TechTalk

An Australian Government Initiative

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TechNyou May 2010

Arguments for and against gene technology

Gene technology refers to the alteration of the genetic material of living things so they may produce new or modified substances, or have a novel function. As with any technology, gene technology carries with it potential risks and benefits. This publication explores some of the questions raised about gene technology, and summarises the main arguments for and against the technology and its applications.

GM food

The arguments below are relevant to any application of gene technology, but much of the public debate has focused on genetically modified (GM) crops and food. In this publication GM crops and food refer to those that have had their genome modified by either the addition of one or more genes from another species or the specific modification of existing genes, for example through gene silencing techniques.

Is gene technology natural?

The argument for

Gene technology is another step along the path of genetic improvement, which began thousands of years ago with people selectively breeding plants and animals for desirable characteristics.

Plants and animals can have more than one hundred thousand genes (humans have about 23,000). Adding one or a few new genes using gene technology is a tiny change to the overall genetic makeup of a living thing. In contrast, conventional breeding technology, which includes non-GM methods such as mutagenesis where a seed's DNA is altered by chemical or radiation treatment, involves the change and/or transfer of many genes in a less specific way[1].

The argument against

Gene technology used to create GM crops is different from historical genetic modification techniques that involve breeding within a species or between closely-related species. Gene technology enables the transfer of genes across species barriers, and this has virtually never happened before, even over evolutionary timescales.

Species have evolved with their genes working together in complex systems. It is difficult to predict the consequences of inserting a foreign gene into an organism. For example, what effect the foreign gene might have on existing and unrelated genes or traits. Also, rapid alteration of a species by gene technology could have unforeseen consequences in ecosystems that are not adapted to the new version.

Stuff to think about.

What do we mean by natural (or unnnatural)?

Is agriculture natural? That is, how natural are the crops we have domesticated and the environments we grow them in? What about the affect of agriculture as a whole (GM or conventional) on the environment?

What about health effects?

The argument for

There are strict legal requirements that control the development, release and use of genetically modified organisms (GMOs) in Australia.

The Office of the Gene Technology Regulator (OGTR) protects the health and safety of people and the environment, by identifying risks posed by or as a result of gene technology, and by managing those risks through regulating certain dealings with GMOs.

Food Standards Australia New Zealand (FSANZ) carries out a thorough risk assessment of all food derived from or containing ingredients from GMOs before they can be sold. This includes examining whether the food has additional allergens or toxins as a result of the GM process.

Although genes that provide for antibiotic resistance have been used as markers in some GM plants, the antibiotics involved are not usually those used in human medicine, and the marker genes can now be removed from the plant before commercial production. It is extremely unlikely that these genes could transfer from plants to bacteria as there are a number of barriers to such transfer. There are several common marker genes that do not confer antibiotic resistance.

The argument against

Added genes could make 'safe' plants produce toxins or allergy-causing substances.

GM foods are quite new, and there have been no studies of the long-term effects on human health.

Antibiotic resistance marker genes are a type of marker gene derived from bacteria. They provide the bacteria with natural resistance to particular antibiotics. They are sometimes used in GM plants to determine if the transgene (new gene) has been taken up by the plant. If such an antibiotic resistance gene moved from a GM plant to a bacterium that causes human disease, the antibiotic to which the marker gene provides resistance may no longer be useful for treating the disease.

Stuff to think about

How do you define safe? All foods naturally contain toxins, allergens and anti-nutrients and all plant breeding techniques (GM and conventional) can potentially introduce these chemical compounds into a food crop, so how safe must your food be before you are prepared to eat it?

In reference to 'long-term effects', what do we mean by long-term?

How will gene technology affect the environment?

The argument for

GM crops such as insect-resistant Bt cotton reduce pesticide use by farmers and are therefore less harmful to the environment than synthetic chemical insecticides. Bt cotton (called Bollgard in Australia) contains two genes from the bacterium *Bacillus thuringiensis*. This makes the cotton plant produce bacterial toxins that specifically target moths and butterflies, a key pest of cotton crops.

Herbicide-tolerant crops can allow farmers to spray less toxic herbicides than those commonly used, and give farmers more and better weed control choices, including the employment of conservation tillage practices which can decrease soil erosion and water loss, and improve carbon retention in the soil.

Transfer of herbicide tolerance to weeds is a concern with some GM and conventionally-bred herbicide-tolerant crops. With proper agronomic practices, however, this risk can be managed.

Research suggests that the frequency of transfer of genes from GM crops to related crops and weed species under Australian conditions is actually low[2, 3, 4]. In addition, precautionary steps, such as the use of 'buffer' zones around GM crops, can be used to further reduce the risks of gene transfer.

Gene technology may produce plants that make more efficient use of available soil nutrients or added fertilisers and so will not need as much artificial fertiliser, reducing run-off to the environment and, in the case of nitrogen fetilisers, reducing emissions of the potent greenhouse gas, nitrous oxide.

The argument against

Bt pesticides may 'leak' out of GM plant roots, harming non-target insects and soil microbes in addition to the pests they are designed to kill[5].

Farmers will still be faced with pests becoming resistant to pesticides, even if pesticides are engineered into crops. Therefore, GM crops do not offer much advantage over existing ways of dealing with pests.

Some herbicide-tolerant plants may transfer their tolerance to related plants, creating weeds that are difficult to control with less toxic herbicides. This would increase the use of more toxic herbicides.

The use of herbicide-tolerant crops encourages farmers to use more herbicide because the risk of killing post-emergent crops is reduced. This will have a damaging effect on the environment. In addition, the companies that produce herbicide-tolerant crops often manufacture the corresponding herbicide, which locks farmers into a single supplier.

Growing GM crops that are more tolerant to drought or poor soils may encourage farmers to encroach on lands not suited to agriculture, resulting in environmental damage. If the genes from these crops tolerant to drought, salinity or other envirnmental stresses transfer their stress-related genes to weedy or related species it might create invasive plants that could monopolise fragile or saline ecosystems.

Stuff to think about

There are risks to growing GM crops and these risks differ for each crop. Can these risks be managed in an acceptable way? How acceptable are the risks compared to growing conventional crops?

Are there markets for GM crops?

The argument for

There is debate if overall yields of GM crops are higher than their conventional counterparts[6]. Certainly in some instances they are higher, in others lower or about the same as conventional crops. Other factors farmers will consider, however, include production costs, ease of management, effects on long-term productivity, market prices and market acceptability of the crop.

Research shows that most export markets for Australia (such as Japan) are prepared to buy GM crops[7].

Markets that ban GM products can be replaced with those that tolerate low levels of GM content, eg. Canada's GM canola is now sold to Japan rather than to the European Union (EU).

With the possible exception of niche markets, GM-free crops have not generally commanded a higher market price than GM crops[7].

The argument against

Australia's 'clean, green' image may be harmed by the introduction of GM crops.

Many countries, such as in the EU, do not want to buy GM products so farmers may lose markets if they grow GM crops. Farmers may also be able to get a price premium in some markets if they can certify that their crops are GM-free.

One hundred per cent segregation of GM and non-GM products will be difficult to achieve and the costs may outstrip any potential benefits to farmers from GM crops.

The costs of identity preservation process, that is clearly verifying GM or non-GM crops, may also deter buyers of GM products.

Stuff to think about

Segregation only guarantees that contamination of a non-GM crop with a GM one will be below a certain threshold, for example in Australia the allowable contamination of non-GM canola with GM canola is 0.9%. Is there an acceptable level of contamination and does this change the perception of any effects on humans for the non-GM variety?

Will genetically modified crops help feed the world?

The argument for

Although not intended to eliminate world poverty, gene technology is one of many modern plant breeding tools that has the potential to develop plants that are more nutritious and yield bigger harvests[8]. This could be in addition to greater resistance to disease and stresses such as drought. One

example with potential benefits for the developing world is 'golden rice' modified to produce beta carotene, the molecule that the human body uses to form vitamin A. This vitamin, which is often deficient in people in developing nations where rice forms the bulk of their nutrition, is essential for good health and helps prevents blindness. Other examples in the research pipeline include CSIRO research that has modified oilseed crops with a gene from a marine micro-algae to produce the long-chain omega-3 fatty acids vital for human health, and Spanish researchers that have modified corn with three genes to produce Vitamin C, beta carotene and folic acid[9].

Gene technology may help produce animals that are more productive or resistant to parasites and diseases, thus improving livestock quality in developing nations.

GM plants that can grow in poor soils will enable countries with poor lands to be able to grow more of their own food and reduce land-clearing.

The argument against

Feeding the world is more to do with politics, economics and population than hi-tech developments. Poor countries often cannot afford to buy from the food surpluses in rich countries. Also, poorer nations are often encouraged to clear land and grow cash crops and animals for export, rather than subsistence crops to feed their population. GM crops will not alleviate these issues.

GM crops such as 'golden' rice may be an unnecessary way to alleviate vitamin A deficiency. For example, programs to grow pumpkins in communities, to provide vitamin A as well as many other nutrients, may be just as effective.

Poor farmers will not be able to afford the GM seeds and the related herbicides they need from multinational companies, who are primarily interested in making a profit.

Stuff to think about

Given that genetic engineering is not a tool that alone will feed the world, if it could, in specific situations, help farmers in developing nations increase the reliability of a viable crop and improve food security, would such a situation change the acceptability of risk for that GM crop? Under what circumstances, if any, would it be acceptable for farmers in a developing nation to grow a GM crop?

Will GM technology benefit us?

The argument for

Farmers will benefit because of the potential for increased yields of crops, healthier animals, fewer diseases, lower costs of production and more sustainable agronomic practices.

There will be some environmental benefits because of the reduction in the use of toxic chemicals, minimal soil tillage and the potential to grow more on less land.

Humans and animals will benefit through more effective drugs to treat diseases and genetic conditions.

Multinational companies have already freely shared some of their GM technology with developing nations. Research groups that work with multinational companies generally own the technology and negotiate the terms of technology delivery. For example, an insistence that developing nations have access to drought-tolerant or nutritionally-enhanced crops.

The argument against

As with introduced exotic species, once GM crops and animals are out in the environment they cannot be recalled, and they may cause irreversible ecosystem changes.

Farmers could be tied to multinational companies selling patented seed and associated chemicals at greater cost. Farmers are already being sued by multinationals for allegedly growing GM crops on their land without a licence.

Multinationals will increasingly own intellectual property in agriculture thus dominating world markets.

Increased costs for segregation of crops and animals could lead to higher prices for consumers.

Stuff to think about

Nearly all crop plants in Australia are exotic (introduced species). Conventional crops have the same potential to transfer their genes to other plants (natives or weeds) as GM crops do. We can create drought-, salt-, herbicide-tolerant crops through conventional breeding techniques. Will such conventionally-bred crops have a greater effect on the environment than GM versions? How do the risks of gene transfer to other crops or native plants compare between GM and conventional crops?

References

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6. There are many references on this topic. The following is reference to a series of letters to *Nature Biotechnology* on results in a report investigating yield of GM crops. There are many references to other reports with each of these letters: *Nature Biotechnology* 27 (9) September 2009, pp801-804

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Further discussion on GM crops and gene technology can be found at the TechNyou web site and blog:

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TechNyou also has access to or files of reports and peer-reviewed papers related to the information in this fact sheet that can be sent to anyone interested.

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