

Unnatural selection

Allison Snow

Debate about the safety of genetically engineered organisms (GEOs) has evoked intense public interest in biotechnology, and engendered varying degrees of distrust in scientists, industry and government agencies around the world. The provocative language used to describe GEOs currently in the pipeline runs the gamut from 'golden rice' to 'terminator', although the subjects of these particular monikers have not been planted commercially. In fact, much of the humanitarian promise of GEOs lies in the future, rather than in currently used products. Likewise, the technology's main hazards are probably yet to manifest themselves.

It is unfortunate that the term 'genetically engineered' has been largely overtaken by 'genetically modified' (GM) in public discourse. People have been genetically modifying crop plants, farm animals and domestic pets for centuries, most recently using 'unnatural' methods such as mutagenesis. It is the engineering aspect of transgenic technology that is both new and a cause for concern to some, as it involves the transfer of genes between sexually incompatible organisms. This approach, along with the ability to design new artificial genes and transfer them between species at will, is far more rapid and powerful than even the most sophisticated methods of conventional breeding. Thus, although the 'GM' label will continue to be used, it is important to understand the process to which this term refers.

In a stunning demonstration of engineering prowess, the plant-biotechnology firm Verdia recently designed a gene that could take the place of Monsanto's highly profitable transgene for resistance to the herbicide glyphosate. Verdia's technique involves using 'directed molecular evolution' to create new bacterial genes that can be inserted into crop plants. First, promising bacterial genes are identified by searching immense genomic databases. Mixtures of genes are then repeatedly fragmented, shuffled and reassembled under intense selection pressure in the laboratory until a useful product is obtained (such as a gene for herbicide resistance). This technology opens limitless possibilities for creating valuable, proprietary transgenes for new types of GEO. Whether the world is ready for the flood of technical achievements that biotechnology companies are eager to release is still a matter for debate.

Polarized opinions make it hard to discuss scientific questions about GEOs without delving into the reasons for the passion on both sides of this debate. To some people, the

idea of transporting genes from animals or microorganisms into food plants is repugnant and reckless, regardless of which transgenic traits are involved. It has been suggested that consumers' anxiety about transgenic organisms might be alleviated by avoiding cross-kingdom gene transfer, such as taking genes from bacteria and putting them into tomatoes, in favour of moving genes between more closely related species, such as rice and maize. But the argument that such 'within-kingdom' transgenic plants are inherently safer contradicts a basic tenet of the scientific community regarding the health and environmental effects of GEOs. For years, national science academies have argued that the products — rather than just the processes — of genetic engineering should be subject to regulation. Some would even say that the process used to acquire useful genetic variants is irrelevant; it is the phenotype that matters when evaluating possible risks.

Focusing on an organism's phenotype is desirable, given that many GEOs have truly new characteristics relative to what can be created by conventional breeding. South Korean scientists, for example, achieved an astounding 35-fold increase in the growth rates of farm-raised fish — in this case, the mud loach (*Misgurnus mizolepis*) — by fusing a native promoter to a native growth gene. In plants, the diversity of new traits that can be transferred within and between species is likely to increase dramatically as new genomics-guided strategies and high-throughput technologies are deployed. From an environmental standpoint, transgenes that confer greater crop yields might generate similar but unwanted effects in their weedy relatives through gene flow. And future types of transgenic, plant-produced pesticides may be harmful to beneficial insects and other non-target species. It is especially important to understand the environmental effects of GEOs that can proliferate freely and perhaps hybridize with other taxa.



Purple patch: transgenic fruits such as these virus-resistant plums could cut pesticide use.

Genetic engineering

Evolving techniques for redesigning organisms have enormous potential but they must be matched with equally sophisticated methods for evaluating their benefits and risks.

At the other end of the spectrum are GEOs that are phenotypically similar to conventionally bred organisms and do not establish free-living populations. Many crops have been improved using genes for disease resistance by crossing them with sexually compatible relatives — and if their relatives lack these genes, the same goal can be met by genetic engineering using genes from viruses, bacteria, plants or other organisms. As a case in point, transgenic methods are needed to develop fruit trees that resist common diseases such as apple scab and plum pox — in some cases, this could benefit consumers and the environment by reducing the need for pesticides. Genetically engineered crops that enhance yields, improve human health and make agriculture more sustainable should be encouraged, assuming that the potential health and environmental effects of these organisms are well understood.

Despite tangled regulatory systems and huge obstacles with public acceptance, harmless and beneficial uses of genetic engineering should be allowed to move forward in an ethical and scientifically informed manner. More questionable GEOs should be handled more slowly and with greater scrutiny. Genetic tinkering with self-replicating organisms requires a great deal of wisdom and caution, both from the scientists who design them and from the regulators who approve their release into the human food chain and the environment. Independent health and environmental experts can play a valuable role in guiding these decisions, but consumers will often have the final say as to which GEOs are adopted widely. ■

Allison Snow is in the Department of Evolution, Ecology and Organismal Biology, Ohio State University, Columbus, Ohio 43210, USA.

FURTHER READING

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