Engineering School Needs

William R. Grogan, in his thoughtful editorial "Engineering's silent crisis" (26 Jan., p. 381), offers some useful recommendations for improving the number and quality of future engineers. Many of the proposals now on the table, including Grogan's, while addressing the needs of some students and some universities, do not adequately provide for the vast second tier of engineering schools, which in fact produce the great majority of engineering graduates at the bachelor's degree level.

Grogan's suggestions concerning expanded relations with industry are good, but do not go far enough. We need to see industry helping students with more part-time employment during the school year. Most of the minority students we wish to attract need financial aid of all kinds, and more than the mandated programs can provide. With part-time employment, we can fill industrial gaps for working engineers and give these young people the wherewithal to attend college. We can also provide meaningful experiences with our industrial partners.

Moreover, industry needs to recognize the needs of faculty and help us help our staff. Faculty salaries for the engineers remaining in the teaching profession can only rise so much. The internal competition for funds from other sectors of the university is too great to treat these individuals specially over long periods of time. Industry can provide incentive for our faculty with consulting and other opportunities. Industry could also release its employees and let them teach a course or two. This would give us and our students the benefit of their experience, knowledge, and training, without the university burden of full-time employment.

Grogan makes an innovative suggestion for a Reserve Engineering Training Corps (RETC). Something like this has recently been developed with the cooperation of local engineering schools in the New York metropolitan area. New York State Assemblyman Dan Feldman has sponsored legislation establishing a "training corps" for local mass transit, providing scholarships for those willing to enter the field and help our local Metropolitan Transit Authority with an infusion of new talent.

We would like to see other initiatives from the federal government, including a move away from "big science, big engineering." These sorts of projects have tended to lock out the young, innovative faculty member from the smaller college. In the late 1950s through the 1970s, many federal programs allowed for small grants or contracts. The government was willing to take risks on developing unproven talent. With larger and larger projects, many of the smaller schools have fallen away. It is often easier for the government to fund large, well-known universities and faculty with proven track records. A little released time and some summer funds do not cost much and can go a long way toward helping us retain our faculty and strengthen our second-tier colleges and universities. While the risks may be great, the payoffs can be significant.

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Grogan's analysis addresses three separate issues facing the engineering community: (i) increasing the quality of engineering education, (ii) increasing the opportunity for a diverse population to enter the engineering field, and (iii) increasing the number of engineering graduates. Although the first two are worthy goals for social action, I believe the third is the one that can be most rapidly implemented in the free market incentive system.

The present poor image of engineers and the declining percentage of college-bound students intending to pursue an engineering career could be rapidly reversed by a substantial increase in the salaries of graduating and experienced engineers. When this country decides to pay its engineers in proportion to their contribution, many of our problems will be solved. *Made in America* (*1*), the Massachusetts Institute of Technology study on industrial productivity, cites the need to revitalize industry and take a new view in our management process. When "Wall Streeters" and "consultants" are paid two to three times what engineers receive for merely moving money, rather than producing tangible products, something is wrong.

The coming shortage of engineers, if we let the normal process act, will result in a free-market price rise that will be good for us all. The higher cost of engineers will lead to additional support personnel, thereby permitting more engineering time on creative activities, reassignment of engineers to more responsible positions, and the use of technicians and "paraprofessionals" in the routine, semitechnical tasks that are unrewarding, but are often so much of the job of experienced, well-educated, capable engineers. The image of engineers will improve, because in large measure public esteem in the professional arena is related to income. Higher pay and a better image will bring the students back to engineering as a career.

I suggest we think carefully about actions that may prevent this shortage from occurring. If we take the long view, as suggested in (*1*), we *need* the shortage to demonstrate just how valuable engineers are in today's world.

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Response: A number of responses to my editorial expressed bitterness at the way engineers are treated by both industry and the federal government. Respondents cited low federal salaries, erratic research funding, and a general tendency to undervalue engineers—complaints that all have merit.

Several respondents who are unemployed took particular issue with a notion of an impending shortage of engineers. But what I predicted was not a near-term shortage across the board but a declining presence of Americans in engineering over the long haul. Closer at hand, the likelihood is for layoffs of engineers in defense-related positions, which will probably produce a further decline in American students' interest in the profession. This in turn will erode the American presence in engineering in the next century.

Those who argued in their replies that a decrease in American engineering graduates will force industry to raise the profession's salaries and status are looking at a progressively minor part of the picture. They do not see the growing availability of off-shore engineering talent in an increasingly global economy. Unless industry and government leaders take a more long-range view than they have done to date, they will continue to get their engineering done however and wherever it is least costly at the moment, letting the future take care of itself. The United States will see a continuing diminution of interest in engineering among young men and women of affluent and middle-class families, while the children of the poor will be less and less able to afford an engineering education.

As for the low status of engineers lamented in several of the replies, the blame here does not reside exclusively with industry and government. Engineers and engineering educators also contribute to the problem by accepting for themselves such a narrow, technical view of their profession and their role in the world that no one knows they are there. Increased esteem will require broader involvement in a myriad of policy issues—social, economic, and political—that are passing engineering by.

The basic issue raised in the editorial was whether industry and government consider it important that Americans continue to have a dominant role in American engineering. If that is important, then there is no alternative to paying the price through support of new educational approaches that will ensure this outcome.

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The Decline of Systematics: Clarifying the Causes

The present crisis in numbers of modern entomologists or other systematists (Research News, 10 Nov., p. 754) should disturb all concerned for the welfare of our planet. The inadequacy of support for all aspects of population and community-level biology, "fundamental" or "applied," is ominous. Thus it is distressing when the efforts of a leading spokesperson, such as Paul Ehrlich, to warn society of this problem are potentially impeded by misinformed remarks from within our profession. A letter from J. R. Grehan (19 Jan., p. 270) quotes an anecdote from David Hull (*1*) to suggest that Ehrlich's views of taxonomy, early in his career, may have somehow contributed directly to the decline of systematic entomology. The anecdote is factually incorrect, and thus the letter does our common concern a grave disservice.

Hull recounts a strident exchange in 1957 between Ehrlich, as an advocate of numerical morphometrics and systematics, and a "classical" systematist, but mistakenly describes it as an attack by Ehrlich on the scientific value of systematics, rather than what it actually was: a debate over how best to pursue the practice of systematics. Hull then extends misunderstanding by saying, "When he [Ehrlich] was hired years later at Stanford University, he put his own preachings into practice by getting rid of its huge collection of butterflies and moths." In fact, Stanford harbored no "huge" collection of Lepidoptera at Ehrlich's arrival in 1959: the major holdings of the Division of Systematic Biology were the Dudley Herbarium and the David Starr Jordan collection of fish and herpetological specimens; what insects were present were in poor condition because of a chronic shortage of curatorial resources. When persons high in the Stanford administration (by an astoundingly short-sighted policy) further restricted the financial and space resources of the division, this was *fiercely protested* by Ehrlich and his colleagues in biology, but to no avail. The only sensible thing left to do was what was done: the housing of the division's collections was transferred to the California Academy of Sciences, where they could be curated adequately. The efforts of Stanford faculty, including Ehrlich, in evolutionary and ecological biology have been inconvenienced ever since.

I suspect strongly that much of the decline of systematics and of "classical organism biology" in general is due to precisely that resistance to new ideas and approaches that Ehrlich was trying to correct in 1957. All too often, practitioners of older biological subdisciplines wrap themselves in the mantle of their own antiquity, proclaiming that newer workers are not "true" marine biologists, or entomologists, or whatever, if they deploy new techniques or conceptual approaches in the study of their material. It is essential that old learning be maintained, but this must often take place in new contexts. As Alfred North Whitehead once remarked, "Knowledge does not keep any better than fish" (*2*). Our challenges as evolutionary, ecological, or systematic biologists are to reilluminate old facts with new insights, as well as to make new discoveries. Only then will we convince our colleagues in genetic engineering or other "new biologies" of the dynamism of our science.

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Genetic and Physical Mapping of the Human Genome

The proposal by M. Olson *et al.* (Perspective, 29 Sept., p. 1434) to standardize genetic mapping vocabularies is advantageous because it would make uniform all physical mapping efforts by bringing them to the same scale—the DNA sequence. It would also allow investigators to be independent of concerns about noncomparable databases. The proposal is based on the use of short tracts of single-copy DNA sequence as landmarks that define position on the physical map of the genome. Recovery of the "sequence tagged sites" (STSs) delimited by these short sequences allows them to be used as primers in a polymerase chain reaction (PCR). One can extend this proposal by focusing on genomic regions that manifest wide genetic diversity in a way that will simultaneously generate a parallel genetic map of the human genome. Microsatellites, of which poly(TG) is the most abundant representative (*1*), seem to be widely scattered throughout the genome and have been shown to be associated with polymorphic loci (*2–6*). Recent studies indicate that most microsatellite motifs (*5*) exhibit highly variable length polymorphisms detectable by the PCR method, while the markers so uncovered bear a high polymorphic information content (*3–6*).

If microsatellite islets are randomly distributed throughout the genome, then they would occur every 30 to 100 kilobases. A significant proportion of them should be adjacent to single-copy DNA sequences. Such single-copy sequences, including the microsatellite motif itself, could serve as highly informative genetic and physical markers for PCR amplification with appropriately selected oligonucleotide primers.

The advantage of this strategy is worth emphasizing: the abundance, informativeness, and apparently wide genomic dispersion of microsatellite islets suggest (*4, 6*) that such genetic markers might be located within short "walking distance" of any gene of interest. Moreover, since microsatellites appear to be ubiquitous and to share similar flexibility in all species, the same principle could be used to speed up the generation of maps for other mammalian species as well.

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Erratum: In the table shown in the Briefing "Who leads the (Ivy) League in " 'citation impact' ?" (9 Mar., p. 1183), the figures shown in the columns for "Citations" and "Citation impact" for Cornell University were incorrect. They should have been "523,878" and "16.53," respectively. The ranking was correct.