Ph.D.'s as Engineering Teachers

As a Ph.D. candidate and a future engineering teacher, I feel a responsibility to answer Marion Richardson's letter ("Who should teach engineering?," 28 Feb., p. 916). [Richardson argued against increasing the proportion of "science-oriented" Ph.D.'s on undergraduate engineering faculties.]

Engineering problems are becoming more complex and the need for the answers to these problems is becoming more urgent. The traditional engineering design courses can no longer be relied upon to prepare a student for an engineering career. On the contrary, such training, emphasizing specific methods alone, may often hinder him. For instance, if he decides to work for a design firm, he would probably have to adopt its methods and "unlearn" certain highly specialized design techniques taught in engineering school. In addition, if he wishes to change his specialty within his field of engineering, he finds he has taken many hours of courses not particularly adaptable to change. A student who has had training in more of the fundamentals and physical principles underlying design has much greater flexibility, both as an engineer in industry and as a researcher. He is able to go from problem to problem with a greater understanding of the ideas involved, rather than knowing only the formulas to use.

Richardson says that teaching undergraduates is boring for a Ph.D. This is not necessarily true. While teaching graduates, one can of course follow those lines that are most closely related to one's own research. But teaching undergraduates still involves a knowledge and use of the work of Newton, Hooke, and their like, and more worthy company cannot be hoped for. Furthermore, in a system of engineering education oriented to the basic sciences, the teacher of undergraduates is called upon to show the derivation of his specialty from these sciences. This requirement creates an excitement and leads to a discipline which result in more effective teaching.

The analogy Richardson makes between medical education and engineering education is one which I find supports my position on these questions rather than his. Medical students, like engineering students, must acquire a strong background in certain basic sciences before their education turns toward practical and clinical courses. These sciences (physiology, anatomy, biochemistry, and so on) are not usually taught by practitioners but rather by specialists in those particular fields. The parallel to science-oriented engineering education is obvious.

The Ph.D. engineer is now essential to the profession. He is responsible for the latest research developments and the most sophisticated knowledge in his field. This is what makes him valuable as a teacher.

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Richardson's letter will, I am sure, receive the approbation of a great number of engineers and teachers. The measure of quality of a school has become ridiculous in that it entails a count of the percentage of Ph.D.'s on the teaching staff; this very measure may be in almost inverse relation to the quality of teaching.

However, the engineering profession must take a large share of the blame for the situation, for in nearly every case, when the engineering societies and institutes are called upon to furnish delegates to the various accrediting bodies, they choose not the successful practicing-engineer members but rather those members who are educators. Consequently the system is simply perpetuating itself. A worthwhile advance will have been made when engineering schools are examined by engineers (as medical schools are examined by physicians) rather than being scrutinized by members of the teaching profession itself.

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Space Flights and Biology

G. G. Simpson's article "The nonprevalence of humanoids" (21 Feb., p. 769) purports to deal with exobiology, a word which I dislike as much as Simpson does, but the picture that he presents is of a subject which I do not even recognize. In raising a few pertinent points I shall brave the built-in defense that in doing so I may be motivated by "many emotional factors and . . . selfish interests" and ignore the gratuitous insult of "ex-biologists now exobiologists."

I cannot think of any exobiologist who would seriously quarrel with the four points that Simpson lists in his conclusion, and I am sure that the final plea to the effect that we should not forget terrestrial science will be generally supported. To put it bluntly, Simpson paints exobiology as a search for humanoid intelligences in the universe. There is literally nobody who is indeed looking for intelligent life in the solar system, nor is it true that exobiology is draining all the funds from other possibly more worth-while research. Any examination of the NASA budget will show that the vast bulk of it is consumed by the manned-space-flight program, while anything that may be labeled exobiology operates on a shoestring. If Simpson wishes to object to the space program he will have to find another scapegoat than exobiology. Rather than review the many erroneous statements which are more competently dealt with by other people, I would like to point out the reason for the urgency of organizing a functioning biology program within the framework of space exploration.

The United States and the Soviet Union are engaged in a program of space exploration regardless of whether we biologists like it or not. If we ever wish to derive any biologically significant information from landings on other planets, then we must plan for it now while it is still possible to include the necessary biological safeguards. The urgency in following a program of space biology is not an intrinsic one, it is imposed on us by external events. The necessity for observing, at least in initial landings, safeguards such as sterility has been widely discussed and needs no further clarification by me. I believe that a landing on a planet such as Mars will yield invaluable data to biology. In the event that living organisms should be found, they will afford us an opportunity to check those physiological principles which we now believe to be generalizations to see whether they apply to all life. In the event that no life is found, we will have at our disposal a planet the surface chemistry of which has not been extensively altered, as has that of Earth, by living organisms. We should in this event be able to learn something about conditions that may have prevailed in an environment in which life may develop. We may learn something about the organic chemistry of a nonbiological world, to discover whether indeed, as we suspect, organic compounds accumulate and what the nature of such compounds is. My main issue with Simpson is that I believe such

information can be much more than just "a little more knowledge of life." Perhaps this is the time to explain my dislike for the term "exobiology." Biology, wherever we find it, is still biology and need not be segregated into a separate subject, and knowledge of life elsewhere will teach us much about our own life on earth.

The question before us is not whether or not to pursue exobiology as an exotic subject; the question is whether, given the opportunity of space exploration, we should exploit it or should throw away the chance of ever doing so.

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Vishniac is not one of those to whom I referred as having selfish interests or as being ex-biologists, so we agree that in his case the shoe does not fit. His statement of his own objectives is admirable. It is, however, largely irrelevant to my thesis, which he has misconstrued and which I therefore restate very briefly as far as it involves the space program.

The possibility of finding extraterrestrial life is frequently advanced as a justification for the space program. That the space program is widely supported in that way is a plain fact, regardless of other reasons for supporting or opposing it and regardless of how much or little of it is now directly devoted to the search for extraterrestrial life. The exobiological argument covers a wide spectrum, from possible microorganisms on Mars to possible humanoids somewhere. I adduced reasons for concluding that the outlook at *all* levels is much dimmer than is commonly claimed in support of the space program. (Of course I did not suggest that anyone is now out hunting humanoids within our solar system, or that humanoids anywhere are the only exobiological topic. It is a fact, however, that exobiologists often stress this one, extreme aspect of their speculations.)

Incidentally, I have no objection to the term exobiology, as a term. It makes a useful distinction from *space biology*, which is not the same thing. I do have qualms about a "science" without known subject matter.

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Ph.D. or M.D.—A Choice Freely Made

D. Brancato's letter (13 Mar., p. 1120) reflects a point of view encountered by many physicians during their military service. Physicians, as a group with special abilities, have special responsibilities (hence the "discriminatory" doctors' draft laws) and enjoy special rewards. Those without postgraduate training who object to the physicians' pay advantages are answered easily: if you want to go through the apprenticeship and join the union, you too can get union pay.

The case of the Ph.D. is perhaps more cogent. Still, it must be clear that realistic considerations of supply and demand must enter into the determination of these pay scales; I do not believe that a Ph.D. draft law has ever been necessary. Further, we might ask whether the income of physicians in federal employment compared with that of physicians in private practice is not lower than the income of Ph.D. scientists similarly compared.

Many will disagree with Brancato's implication that respect is to be measured in terms of monthly pay. Many physicians choose to spend several years in poorly paid specialty-training programs and in research fellowships; those who merit respect are well respected by the medical, scientific, and lay communities. Some of the scientists for whom I have the greatest admiration are university faculty members earning less than they would earn in the Public Health Service. No: respect has more to do with value than with money.

What it all boils down to is this: those of us who choose a job with a lower income than we could have gotten elsewhere do so voluntarily, because other considerations make our choice seem appropriate. How can we complain of the results of such a choice, freely made?

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Reviewing Educational Films

Sherburne's comments on the difficulty of reviewing films (21 Feb., p. 792) seem to me to be worthy of further thought and discussion.

In his observations on a series of films for TV use he reports that "This is the second time that an educational TV series has been reviewed in *Science*," and goes on to describe the problems of equipment and time in reviewing films. It seems strange that a publication devoted to reporting and evaluating the latest in scientific developments—including communications—should take such a conservative approach to films and television. Surely the implications of these new media in science teaching and reporting are now apparent. Almost every new curriculum-study and development program in the sciences includes, in addition to text materials, visual aids in the form of films and filmstrips. In most cases the films are produced because it is believed that they perform a unique function essential to the program. It does not seem logical to review the texts and ignore the films.

In addition to films and other visual aids produced for the big science-curriculum programs, there is a steady flow of individual documentary and teaching films in many areas of scientific interest. These come from institutional as well as commercial sources, and they have greatly improved in quality in recent years. Materials produced for educational TV are often very useful, as Sherburne notes, and unlike the programs used on commercial TV they are available for later use.

The very problem to which Sherburne points—the difficulty of screening and evaluating films—might well suggest to the editors of *Science* and other scientific journals that greater effort be made to establish reviewing procedures and provide adequate evaluations and film-TV listings. Readers of *Science* look to the thoughtful comments of its reviewers for guidance in selecting books. It is no less time-consuming to read them all and choose the most likely than it would be to try to locate and preview all the film and TV materials. I believe that regular listings of new scientific and educational film and TV releases and frequent reviews of timely materials for projection would be a useful addition to the pages of *Science*. Sherburne makes the point when he indicates that the audience to these materials is remarkably large. This is surely a reflection of the degree of interest in them.

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