Letters

Purism in Science

Alvin M. Weinberg's article ("But is the teacher also a citizen?," 6 Aug., p. 601) contains many ideas which I share fully. There can be little question that in the comparatively brief span of their existence national laboratories have made great contributions to our society by applying not only the results but also the methods of scientific inquiry to a broad range of problems. Indeed, I am convinced that the scope of national-laboratory activities, which have by and large been restricted to matters related to nuclear energy, should be extended to other broad interdisciplinary, "mission-oriented" efforts. Two obvious candidates would be oceanography and space exploration. . . . It is also true that the universities have run into difficulties and deserve to be criticized. However, it would seem to me that at least some of the criticism should take a different form from that employed by Weinberg.

Like money, academic degrees have become inflated over the years, but the inflation has been variable, not only between institutions but also between faculties. While it is a long time since a physician was a bachelor of medicine rather than a doctor of medicine, most engineers and lawyers hold no more than a bachelor's degree even today. The institutions or the divisions of a university which grant these degrees are still called "schools" or "colleges." It is important to realize that the situation used to be hardly different in the case of the sciences. Our educational system derives directly from that of Britain, where to this day some of the most illustrious scientists hold only bachelor or master's degrees.

There are some indications that reversal of the inflationary trend may occur because of the "new curricula" in primary and secondary schools. Behind attractive trappings these "new" approaches are in fact nothing more than a return to the older orientation towards intensive teaching which was weakened by "progressive education." The acceleration may perhaps prove sufficient to permit didactic education to terminate again with a bachelor's or master's degree. But whether their title is doctor or mister the investigators required for the most advanced or complex "mission-oriented" activities of the national laboratory, industry, or foundation must certainly be well-rounded, knowledgeable, and competent practitioners of a specialty. Institutions of higher learning must provide an increasing flow of such professionals, and Weinberg is quite correct in insisting that this obligation must not be frustrated by a refusal of instructors to climb down from ivory towers.

Whatever terminology may be used now or in the future, it is essential that one separate these functions of advanced professional education from those of philosophical inquiry. There must be a portion of a university, be it called graduate school, postgraduate school, or institute for advanced study, which is truly a faculty of philosophy. Like geographic exploration, the search performed here may have immense implications for human destiny but must be pursued for its own sake, and its scope *must* be "narrow." . . . Many if not all of the most important scientific discoveries were made as a result of protracted preoccupation with very isolated facts. . . . The doctoral thesis should be just this kind of endeavor, deliberately restricted to a very circumscribed subject. The U.S.A. is the only country in the world where most of the support of this kind of activity has been provided by private sources. It is evident that despite or perhaps because of breakneck expansions our universities have been forced to steadily curtail their support of basic research, since they are barely able to meet the expenses of professional instruction. One wonders whether, in addition to an obviously decreasing ratio of "discipline-minded" to "mission-minded" investigators, the absolute number of the former is decreasing.

Our "mission oriented" research is based on fundamental discoveries which are mostly at least a quarter of a century old and frequently over half a century old. If we want to continue to draw interest we must add to our investment. As far as I can see, only the federal government can provide the funds. . . .

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. . . I would like to make several comments drawn from my own experience, which has several points of contact with the subjects of Weinberg's article: I am a (pure) mathematician currently working on applications to high-energy physics of a subject (Lie group theory) that was a very short time ago in a very "pure" stage. Further, I am jointly employed by a national laboratory (Argonne) and a university (Northwestern) and have worked in a mission-oriented quasi-governmental laboratory (Lincoln).

First, many mathematicians who are not very vocal agree that there is a danger of overreacting against the traditional dreariness of mathematics in American schools and colleges and substituting an echo of the fads in graduate schools of 15 years ago. However, many of those who are most vocal against the changes had at least their secondary education in European schools and do not realize how bad things used to be here. . . . Those who criticize the changes (and that includes myself to a certain extent) have done very little in a practical way to provide alternatives for the individual teachers who must make the decisions. For example, as we found at Northwestern recently when we tried to start an applied mathematics program with very little tradition in the subject, the relatively few centers in applied mathematics (which have been supported quite handsomely by the government) have not done enough to train people who can teach it effectively, nor have they provided model curricula which we could use as a foundation.

I think it is all to the good for a physics professor to write an elementary calculus book, as in the instance Weinberg cites. I am sure it is much better than anything we can do, since many parts of traditional mathematics (such as extensive practice and technique in integration)

have no scientific vitality in mathematics today but still have some in physics, and it is much more effective for students to learn them where they are used. What one might ask for is greater coordination between mathematicians teaching "service" courses and other scientists. Here it must be admitted that some mathematicians have rather arrogantly decided that mathematics has no further need for its traditional ties to science; but there are enough remaining with contrary views to carry on the work. However, I suspect it will be necessary that interested nonmathematicians have a much greater sophistication about the present mathematical world.

I have less professional competence to comment on Weinberg's views on high-energy physics, but by emphasizing that the impetus for new expenditures in high-energy physics comes from the universities he has provided a rebuttal to his own argument. American universities are by far the most vital part of American cultural and intellectual life. This may be undesirable in certain fields; it seems to be so in literature. One would wish that the quality of nonuniversity life were much higher. However, especially if one looks at the political alternatives in American intellectual life outside the universities, one may suspect that if a large portion of the relevant university community believes that a program is worthwhile, money is better spent on it than on most of the alternatives. . . .

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Weinberg's paper will help dissipate the smoke screen that obscures the two-way movement of ideas between research, teaching, and social change. . . . But he does not describe the implementing procedures with the degree of specificity necessary to help us move beyond head-nodding agreement with his theme, the dissonance of "the mission-discipline duality." Mathematics contributes to physics, physics to engineering, and engineering to society because someone is active at the interface and doing something to facilitate the transition. Weinberg notes that too few university professors are making this effort, and I believe he is correct and for the reason that he gives ("In the university the specialist and analyst is king").

The literature is peppered with exhortations about these and similar problems, but as teachers we are too often left without guides to the appropriate next steps. . . . With his concept of the scientist as a teacher, Weinberg has his finger on the key, but he is trying to unlock only two academic barriers—curricular purity and disesteem of applied science. I believe a better place to look for the desired change will be in the area of educational technology and especially the development of computer-assisted instructional systems. In making this suggestion I am simply trying to direct the momentum of Weinberg's logic into educational action to illustrate an instructional setting where it might be difficult for the scientist-teacher to bypass his "codifying" and "integrating" functions.

Instructional automation has the potential, at least, of bringing the teaching and researching roles of the university professor closer together. As long as the teacher feels that his primary obligation is to present information to students, he is free to follow this path of least resistance. . . . On the other hand, if the basic information and the descriptive materials were programmed into the computer as a master teaching machine and made available to the student in his automated study carrel, the classroom teacher would be freed to demonstrate the integration of one body of knowledge with another and to discuss the social implications of scientific data, research programs, and areas of investigation (including high-energy physics)—value judgments that the computer cannot handle. . . . Sooner or later the scientist-teacher must accept the explicit requirement to contrast his own presentation with the kind that can be made equally well, or better, via the computer. . . .

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Since the appearance of my article I have received several letters from scientists and teachers engaged in curriculum reform objecting to what they interpret as a blanket indictment on my part of all curriculum reform. I am disturbed by this interpretation of my views, since I qualified my indictment thus: ". . . insofar as the new curricula have been captured by university scientists and mathematicians

of narrowly puristic outlook . . . I consider them to be dangerous."

I am not familiar with all the new curricula. There are many that do not seem to suffer from these shortcomings, and several, notably the BSCS biology courses, have since been brought to my attention. Nevertheless, I do believe that the considerations I mentioned in my article must be taken seriously by those who have erred in the past and by those who, unless exhorted by conservatives like me, may err in the future. Educating children is a heavy and difficult responsibility —one which those who create new curricula often are unable to assess until it is too late. All of us, scientists and teachers alike, must do our best to help strike a proper balance. I hope that the debate provoked by my article will serve to clarify some of the philosophic issues underlying curriculum reform and thus contribute to maintaining the necessary balance.

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Dael Wolfle's editorial "Save the world" (20 Aug., p. 819) calls for an immediate systems analysis of the problems of preserving the quality of life on Earth. He acknowledges the cause of the problems—the population explosion—and notes that governments and the Catholic Church have recognized its seriousness. He says that it must be assumed that we will succeed in stemming population growth.

The assumption is reasonable; but the question is, By what means and at what level will the world population be stabilized? The techniques used for lowering the birth rate are a product of scientific research, and it is not unreasonable to believe that more research will result in more and better techniques. Despite the recommendations of the National Academy of Sciences that research in the control of reproduction be greatly increased, there is, I believe, a remarkable inertia. We have governmental and private research institutes for the study of a great number of exotic diseases, yet to my knowledge we have not a single large, multidisciplinary institute concerned with research in reproductive biochemistry and physiology and the development of mechanical and pharmacological means of preventing ovulation, fertilization, implantation, or zygote growth. It is ironic that recent interest in the development of anovulatory drugs had to await the realization that the contraceptive market was immensely rewarding financially.

I see no reason why the urgency of the situation should not be recognized by the scientific community and appropriate action taken. The Second World War saw an unparalleled pooling of scientific brain power which resulted in an extraordinary scientific achievement—the atomic bomb. I believe that a comparable scientific effort could yield a spectrum of pharmacological agents enabling human reproduction to be prevented or induced as desired. Were this to occur, the quality of life, both in the family unit and on a global basis, would be enriched. We would witness the exciting phenomenon of continuing technological progress being applied to a stable population.

The National Institutes of Health, the National Science Foundation, or other appropriate agencies should offer financial support, and if necessary propose legislation to Congress to this end. . . .

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Fuel for Indian Reactors

McElheny's report from India ("Electric power remains emphasis of India's nuclear energy program," 16 July, p. 284) is thorough and detailed, but there is one omission that might give a false impression. McElheny mentions that the uranium for the reactors at Rana Pratap Sagar and Kalpakkam, "as for the Canada-India reactor, will come from the monazite sands of Kerala and a mine being developed in Bihar." In fact, the original fuel charge for the Canada-India reactor, consisting of 12,000 kilograms of uranium metal, was supplied by Canada and is still in place in the reactor. In addition, Canada is supplying half the fuel elements (uranium dioxide) for the first charge of the 200-megawatt CANDU reactor being built at Rana Pratap Sagar.

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