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Safety of Genetically Engineered Foods: Approaches to Assessing Unintended Health Effects, NAP pp 255 Washington (Report)
<http://www.nap.edu/catalog/10977.html> AND <http://www.botanischergarten.ch/Food/NAP-Safety-GMO-Food-2004.pdf>

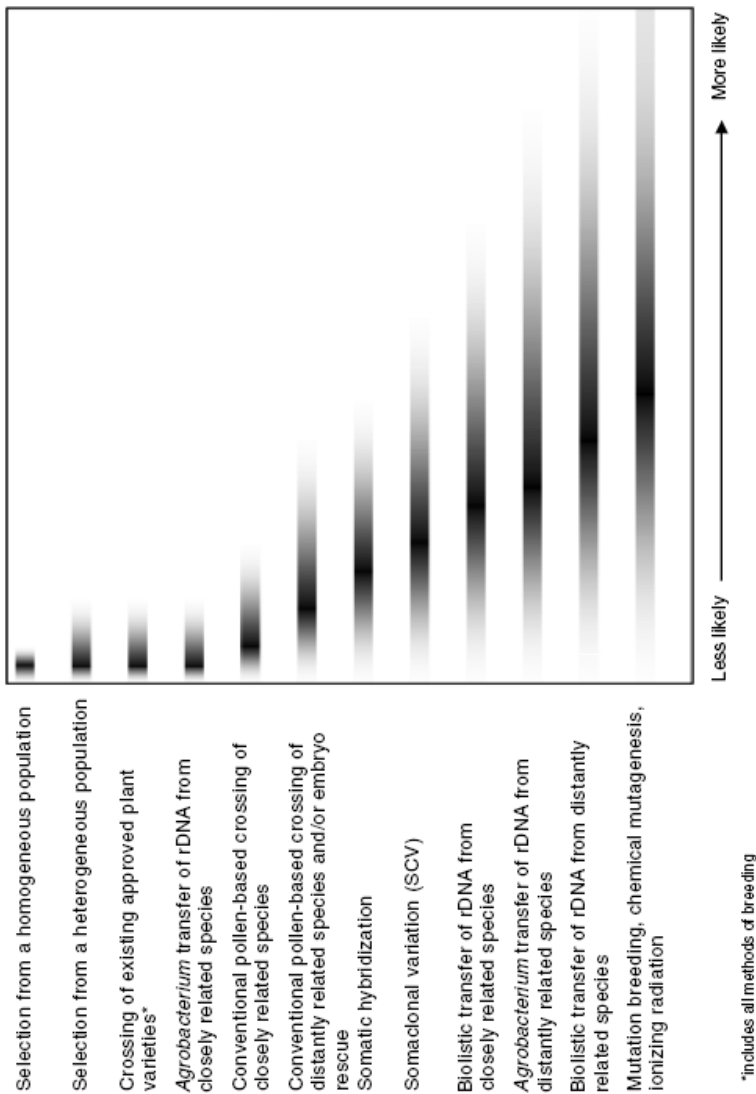


FIGURE 3-1 Relative likelihood of unintended genetic effects associated with various methods of plant genetic modification. The gray tails indicate the committee's conclusions about the relative degree of the range of potential unintended changes; the dark bars indicate the relative degree of genetic disruption for each method. It is unlikely that all methods of either genetic engineering, genetic modification, or conventional breeding will have equal probability of resulting in unintended changes. Therefore, it is the final product of a given modification, rather than the modification method or process, that is more likely to result in an unintended adverse effect. For example, of the methods shown, a selection from a homogenous population is least likely to express unintended effects, and the range of those that do appear is quite limited. In contrast, induced mutagenesis is the most genetically disruptive and, consequently, most likely to display unintended effects from the widest potential range of phenotypic effects.

Analysis of the Continuum

As noted earlier in this chapter, unintentional changes are possible with all conventional and biotechnological breeding methods for genetic modification. It is possible to represent the likelihood of such changes as a continuum, albeit only a partially understood one. Placement along this continuum has no bearing on risk of adverse outcomes, but only on the probability of unintended changes, which need not be hazardous. The potential for hazard resides in specific products of the modification regardless of whether the modification was intentional or unintentional.

Again, unintended effects do not necessarily imply hazard. If a particular method were inherently hazardous, all products resulting from its use would be potentially harmful. However, it is known that each method can provide safe products, so the key for breeders and regulatory agencies, in their reviews of specific products, is to identify the relatively rare, potentially hazardous products resulting from any method.

In breeding, the developer can generate literally thousands of breeding lines; each might be progeny of the same parents, thus bringing together the same set of genetic information, and yet possess subtle differences. As noted previously in this chapter, conventional breeders may scrutinize 2,000 of these “sister lines” of a single cross of two parent plants. Meiotic recombination allows sister lines to show a continuum of phenotypic expression. Over several years, the breeder eliminates most, or sometimes all, of those breeding lines because they are unsuitable. Plant breeding is often said to be a process not of selection, but of elimination. Any off-types, unstable lines, or lines showing characteristics such as significant differences in nutrient content, responses to environmental stresses, diseases, or the presence of other undesirable traits are discarded as soon as they are noticed. This winnowing takes place over several years, so the remaining lines identified for prospective commercial release are unlikely, but not guaranteed, to have any significant compositional changes other than those related to the desired trait. For this reason, regulatory scrutiny focuses most often on the new trait and its metabolic perturbations. Nevertheless, the appearance of subtle or obscure phenotypic changes can go unnoticed by breeders or regulators and may subsequently have to be recalled from the market, as in the case of the Lenape potato developed using non-genetic engineering methods—discussed previously in this chapter (Laurila et al., 1996). The products of a narrow cross-pollination, from a plant of a given species to another plant of the same species, or even the same subspecies, are less likely, but not guaranteed, to pose unintended risks. This is due to the expectation that pollination is inherently safer than other methods of gene transfer because the range of resulting products is typically limited to those products already present in the species or subspecies. However, even this likely “safe” method is subject to occasional spontaneous mutations or infelicitous genetic recombination events leading to novel and unexpected products, and these products may carry some degree of risk, such as disease susceptibility, leading to, for example, hazardous levels of fungal mycotoxins. Expanding the range of conventional breeding beyond the same species provides a greater opportunity to introduce novel genetic information and thereby novel sources for unexpected effects.

Triticale is a man-made crop developed by breeding wheat with rye; *hordecale* is a similar product of barley and rye. Both examples bring together thousands of genes in a way that does not occur in nature and which conceivably could result in the production of undesirable toxicants. As discussed previously in this chapter, the conventional potato breeding program combining *Solanum tuberosum* and *S. brevidens* produced not only the expected toxicants, but also a new one, demissidine, which is not produced in either parent (Laurila et al., 1996). Although some products can be reasonably predicted to be hazardous, this does not imply that all products of rDNA—or other methods of bringing together genes—are necessarily hazardous. *Agrobacterium* and the particle gun are the only two rDNA methods represented on the continuum in Figure 3-1 because they provide almost all of the GE crops approved for commercial release. They are depicted separately because of the documented predilection of the particle gun to introduce multiple, broken, or rearranged DNA segments, in contrast with the usually singular and high-fidelity transfer typical of *Agrobacterium*.