

# Letters

## Education and Research

"Are we retrogressing in science?" is a vital question for Hubbert to ask [*Science* **139**, 884 (8 March 1963)]. Many college and high school science textbooks, other than those used in physics, are written from the authoritarian approach. Significant attempts are being made to change this by reverting to the experimental approach, but the success and spread of this plan will depend on teachers who are not authoritarian by nature or education. Even the best teachers find it hard to work against an average student attitude of "give me some facts to learn so that I can pass the test." The joy of discovery and the search for the why of things have often—not always, I admit—been stifled.

Hubbert deplores the university atmosphere of applied research with its research-project employees rather than thoughtful scholarship. Although I know of college-trained people who are happily employed in some of these projects I have known others who were bitterly disappointed to find themselves merely status symbols for doctors with grants and no useful project. But I hardly think Hubbert would discourage research activity even at the undergraduate level. Most of us who have been assisted by the Research Corporation, the Petroleum Research Fund of the American Chemical Society, or the National Science Foundation with a few thousand dollars, rather than university grants of millions, have found these grants our only source for supporting student research which is not spectacular but which gives the students valuable experiences in learning *origins* and in applying Galileo's criteria of valid observation and experiment. The budgets of small, but good, liberal arts colleges usually cannot include expensive instruments, and many measurements today must be made on such instruments.

While I agree with Hubbert that

teaching should take precedence over research (for research's sake) and publication I shudder to think of the criteria which might be set up for teaching and I know that many teachers and professors will sabotage any such attempt. The good teachers will go right on teaching well. Teachers generally, however, while they will approve higher salaries for seniority, tenure, degrees, or records of courses taken, want themselves considered as able as any one in the system when it comes to teaching ability. We all know that the most popular teacher is not necessarily the best, that capable students obtaining good grades on comprehensive examinations do not necessarily reflect the teaching they have received, and that the teacher who coaches for examinations is not necessarily the best. So confusion we have; changes we devoutly wish for; may true science prosper!

SISTER MARIE JAMES (GIBBONS)  
*College of St. Catherine,  
St. Paul 16, Minnesota*

... Hubbert's remarks on "authoritarianism" remind me of a story regarding the late Andrew C. Lawson of Berkeley who was much in demand as an expert witness in the days of apex litigation in the mining industry. In one lawsuit he had given direct testimony which was at variance with the theories of Van Hise as expressed in his monumental monograph on metamorphism. This led the cross-examining attorney to inquire: "Dr. Lawson, do not eminent geologists agree that Dr. Van Hise is an authority on metamorphism?" Lawson replied: "No eminent geologist ever admits that any other eminent geologist is an authority on anything."

The theme of this article also brings to mind an incident in a seminar with the late Reginald A. Daly of Harvard. One of his graduate students was frequently breaking into print with unimportant articles and then proudly distributing the reprints at the seminar meetings. On one such occasion Daly

inquired: "Why, Smith, do you insist on constipating the literature of science in this manner?"

It is hoped that Hubbert's remarks may yet bring about the synthesis of a beneficial cathartic for the literature of science.

HERBERT N. WITT  
*1 Montgomery Street,  
San Francisco, California*

In response to the excellent paper by Hubbert, whose perspective I applaud, I would like to comment on science and technology.

If we define science as "knowledge amassed, severely tested, coordinated and systematized, especially regarding those wide generalizations called the laws of science," then we could say that scientists have the latter as their goal. Scientists have developed methods involving observation, hypothesis, prediction, and verification. If we define technologists as those who use the methods of scientists we arrive at our present situation.

I don't believe that science or *real* scientists have retrogressed at all, for there never has been more than a small number in that intellectually royal category. Technologists in engineering, the natural sciences, and other fields have multiplied rapidly; they have infiltrated scientific journals, and started new journals, and they are the ones producing the mass of papers referred to by Hubert. In fact the situation is very sad because most of these technologists believe themselves to be scientists and would be horrified if awakened to the truth.

Technologists perform useful services and are good citizens but they are simply not scientists. It was only a few years ago that I recognized that I am a technologist, and now in my middle years I am no longer ashamed to admit it publicly.

HAROLD E. YOUNG  
*University of Maine, Orono*

The appeals made by Hubbert should be strongly supported by all who are interested in scientific education. The transition of universities from educational to research institutions with resulting dependence on government funds is well known although apparently of little concern to many.

It is logical that professors be evaluated on their competence as teachers, not on the quality of their supposed research measured in terms of quantity

of publication. I have known a professor who was not granted tenure because of lack of publication despite the fact that he was a gifted educator. I have also listened to professors speak disdainfully of educating undergraduates and profess their primary goal of attaining scientific stature through writing. It appears that too much sophistication is overpowering the virtue of humility which apparently was held in higher esteem by bygone academic generations.

The plethora of scientific material is only beginning to plague us and the present educational system has, as noted by Hubbert, constrained most of us to select some limited domain. We are succeeding in producing a large population that is able to read but unable to distinguish worthwhile reading. The end results are confusion, stifling of creative thought, and ironically, suppression of education. From the utilitarian viewpoint, we have succeeded in concocting a truly wondrous paper mill.

KEITH WESTHUSING  
Texas Instruments Incorporated,  
P. O. Box 35084, Dallas, Texas

Anyone familiar with the government support of scientific education and research in American colleges and universities can only be astonished at the gross errors and misinterpretations of this situation contained in the article by M. King Hubbert. The errors and the misinterpretations are especially surprising in view of Hubbert's own admonition in the early part of his article that "the acceptance of any conclusion, valid or otherwise, by an individual who is not familiar with the observational data on which it is based and the logic by which it is derived is a negation of science . . ."

The source of most of Hubbert's errors is contained in his Table 1 entitled "Federal contract support of rep-

resentative endowed universities, 1958-59". The figures in every line of that table, except one, are wrong—many of them grossly wrong—and the entire table is misinterpreted within the body of the article.

The figures given in his table for the "Total income" and the "Income from contracts" of a selected group of private universities are obtained from the volume *American Universities and Colleges* (American Council on Education, Washington, D.C., ed. 8, 1960). This is an excellent volume for general information about the organization, admission requirements, curricular offerings, enrollments, and fees of the colleges and universities of America. It is not, however, a suitable source for financial data from which important conclusions are to be drawn. The figures reproduced are sketchy at best; they follow no uniform pattern and do not pretend to be a complete statement of the institution's financial situation. The financial statement is normally contained in a short paragraph of five to six lines, giving only such figures as the college itself deems pertinent to this particular volume. The least that could have been done by an author pretending to be "familiar with the observational data" and wishing to draw sweeping conclusions therefrom would be to consult the official annual financial reports of the universities concerned. Figures drawn from these reports are shown in Table 1.

The important point is to note the contrast between the figures given in the last two columns of this table. For example, Hubbert concludes that Caltech receives 88 percent of its "operating income" from government sources. The true figure is 38 percent.

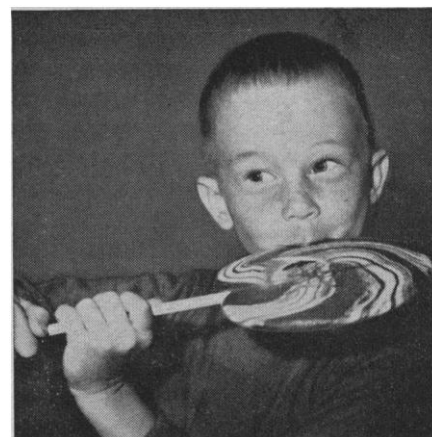
The differences between the two sets of figures for the first three institutions result from the fact that Hubbert's table includes in "Total income" and "Income from contracts" the costs of oper-

Table 1. Financial data for selected private universities, 1958-59. Figures for Rice University are omitted since its report was not in our files. Hubbert's figures are given in parentheses for comparison.

University	Total income for campus operations (\$)		U.S. Government grants and contracts			
			(\$)		(%)	
Caltech	11,564,530	(60,675,342)	4,343,605	(53,600,442)	38	(88)
M.I.T.	49,378,129	(101,386,000)	28,444,832	(67,276,000)	58	(66)
Chicago	51,073,083	(103,771,777)	10,787,065	(61,531,262)	21	(59)
Princeton	31,563,460	(31,563,000)	17,511,579	(17,723,000)	55	(56)
Harvard	67,292,489	(67,292,489)	13,053,342	(16,307,946)	19	(24)
Stanford	33,521,000	(34,663,961)	11,180,158	(8,312,208)	33	(24)
Yale	32,978,787	(36,985,998)	5,207,431*	(0)	16	(0)

\* Includes "grants" only.

10 MAY 1963



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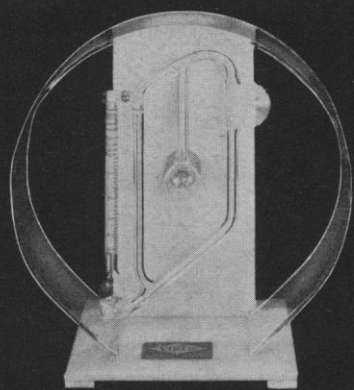
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ating large off-campus facilities (the Jet Propulsion Laboratory, the Lincoln Laboratory, and the Argonne National Laboratory, respectively) which have only a remote relation to the campus programs and do not constitute "support" for such programs. The funds received and expended for these large national laboratories are removed from the amounts I have set down.

As an example of another error, the M.I.T. entry in *American Universities and Colleges* includes under "contract research and services" a figure which encompasses both government and non-government research support. The non-government, mostly industrial, support amounts to \$3,144,000.

Finally, the astonishing entry in Hubbert's table indicating that Yale receives no government support is a conclusion he draws from the fact that the Yale entry in *AUC* simply fails to mention the university's government contract and grant figure. Yale's annual report, however, for 1958-59 shows \$5,207,431 in "gifts" (that is, grants) from federal agencies. The report does not mention "contracts," though it is known that such contracts do exist in addition. Anyone familiar with the scope and high distinction of the Yale program of research and graduate education knows perfectly well that a substantial portion of it is of high enough quality to command support from government sources—as are such programs at every major university, both public and private, in the country. A university would be doing its faculty a gross injustice if it declined to accept government funds to support their research.

Hubbert comments at some length on his incorrect figures. He says, in the first place, that "universities have entered the field of big business by becoming the operators, under government contracts, of several very large industrial-research laboratories." Many individuals join with Hubbert in their doubts as to whether the management of such national laboratories is a proper university function. Universities engaged in such operations are doing it because they have been persuaded it is in the national interest to do so. Whatever the merits of this argument, however, it is incorrect to say that the universities are in the field of "big business" or that these are "industrial-research laboratories." These are all scientific research and development laboratories doing both basic and applied research in some fields of im-

portant national interest—for example, electronic systems for national defense, nuclear energy, space research. For a variety of reasons (too lengthy to discuss here) such laboratories cannot be well operated either by commercial corporations or by the government itself. The universities have filled an important gap.

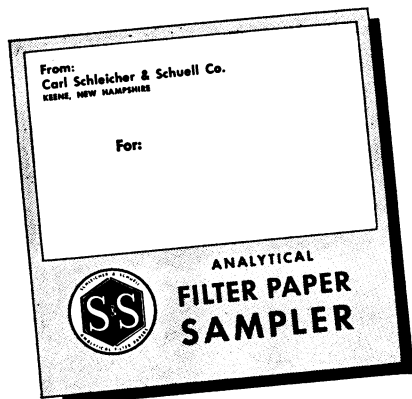
In any case, these laboratories are off-campus establishments; no faculty member is required to be involved in them and very few, often none, are so involved. They exert no necessary influence on the academic program of the institution unless members of the academic staff find it useful to employ in the teaching program some of the exceptional talents which these laboratories often attract. To state that "the effect upon the universities of this type of diversion has been devastating" is to make an assertion quite contrary to the truth, even though certain "headaches" have often been involved.

As one proceeds from the off-campus establishments to the on-campus support of research and education by the government, one finds Hubbert still drawing unjustified conclusions. The universities which he mentions can, by no stretch of the imagination, come under his description of "essentially war-research laboratories employing large staffs of nonacademic personnel" or even as "large centers of applied research." The funds provided to these institutions by such agencies as the U.S. Public Health Service, the National Science Foundation, the Office of Naval Research, and the Atomic Energy Commission, are almost entirely devoted to basic research. Caltech, for example, has not a single classified military research project in progress on the campus, and most of the other institutions have adopted essentially the same policy. On the contrary, vastly important and exciting basic research projects are being supported in fundamental nuclear physics, in seismology, geophysics, and astronomy, in genetics, biochemistry, and plant physiology, in the various areas of chemistry—programs of the "pure research" type which universities have long cherished and which thrive primarily and to best advantage in the university atmosphere. That government agencies have seen fit to support such basic research is a tribute to the wisdom and farsightedness of these agencies. It is surely obvious that the extensive and high-quality programs of

(Continued on page 716)

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## LETTERS

(Continued from page 574)

university research could not possibly be carried on these days with private funds alone.

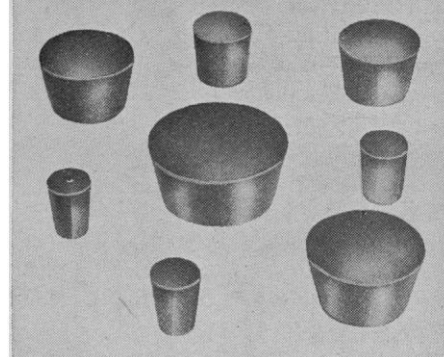
That this government support of research on university campuses has raised some problems goes without saying. There are difficulties in fiscal and contractual management. There are difficulties arising from the fact that some scientific fields are adequately supported while others are not. Some institutions have, no doubt, overreached themselves and have taken on larger projects than the quality of their staffs warranted.

However, these difficulties and headaches should not lead one to assume that the entire picture is as black as Hubbert claims. A vast amount of fine research is being properly carried on and adequately supported under suitable conditions. A very large number of graduate students and postdoctoral fellows have been enabled to carry on their studies under these research grants and contracts, and many more have been enabled to pursue their studies by virtue of government fellowships of various types. Most universities have greatly improved both their undergraduate and graduate instructional programs in pure and applied science by virtue of these government funds.

Hubbert also regrets that universities have become "dependent" on federal support. It is obvious that if the Congress of the United States suddenly refused to appropriate any money for university scientific research, many universities would face catastrophic disruptions of their programs. Many universities faced such disruption during the great depression of the 1930's when private funds were so drastically reduced and when state appropriations to public institutions were heavily curtailed. There is risk and a danger of "dependency" in any form of financial support of university education and research. Actually, the government programs have, since the war, shown a remarkable stability and a healthy growth rate. The benefits to the nation and to science have been so spectacular that it seems unlikely that any Congress would suddenly drastically reduce the research budgets of all government agencies. And government agencies have not sought to direct either the academic or research programs of the institutions whose self-initiated proposals they help to support.

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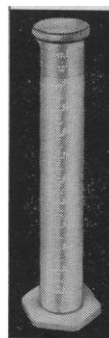


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I need not comment on Hubbert's gratuitous remark that there has been "a reversion to pure authoritarianism . . ." There is no evidence for this assertion, and Hubbert himself warns us of the dangers "whereby statements, if made by proper 'authorities,' are to be accepted as valid, independently of any supporting evidence."

Scientists, educators, and government officials do face problems in properly carrying on the great programs of education and research in the sciences in our colleges and universities. Much open and frank discussion and debate on the essential issues is necessary. Such debate, however, is not assisted by the misinterpretation of incorrect data from improper sources.

LEE A. DuBRIDGE

*California Institute of Technology,  
Pasadena, California*

In my presidential address before the Geological Society of America, "Are we retrogressing in science?", a condensed version of which was published in *Science*, I expressed concern over the direction in which science in the United States has been evolving during the last few decades. As evidence of retrogression, a few examples were cited on pages 884-886 from recent major treatises and textbooks of physics which indicate either an indefensible carelessness on the part of authors, referees, and editors with regard to some of the fundamental principles of physics, or else the emergence of a generation of physicists who are inadequately acquainted with those principles. In either case misinformation of the kinds cited is being extended to another generation of physicists who are now, or recently have been, students in American universities.

In seeking for a reason for this abandonment of intellectual standards, I directed attention to a number of probable contributory factors. One of these, with which I have been associated (on the giving end) for some 20 years, is the contract-grant system of supporting scientific research in universities. I have seen this system grow, since about 1935, from small grants of a few hundred dollars from private funds, each made to individuals, to grants in the range of tens-to-hundreds of thousands of dollars from government funds, still made to individuals.

Over the years, I have served on several committees or advisory groups concerned with the distribution of such funds, principally to academic person-

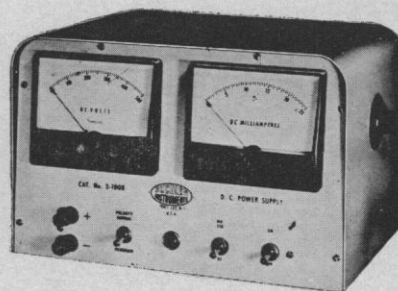
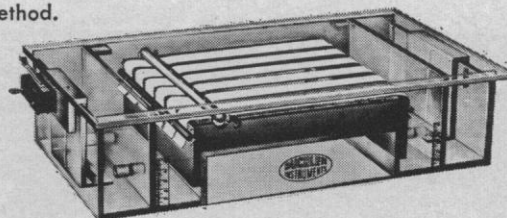
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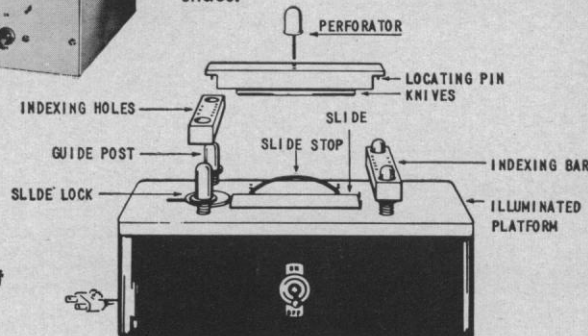
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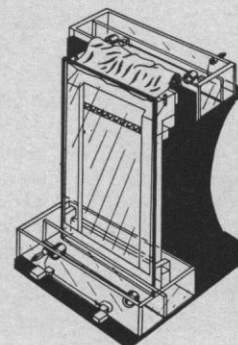


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nel: the Projects Committee of the Geological Society of America, the Advisory Committee for the Earth Sciences to the Office of Naval Research, and the Advisory Panel for the Earth Sciences of the National Science Foundation. In addition, I have had a continuing load of related projects which have been sent to me for refereeing.

On the academic side, I have served as a member of the Visiting Committee of the Department of Geology and Geophysics of Massachusetts Institute

of Technology, the Visiting Committee of the Department of Physics, University of Houston, and the Advisory Council of the Institute of Geophysics and Planetary Physics of the University of California.

It was largely on these firsthand personal observations that my analysis of the objectionable effect of the contract-grant system was based. From such information it was clear that most of our universities, especially the privately endowed ones, are becoming increas-

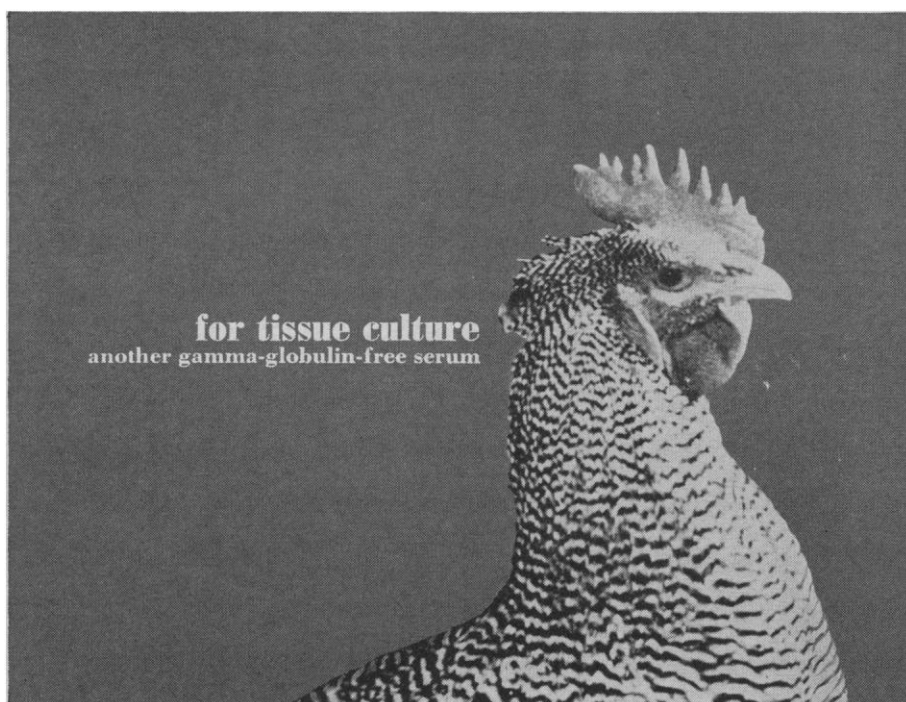
ingly dependent upon this contract-grant system for their essential financial support. In order to obtain approximate information on the extent of this support I referred to a standard secondary reference, *American Colleges and Universities* (8th edition, 1960), from which I obtained the data I gave in Table 1. A recheck of this source confirms that all the items in my Table 1 are correctly quoted except those for Rice and Yale. The Rice figure for "Income from Contracts" was quoted as \$633,500; it should have been \$633,300.

The Yale figure is more interesting. No information on "Income from Contracts" was given, and this was erroneously interpreted as being zero. Several previous correspondents have pointed out this error, and it has already been corrected in the full version of the address which is shortly to appear in the *Geological Society of America Bulletin*.

In an effort to obtain a valid figure for Yale the "Report of the Treasurer of Yale University for the Fiscal Year 1958-1959" (Series 55, Aug. 1959, No. 15) was studied in detail. The figure on "Income" for 1958-59 agreed exactly with that cited in Table 1. The sources of income were also listed, but the United States Government was not included. Finally, on the back pages of the report the donors of gifts were listed. Of these "gifts" five, totaling \$2,075,745, were from the National Science Foundation; five others, totaling \$3,075,788, were from the U.S. Public Health Service; and one, of \$2900, was from the U.S. Forest Service. Unofficial information from government sources indicates that Yale also receives grants from other government agencies.

DuBridge has seized upon this error of interpretation and has magnified it out of all proportion to its importance. He has also implied that all the data in my Table 1 are misleading and has substituted a table of his own, whereby, by excluding the large-scale operations such as the Jet Propulsion Laboratory, the Lawrence Radiation Laboratory, the Argonne National Laboratory, and other such essentially industrial laboratories which I had criticized as having no legitimate place in universities, he has drastically scaled down the amount of apparent federal support.

I have not had an opportunity to examine the financial reports of all the universities cited in Table 1, but I have seen that for California Institute of



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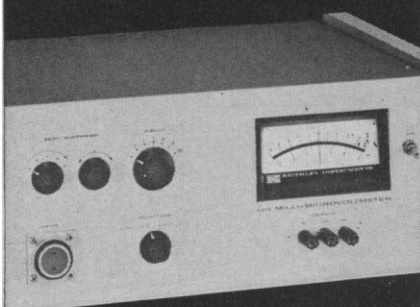
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Technology (1). On page 58 of this report, the following data are given for the year ending 30 June 1959:

Total Income	\$60,675,342
Income from research under agreements with the U.S. Government	50,731,179

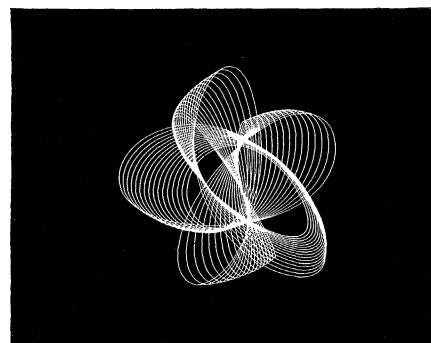
The first of these figures agrees exactly with that of my Table 1. The second is lower by \$2,869,263, which represents income from "wind tunnel tests and other special research." Apparently the latter amount was erroneously ascribed to the U.S. Government by the editors of *American Colleges and Universities*.

The correct figure in my Table 1 for the percentage of total income represented by federal funds for California Institute of Technology should, therefore, be 83.6 percent instead of my original figure of 88 percent, or DuBridge's figure of 38 percent.

However, all of this is largely irrelevant with respect to the main problem which I was discussing. Regrettably, in the *Science* condensation, my own position with respect to the government-support problem was not made sufficiently clear. In the full version it was pointed out that public support of education at all levels in a modern industrial society is a social necessity, and that in the United States this is coming increasingly to mean support by the federal government. That this is not an onerous burden to the government or to our society is indicated by the fact that the entire cost of operating all the colleges and universities in the country amounts to but about \$3.5 billion per year, as compared with President Kennedy's recent statement that the space program budget for this year would be \$5.4 billion.

My real point was not to criticize the government for supporting the universities, or the universities for accepting such support, but rather to criticize the chaotic way in which such support is now being administered, and to point out its bad effects upon the universities. It is my opinion that, when the funds to be dealt with are small, the making of modest individual grants upon recommendation by the people who are acquainted with the subject concerned, and preferably with the applicant also, is the best procedure. When the sums to be dealt with reach the magnitudes of tens-to-hundreds of millions of dollars per year, as is now the case for the National Science Foundation, the Public Health Service, the Atomic Energy

## Nuclear-Chicago liquid scintillation chemicals



### POPOP

P-BIS[2-(5-phenyloxazolyl)]-benzene  
5 grams 25 grams 100 grams

### PPO

2,5-diphenyloxazole  
25 grams 100 grams 500 grams

### Liquifluor\*

25X concentrate liquid scintillator  
(500 ml. toluene solution containing  
50 g. PPO + 0.625 g. PPOP)

\*TM Pilot Chemicals, Inc.

### PBD

phenylbiphenyloxadiazole-1, 3, 6  
2 grams

### Starter Set

POPOP, 5 grams  
PPO, 100 grams  
Liquifluor, 500 ml.

### Scintillation Standards

SK-4 Set consists of two unquenched samples—carbon-14 and tritium—and a blank. Prepared in our own standards laboratory.

Write for details and prices of these and other scintillation products. Ask for new bulletin, "Scintillation Chemicals." Also available on request are Technical Bulletin No. 11, "How to Prepare Samples for Liquid Scintillation Counting," and Technical Bulletin No. 13, "How to Determine Efficiency Automatically in Liquid Scintillation Counting."

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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.

M. KING HUBBERT

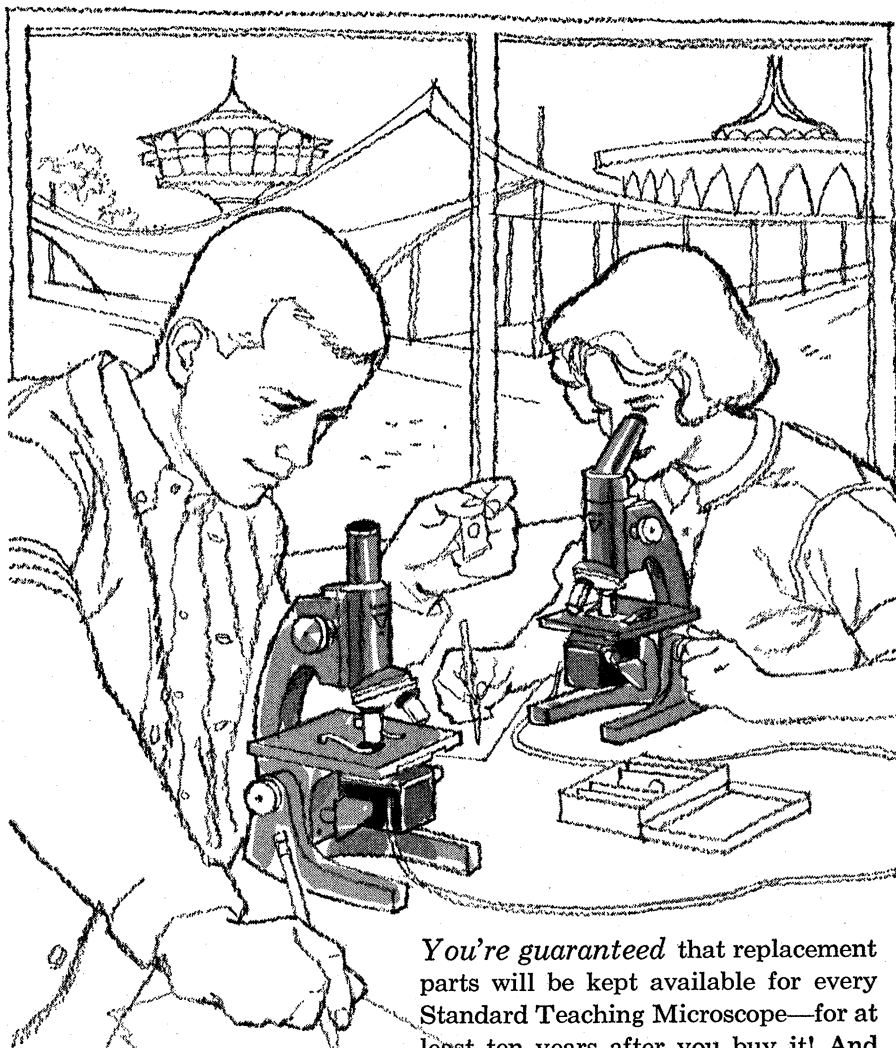
Box 481, Houston 1, Texas

#### 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



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