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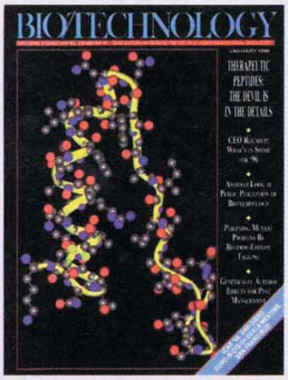
To the editor:

In the January 1996 issue of *Bio/Technology*, Patricia Ahl Goy and John H. Duesing present an analysis of 391 European field trials with transgenic plants, made to assess the environmental impact of gene transfer to wild relatives (*Bio/Technology* 14:39-40). Ahl Goy and Duesing define potential impact as the product of "probability of transfer" and "consequence of transfer". They divide crop plants into three classes having minimal, low, or high probability of gene transfer to wild relatives. Likewise, the engineered traits are divided into those giving a minimal, a low, and a high advantage to the plants possessing them. The authors conclude that 91% of the trials were likely to have minimal potential impact, the remaining 9% having low potential impact. They found no trials with high potential environmental impact.

We have several objections to this analysis. According to Ahl Goy and Duesing, the probability of transfer should be estimated "using evolutionary criteria." In that case, what does "a low probability of transfer" actually mean? For instance, Ahl Goy and Duesing place oilseed rape in the low probability group. However, recent experiments have shown that when single plants of the weedy relative Brassica campestris were placed in a field of oilseed rape, 93% of the germinated seeds from these plants were interspecific hybrids (Jørgensen and Andersen. 1994. *Am. J. Bot.* 81:1620-1626). This could suggest that our knowledge about gene exchange between crops and wild relatives is insufficient, and that more research on this subject is needed. Even in cases where gene exchange is rare, evolutionary history teaches us that events with a low probability did happen and had a large impact. Ahl Goy and Duesing seem to be somewhat confused about what gene transfer really is. They declare that the consequence of gene transfer depends on "...whether a hybrid between a GMP and a wild relative could exhibit enhanced competitiveness..." But later, inserted traits are classified according to whether they can confer "...selective advantage to wild relatives..." We think it is important to distinguish between transgenic hybrids and transgenic wild relatives. Hybridization is a necessary, but not sufficient, condition for introgression (i.e., the incorporation of transgenes into a wild genetic background).



As to the consequence of transfer, the problem is that we lack knowledge about which factors limit the distribution of wild relatives. Therefore, we believe it can be difficult to predict whether the transfer of a particular transgene to a wild relative will have unwanted ecological consequences. That this invasiveness is not as easy to predict as it seems from the Ahl Goy and Duesing paper is illustrated by a study of Bergelson (1994. *Ecology* 75:249-252), in which a genotype of *Arabidopsis thaliana* with inferior seed production could, surprisingly, invade natural habitats as successfully as a wildtype genotype. Furthermore, it is not obvious to us why resistance to insects, diseases, viruses, and stress is placed in a "low advantage class" by Ahl Goy and Duesing.

Finally, we disagree with the notion that the combination of a serious consequence with a minimal transfer probability results in an overall minimal potential impact. It seems to us that the product of a high and a low number might very well be a high number.

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Commentary on Education

Parascientific education for PhDs

Aris Persidis, Wendell E. Dunn, III, and Ian C. MacMillan

What are appropriate educational requirements for current and future scientists? The dramatic changes that have occurred in the scientific infrastructure during the past five years are forcing a rethinking of what it takes to compete in the scientific arena[1]. Doctoral training in particular is in the spotlight because of the declining number of jobs in relationship to the sum total of degrees awarded[2]. Speculation on how scientists will need to prepare for 21st century research is now a hotly contested topic in the literature[1-7].

Our view is that the forces that are reshaping the research infrastructure are not singular to science. Rather, they are global changes brought about, in part, by the fruits of science. If the debate on scientific education is to generate light as well as heat, then it must be grounded in a discussion of how scientists can most successfully adapt to this new order.

What forces are reshaping science? Certainly the greatly expanded communication links that have contributed to the "information explosion" are factors. This has not only accelerated the pace of research, but has also increased the level of competition, or at least awareness of it. In addition to the benefit of being able to communicate with colleagues at will, there is a greater sense of time pressure because of how easy it has become to keep tabs on colleagues—and competitors—around the world.

Another factor is that the cost of conducting research has skyrocketed. The tools scientists need to work faster are expensive, and with freezes on hiring, many times a piece of equipment can be approved much more quickly than opening up a new line of funding for a postdoc.

Further complicating the picture is the fact that the structure for funding science is moving away from government sponsorship. Those researchers looking only to traditional sources have found that the demand outstrips available funds. This means that increasingly significant contributions to basic science are coming from industrial sources. New arrangements have emerged—from loose collabora-

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