDON E. LEE, JR.
PHILLIPPE SHUBIK
FRANK M. TOWNSEND
J. WALTER WILSON

The recent "scandal" involving the use of federal funds by the American Institute of Biological Sciences has reinforced an impression that has developed through the years: first, that much grant money is indeed being used improperly as a federal aid to education, and second, that the grant recipient or principal investigator may be the victim of embezzlement of his research funds by his chief or even by the institution which employs him.

Much of this situation can be remedied by rescinding permission for research grant funds to be used as salary

or salary supplement for the principal investigator. This would take the granting agencies away from the business of providing federal aid to education. There is certainly nothing wrong with the assignment of federal monies to supplement education, but it should come from a source so designated.

Rescinding this freedom would return the grant systems to rules under which they operated 12 years ago, would remove any conflicts of interest that had developed, and, in institutions, would avoid placing in the hands of department heads the temptation to expand their departments by the use of grant-in-aid funds.

The second remedial step would be to insure that the grantee alone had the privilege of directing the expenditure of his own funds. This would prevent intradepartmental pooling of misappropriated funds, which is so often used to keep some institutes alive. The third step would be to dispense with the $100,000 grants or "megagrants," for scientists may then hire other scientists, and we are back to some type of institutional aid program. After all, $100,000, when properly invested in research, can produce more data than any single man can digest in a year. Why not break big grants down into subgrants for those professionals working on different aspects of a major problem?

Proper administration of funds of this magnitude is almost a full-time job in itself. When large research plants are heavily endowed with scientific equipment bought on grant monies, and then heavily stocked with scientists, the granting agency finds itself burdened with the obligation to keep the place endowed or watch it fold up. Add to this porridge the fact that the grant award committees are heavily staffed by the most important scientists in their respective fields, who are aware that those coming up for review this year may be passing on committee members' requests next year, we find that we have a pyramiding system which might run out of funds before it reaches its apogee.

I would be inclined also to trust the small investigator a little more. One gets the impression that monies have been given recently to institutions rather than to individuals, and institutions of themselves have never produced research.

In short, all forces in the grant system as it exists today supplement one another, and the crusty, cynical system of checks and balances that seems to be

the glue of our society, and which guards it against man's natural cupidity, is missing.

Somehow, either the government or the scientists themselves will have to provide the feedbacks or opposing forces that will make the grant systems fair, functional, and operational.

There will be much talk during this ferment about "getting the most out of our dollar," and rules will be offered that may well destroy the freedom that is the heart of productive research. This must be prevented.

Research by its very nature is inefficient and its value cannot be measured in dollars. If measurement could be made it might take a generation or so to appraise its true worth. Investing in research is an act of faith. Thus the issue is not how to get the most out of the research dollar, but how to keep the research dollar honest, and toward this end the scientific community must now address itself.

CHARLES HARRIS
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I cannot resist commenting on your editorial "More paper work, less research". This is another of a series of commentaries that seems to say that "scientists" are or should be a race apart when handling money other than their own. Present evidence is against this view and I, among many, am disappointed in your failure to appreciate that reasonable and generally accepted accounting procedures are desirable whether applied to expending taxpayers', a company's, or an individual's money.

I assume you are exaggerating for emphasis when you state that the 1 to 7 days required to fill out the "new" form would cost millions of dollars in time. A single million dollars is quite a lot of money. It would pay a scientist $24,000 per year for more than 40 years, or 3650 scientists at the same salary for the average of 4 days required to fill out the form. Yet you think it would cost not 1 million, but millions.

I will also have to take exception to your downgrading of administrators, "who will not be able to handle scientific problems with confidence. They can only run scared, go by the book. . . ." I can't believe you mean what you have written. Scientific administrators aren't really that bad and I am sure you know it.

Don't you believe that our "public image,"which seems to be of such con-

cern these days, will be improved if we follow the same rules as nonscientists who spend someone else's money?

JOHN R. WARREN
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I did not overestimate the cost of the recent changes in NIH procedure. There are about 15,000 NIH grants presently in effect, each involving from one to many scientists—amounting to a total of perhaps as many as 50,000 persons.

When scientists are highly irritated by extraneous annoyances, they stop functioning creatively. Some days usually elapse before the normal rate of progress is resumed following a bout of paper work.—P.H.A.

Reporting Oceanographic Data

In a story about pirates and treasures, it is fascinating and quaint to hear about knots and fathoms. In a journal, however, whose readership overwhelmingly does not belong to the class of old tars and salts, one might expect the use of kilometers, meters, and where necessary, centimeters.

In the 15 February issue of *Science*, I read with interest three articles on oceanographic topics. One dealt with oceanographic experience and expressed the depth of water in meters and distances in kilometers; the second on uplifted islands, described distances in kilometers, and thickness of sediments in meters; the third, however, in a discussion of ripple marks in the Florida Straits, recorded the flow of water in knots, distances in miles, depth in fathoms, and heights and lengths in feet and inches.

I am a chemist. Those who plied my trade before me used the impressive units of stones, grains, and other quaint weights. Some time ago a switch was made to the cgs system. Why do not others, writing in *Science*, make the same switch? If great hardship should be involved, knots and fathoms could still be added in parentheses.

WILLY LANGE
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The Ninth Eastern Pacific Oceanic Conference adopted a resolution urging authors and editors to use metric units and the Celsius scale in reports on oceanographic research. We shall follow this suggestion—EDS.