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# Designing Biotechnology for Biosafety

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## ABSTRACT

Public perception of transgenic plants has often been based upon information provided by vocal, anti-transgenic groups. Companies marketing transgenics have not been viewed as an unbiased source of information, and presentations have not been effective. Government regulatory agencies provide the public with reassurance that consumption and environmental risks are being addressed, but these agencies provide only limited public presentations on risk: benefit studies of transgenic plants. Scientists developing transgenic plants are well positioned to explain how they develop the plant materials and why they are safe, yet they fail to interact with the public and provide this much need information.

**Keywords:** Public; Self-regulation.

## INTRODUCTION

### Consumption of Early Development Transgenic Plants.

Many of the initial transgenics submitted for field release and potential commercial use were straightforward in their scientific design. They relied on well characterized

genetic systems found in nature. The development of Bt toxin crop plants were based on the long term, safe usage of the bacterium *Bacillus thurengiensis* for control of lepidopteran larvae. As a control treatment favored by organic growers, the bacteria may be applied anytime up to harvest, ensuring eventual ingestion by consumers. From a scientific perspective the risks are negligible. Virus resistant transgenics, expressing a portion of the target virus, results in consumption of a small fraction of the viral transcript and protein found in non-transgenic, virus infected food crops. Again, scientists would feel there is no consumption risk. A third major area for transgenics was herbicide resistance. In cases where the herbicide resistance was derived from herbicide-insensitive plants, resistance was attributed to a single amino acid change in the target enzyme. Changes in a single amino acid were perceived as unlikely to induce consumption risks.

In all of the transgenic plants, antibiotic resistance is incorporated as a by-product of the initial selection process. Selection on kanamycin would not introduce resistance to a medically widespread antibiotic, and DNA transfer has proven unlikely (Gay and Gillespie, 2005). None of the early transgenic plant material has been shown to pose a consumption risk, representing well designed scientific choices for transgenic plants. Interestingly, traditional breeding has generated greater consumption risk, as evidenced by recalls of a high glycoalkaloid potato and a high cucurbitacin summer squash (Rymal et al, 1984, Zitnak and Johnston, 1970).

**Environmental Impact of Early Development Transgenic Plants.**

Controlling crop seed viability was an issue addressed by scientists at an early stage of transgenic development. This was seen in the proposed, although never demonstrated, technique referred to as the "terminator". Unfortunately, commercial

acquisition of the technology cast a negative impression on use of the technology. Thus early attempts to avoid genetic dispersion were put on hold (Lee and Natesan, 2006). Efforts to limit genetic dispersion, and other potential problems with transgenic plants in the environment, were relegated to agricultural producers, who were relied upon to carry out proper crop management practices. These practices include crop rotation, suitable field spacing relative to non-transgenic fields, herbicide rotations and planting of non-transgenic refuge crops.

Scientific input on environmental issues is generally focused on refuting data presented by groups opposed to transgenic technologies. Scientific scrutiny of environmental risks has yet to find evidence of impact any greater than the general impact found with commercial agriculture. Unfortunately, scientists that develop transgenic crops do not have the opportunity to explain the rationale behind their designs, and the potential environmental benefits they hold. Benefits such as reduced exposure to chemical pesticides, reduced soil erosion due to less tillage, and lower energy inputs are not being defined by scientists. The public perception of transgenics comes largely from the corporations selling the plant material, while independent public scientific presentation and discussion is desperately needed.

**Future Transgenic Plants.**

As is the case with most technologies, complexity grows with our increased understanding of the science driving the technology. Transgenic technology is advancing on two major fronts, promoter regulation and incorporation of multi-genic traits (Halpin, 2005). Promoter regulation is a scientist's answer to environmental containment, and to consumption risks that may be posed by certain genes introduced to control insects and plant pathogens.

Promoter regulation provides the opportunity to produce seedless fruits, providing containment and value-added crop traits simultaneously (Ficcadenti *et al.*, 1999). In cases where there is no need for seeds (eg. potatoes, tobacco, and alfalfa), promoter regulation can provide plants unable to produce pollen. Promoter regulation may also be useful when expressing genes encoding antimicrobial peptides. A wide array of peptides is known that provide inhibitory activity to a range of plant pathogens. Certain peptides are also known to regulate biochemical aspects of insects. Current expression technologies, involving fusion proteins, allow peptides of 6 to 12 amino acids in length to be produced in plants (Jones *et al.*, 2004). Deployment of antimicrobial peptides requires special attention due to our limited knowledge of how they may interact after ingestion. Single amino acid changes in small peptides can represent a ten percent change in amino acid composition, producing unforeseen consequences (Groot *et al.*, 2006). Scientific rationale would suggest that antimicrobial peptides be limited, through promoter regulation, to non-edible portions of plants, although expression in edible portions of plants may be possible after consumption risks have been evaluated.

Multi-genic traits are evaluated scientifically through understanding what changes occur to the overall metabolic profile of the transgenic plant. The same could be said for introduction of individual genes that are part of a biochemical pathway. Understanding the biochemical pathways allow the scientist to predict what other effects may arise in the transgenic plant, and this knowledge is incorporated into decision making and engineering. Scientists have developed methods of metabolic profiling (metabolomics) to try and determine if non-target characteristics are being affected by the transgene expression. Scientists are well aware of the limits to

metabolomic studies. First there is insufficient baseline data available to know what a "normal" profile should look like. Variations between cultivars of a given plant species, and variations due to environmental conditions, can easily exceed differences between transgenic and non-transgenic (Catchpole *et al.*, 2005, Matthews *et al.*, 2005, Rischer and Oksman-Caldentey, 2006). Overall risks in pathway modifications may be even less than early stage transgenics, as attributes such as enhanced nutritional quality would not be expected to carry a consumption risk or an environmental risk.

**Scientific Self Regulation.**

While countries such as the United States have an elaborate framework of regulations governing transgenic plants, it cannot be assumed that constraints needed to be placed on scientists developing transgenic plants. Scientists are in general a very rational group of professionals, and rank among the top five most respected professions in the US and UK. They are quite unlike the mad scientists portrayed by anti-transgenic groups as creating "Frankenfoods". Transgenic material being sent for regulatory approval has already met the safety criteria of peer-reviewed science and should be fairly easy to approve. Any regulatory judgment on safety requires guidance from the scientific community.

Since the advent of molecular biology, scientists have shown their concern for issues of safety and environmental impact. A landmark meeting in Asilomar, California in 1975 called for a temporary self-imposed moratorium on molecular cloning. This was followed by agreement among scientists on the proper procedures for carrying out cloning experiments, beginning with use of bacteria unable to survive out of the laboratory (Berg *et al.*, 1975). Subsequently, government regulations were put in

place for recombinant DNA studies. Advances in molecular biology have brought scientists to a new era of self regulation. Development of "synthetic biology", wherein a basic form of microbe is created by introduction of wholly synthetic DNA, has called for new agreements among scientists on the procedures that need to be adhered to for safety and public approval (Service, 2006). Some scientists have called for formal training of new scientists in the art of self governance (Davies and Wolf-Phillips, 2006). This has already occurred, without training, however the idea of training scientists to be more interactive with the public would promote acceptance of advances in biotechnology.

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