their student supporters and faculty sympathizers consider launching their own "teach-ins," if not their own "sit-ins"? More important still, may not these potentially powerful leaders of our political establishment, when they come to power, take active steps toward changing the political complexion of the academic establishment? If they did not, it would be one of the most remarkable cases of political abstinence in history.

When that day comes, with what moral conviction or sense of justice will professors be able to resist the incursions of the public into their preempted domain over such educational questions as curricula and courses, student admissions, faculty appointments, extramural speakers, and "neutral" uses of university facilities. Now is the time for scholars and scientists to ponder whether they want to see a further politicizing of the American university at the expense of its continued growth in the realm of the intellect.

References and Notes

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2. K. E. Gales, "Berkeley Student Opinion, April, 1965," news release, Office of Public Information, Univ. of California, Berkeley, 27 July 1965; A. M. Heiss, "Berkeley Doctoral Students Appraise their Academic Programs" (Center for the Study of Higher Education, Univ. of California, Berkeley, 1964). For the British reaction to American higher education, see *United Kingdom, Committee on Higher Education, Report 1961–1963* (the Robbins report) and *Higher Education in Other Countries* (United Kingdom, Committee on Higher Education, London, 1963), appendix 5; see also Lord Robbins' convocation address delivered at Berkeley in the spring of 1965. Non-teaching demands upon the time and energy of American faculties were analyzed early by Logan Wilson in *The Academic Mind: A Study in the Sociology of a Profession* (Oxford Univ. Press, New York, 1942), Table 1.
3. T. I. Emerson and D. Haber, *Law and Contemp. Probl.* **28**, 548 (summer 1963).
4. *AAUP Bull.* **51**, 318 (June 1965).
5. For discussion of the full experience of the AAUP with respect to academic freedom and related problems, see "Report of the Self-Survey Committee of the AAUP," *ibid.*, May 1965.
6. The much-publicized faculty resolution of the University of California's Academic Senate, which was similiar to the later AAUP resolution, was adopted 8 December 1964 by a vote of 824 to 115. A resolution drafted along the lines of the analysis presented in this article had been previously defeated by a vote of 737 to 284.
7. Emerson and Haber seem to be among the few authorities who have carefully weighed this distinction between the act of communicating and overt action (see *3*).
8. T. I. Emerson and D. Haber, *Political and Civil Rights in the United States* (Dennis, Buffalo, 1958), vol. 1, pp. 334–338, 480–503; vol. 2, chaps. 4 and 5. See also R. F. Fuchs, *Law and Contemp. Probl.* **28**, 444 (summer 1963).
9. P. Monypenny, *Law and Contemp. Probl.* **28**, 629 (summer 1963); T. I. Emerson and D. Haber, *ibid.*, pp. 550, 556. Compare Association of American Universities, "The Rights and Responsibilities of Universities and their Faculties," as reprinted in T. I. Emerson and D. Haber, *Political and Civil Rights in the United States* (Dennis, Buffalo, 1958), vol. 2, pp. 1070–1077, with "Academic freedom for national security," *AAUP Bull.* **42**, 49 (spring 1965).
10. In contrast to the circumstances at Berkeley, this was the issue at Columbia in the disturbance there of 7 May 1965. The students later "regretted" their "disruption" and the "infringement" upon the rights of their colleagues and were subsequently disciplined by the University administration, apparently with faculty acquiescence. [Letter from deans Ralph S. Halford, Wesley J. Hennessy, and David B. Truman to the university president, 17 May 1965, and enclosures; "Memorandum from the President to the University Community," 20 May 1965].
11. S. M. Lipset, *Political Man* (Doubleday, New York, 1960), pp. 21, 315–316; A. W. Kornhauser, "Attitudes of economic groups," *Public Opinion Quart.* **2**, 264 (Apr. 1938); P. F. Lazarsfeld and W. Thielens, Jr., *The Academic Mind* (Free Press, Glencoe, Ill., 1958), p. 14; H. A. Turner, C. G. McClintock, C. B. Spaulding, "The political party affiliation of American political scientists," *Western Political Quart.* **16**, 652 (Sept. 1963); A. Gottfried, "Political attitudes and behavior of university faculty," (summary of proceedings of the Western Political Science Association), *ibid.* **14**, 45 (Sept. 1961); R. Yee, "Faculty participation in the 1960 Presidential election," *ibid.* **16**, 219 (Mar. 1963).

Pure Research, Cultism, and the Undergraduate

The student, less informed but also less prejudiced than his professor, is the effective critic of a discipline.

Richard Wolfgang

The wellspring of science is traditionally, and with reason, considered to be pure research. This in turn is defined by its motivation, as that branch of science which ideally seeks only intellectual goals and satisfactions. If material objectives, such as profit, military advantage, or the social or physical welfare of man, are achieved, they are considered to be incidental. But, in renouncing the more tangible goals, pure science also renounces the relatively clear-cut economic and social principles which serve to guide the direction of more applied research.

Since there are no readily defined material objectives, the guidelines of pure research are more subtle and harder to find. By common consent, its objective is an increased knowledge of nature and an ordering and simplification of that knowledge. In particular, our anthropomorphic outlook makes especially attractive any study which gives a clearer idea of man's place in the universe. This prescription is general but also rather vague. To determine whether a given study is important or trivial by this criterion is an esthetic rather than a quantitative decision. And in science as in everything else, esthetics and taste may easily be confused with fashion.

Sometimes it seems easy to judge the importance of an area of pure research. It is obvious that particle physics is important simply because it concerns itself with an elementary and therefore important aspect of nature. It is almost as obvious that indiscriminate accumulation of data on some system into which many complex factors enter is unlikely to produce much enlightenment. In general, however, it is difficult to make a definitive judgment on the absolute and relative merit of a field. The fact that a given problem may demand a very

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high level of insight and intelligence and that its solution may be intellectually satisfying says little about its importance. A problem in pure science may be akin to a crossword puzzle not only in its purity, but also in the pleasure to be found in its solving, and in the sterile nature of the final result.

How then does a pure scientist choose a research problem? He does not, except in rare cases, review all of science to then choose, in broad perspective, the problem that he can handle which will give the greatest new insight in nature. His guidelines are more personal. Educational background and desire to win recognition are factors which are frequently dominant. With better people there is superimposed on this a clear sense of what is required to advance their field. Relatively few have the wide grasp and courage to choose not only a new problem but a new and more significant field.

Most scientists feel as their most immediate influence their colleagues and peers in the field. It is they who set the standards and criteria and who judge the quality of a scientist's work. It is they who organize colloquia, invite the invited speakers, write the letters of recommendation, and confer the medals. It is with his colleagues that a scientist must make his reputation in the first place—the rest of the world will take their word on how good he is.

This is a good system, and yet in itself it can be pernicious. It succeeds remarkably well in setting standards within a field at the highest level possible and in recognizing only that work which has validity. It fails totally when it comes to assessing the importance of the field itself. It accurately appraises the relative significance of research within a field but is incapable of judging its meaning in a wider context.

Within a field, criticism is usually vigorous and effective, but it is almost impossible to find an appraisal of the field itself. It is indeed a rare scientist who is inclined to say that his area is dead or dying. Even if he has the perspective to see beyond its internal criteria and recognize weakness, he will have the good sense to avoid any such tendency towards uncalled-for honesty. He knows that many of his colleagues are sincerely convinced of the importance of the field and that most of the rest are bound more by vested interest in the only area in which they feel secure than by intellectual honesty. Nearly all would join in unspoken agreement to silently consign such traitors to the limbo reserved for cranks. It is much more comfortable for a group of experts and academicians to regard The Field as an entity almost beyond question, to be religiously followed wherever it may lead. Thus one can find areas of knowledge in which the important problems may be largely solved, where the setting of new goals seems to be based on fashion rather than on the search for the broad underlying truths. In extreme cases a cult can develop, with its own internal standards and the sublime self-assurance that can come only from ignoring the rest of the world (*1*).

If a field is to be judged in cold impartial perspective, this must be done by outsiders. But in pure science there are few outsiders who have the temerity or foolhardiness to call somebody else's field trivial, unless there happens to be a direct conflict for funds or resources. To do so would be impertinent and in any case ineffective. But there is one group that does ask, and often rather loudly, why a field is supposed to be important. This is the student elite. They have the idealism of youth, the temerity then can always be excused as coming from ignorance, and the reassurance that nobody takes them seriously anyway.

In this last respect, I believe they are wrong. Every scientist directing graduate students knows that the better ones bring in fresh ideas and attitudes which, allowing for the fact that they are usually wrong, he does well to consider. But to some extent a graduate student has already been captured by the field and its standards. He may be quite content with solving a crossword-puzzle-type problem, the actual solution of which may not have much significance, because he knows that working it can teach the attitudes and techniques required to be a working scientist.

The most effective way in which a graduate student can question the importance of a field is by not entering it; and the decision to do that he generally makes while still an undergraduate. While the graduate is mostly involved with learning research methods and acquiring specialized know-how, the undergraduate with his lesser sophistication is more involved with broad content. And for this reason it is the intelligent undergraduate with still-broad interests and unencumbered perspective who can have a pronounced and beneficial effect on the direction of science.

That he does have such an effect is apparent to those research scientists who teach undergraduates at a good university and who take the trouble to do it well. A good undergraduate is not content with memorization and fluency in mathematical manipulations. He struggles to understand concepts and assimilate them into his intuition. He is impatient with the textbook author or instructor who displays his incomplete understanding by failing to make a subject cohere internally and with related disciplines. In trying to comprehend at a fundamental level, he may force his teacher to do so also—sometimes for the first time. An outstanding student is probably at least as bright as his instructor, less informed but also less prejudiced. He asks what the significance of a certain topic may be, needing to see it in its proper perspective, so that it explains to him a significant aspect of the working of nature. A good professor always tries to answer such a question. Usually he succeeds, but sometimes he fails—and is perhaps left wondering if the subject really does matter that much. The net effect is that in the elite student's unencumbered search for truth, he sometimes takes his professor with him.

The influence of the good elementary student on pure science is, of course, not direct. He rarely knows of the research his professor is engaged in and would be unable to appraise it in depth. If asked what problems ought to be investigated, his suggestions would generally be so broad as to be hopelessly vague or impractical. But his indirect influence on his teachers, their research, and on pure science in general, though difficult to measure, is probably quite effective because it is such a pervasive and constant pressure. The student forces the professor to look away from his specialty and to see the broader science in perspective. He returns him to fundamentals and thus to what is important. The professor, as researcher, is kept thinking about his own work in these terms. Is it important enough ever to find a place in a good elementary textbook?

The net effect of this student pressure is to help keep science from turning inward towards sterile cult and fashion. Wilhelm von Humboldt said in 1810, "The progress of knowledge is faster and more lively at a University, where it is constantly being mulled over and examined by numbers of vigorous and youthful heads" (*2*). This is probably still the vital factor in the university's continuing dominance in our study of nature, despite increased competition by institutions where the researcher is not bothered by students. It is frequently and truly said that the best instructor for the elementary student is the active scientist and scholar who brings with him the enthusiasm and insight that comes from working at the frontier. We should admit that this relationship is symbiotic. Perhaps the lively and intelligent student even plays the more important part in helping to provide perspective and direction in our study of nature.

References and Notes

1. Such cultism can be even stronger in the humanities than in the sciences. One frequently witnesses the spectacle of whole schools of scholars swooping down to exhaustively examine every scrap ever written by some minor poet whose innate intelligence was probably far below that of his modern critics. Such slavery to fashion is perhaps more pronounced in the humanities, because there absolute standards which set a direction for scholarship are much harder still to define than in pure science. Correspondingly, nuances of taste become more important.
2. W. von Humboldt, "Uber die innere und ausser Organisation der hohere wissenschaftlichen Anstalten in Berlin," in *Gesammelte Werke* (Preussische Akademie der Wissenschaften, Berlin, 1903–1918), vol. 10, p. 250. Although the present article deals with pure science in the modern context, the most general concept which underlies it was already clearly recognized by Humboldt: "It is not possible to lecture on science [*Wissenschaft*] as science without at the same time comprehending it anew, and it would be incredible if sometimes, perhaps often, one did not come across new discoveries." Again: "The professor does not exist solely for the student, both exist for the sake of knowledge. The professor depends on the presence of students and without them he could not proceed. He would have to find them, thereby to attain his goals through the connection between his practiced but therefore more one-sided and already less lively mind, and the weaker but less partisan and wider-ranging powers of the student."
3. This article grew largely out of extended discussions with Miss Nancy Doe and Prof. William von E. Doering, and Dr. Helmut Krauch. It was written while the author was a guest of the Institut für Systemforschung, Heidelberg.

NEWS AND COMMENT

Reuss Committee: New Probe Planned into Priorities for R&D

When Congress reconvenes next month, the subcommittee headed by Representative Henry S. Reuss will embark on its second study of matters related to federal support of research and development. In the Capital's science establishment, the announcement of this forthcoming event has stirred a good deal of interest and perplexity over what the congressman is up to and how his subcommittee fits into the patchwork of research jurisdictions on Capitol Hill.

Reuss, a Milwaukee-area Democrat, chairs the Research and Technical Programs Subcommittee, which was established last year by the Government Operations Committee. In October, upon completion of its first study (*Science*, 22 October), the subcommittee concluded that the federal government's $16-billion outlay for research and development "has actually harmed higher education in this country." The judgment generally pleased persons outside the mainstream of the $16 billion, and infuriated or at least displeased many of those who dispense and receive the money. (See letters scheduled for publication in 31 December issue of *Science*.)

Government administrators and staff people appeared to have been particularly aggrieved by Reuss's findings and use of statistics, but they showed no desire to get into a public row with the congressman. As one administration aide put it, Reuss has a solidly liberal, pro-education, pro-science voting record, and furthermore, whatever his findings, his recommendations jibed with the administration's own goals in this area: greater geographical distribution of research funds, more institutional grants, and increased support for the humanities and social sciences.

A few weeks ago Reuss announced that his subcommittee will next look into the question, "Do we now possess efficient machinery for determining that our scientific resources are economically employed to achieve our vital national goals?"

The question, in one form or another, has for some time been bothering a lot of people, but on the basis of the subcommittee's first performance, and the text accompanying the announcement of the new hearings, there is abundant curiosity not so much about the question as about the subcommittee.

In the announcement, for example, Reuss notes that almost 90 percent of the $16 billion in federal R & D expenditures is for military, space, and atomic energy programs, and he questions whether civilian needs are being shortchanged in this order of priorities. "If anyone in the Administration or Congress is now asking these hard questions, it has escaped notice," he states—a view that no doubt was greeted with words of one syllable at the Bureau of the Budget, the Office of Science and Technology, and the Federal Council on Science and Technology, and in the various congressional committees that have worked on the subject in recent years.

Reuss, in his statement, goes on to recommend the following: "Army Field Manual 101-5, which outlines for the field officer an approach for determining the most suitable course of action to accomplish his mission, provides an example in decision making which should be useful to those responsible for allocating federal research and development funds: he is told to consider alternative courses of action before coming to a decision." (Those inclined to accept this recommendation might also look at paragraph 6.19, of the manual, dealing with "The Tactical Cover and Deception Estimate," which "is used to determine the deceptive measures which will contribute most effectively to the successful accomplishment of the mission.")

In view of all this, a reasonable question is, What's going on here? To get the answer, it is necessary to go back to the demise last year of Representative Carl Elliott's Select Committee on Government Research (*Science,* 8 January). Upon expiring, it left behind a series of recommendations for improving congressional handling of scientific and technical matters, all of