Applications for food and agriculture

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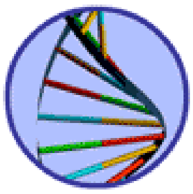

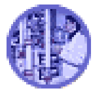

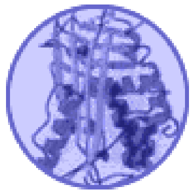

Gene technology may be used in many aspects of agriculture and food production to:

- increase crop or animal resistance to pests;
- increase crop or animal tolerance to chemicals that are used to kill pests that harm the crop or herd;
- create disease resistance in crops or animals;
- improve the food yield per plant or animal;
- make plants or animals more suited to special environmental conditions such as making them more drought tolerant;
- improve the nutritional quality of the food produced by the plant or animal.

There is also the potential that gene technology will deliver benefits to forestry and fishery enterprises.

The development of pest resistant and herbicide tolerant crops raises an environmental dilemma. On one hand there is the potential to reduce the use of chemical sprays. This will limit the build up of toxins in the food chain and other species not targeted by the sprays. However there are concerns about the potential of the introduced genes transferring from the crops to other species. These altered species could then become an environmental problem.

In Australia there is much current research into the agriculture and food applications of gene technology. The only major product of this research that has been released for use so far is Bt cotton.
Genetically modified (GM) canola, soy, potatoes, corn and sugar beet are grown commercially in the USA and products from these crops may be a part of the food we eat in Australia.

A food biotechnology timeline

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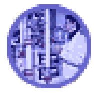
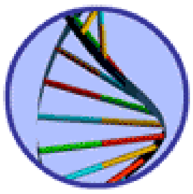
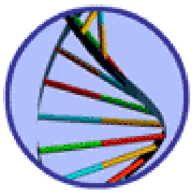


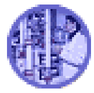
This timeline includes significant events that have led to the current use of gene technology in food technology. There are also some predictions about future developments in the application of gene technology to food production.

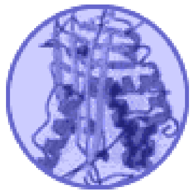


View the timeline

Biotechnology food timeline





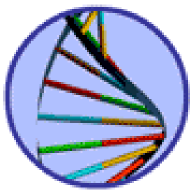


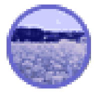
6000 BC	Yeast was used by Sumerians and Babylonians to make beer.
4000 BC	Egyptians discovered how to make bread using yeast. In China, other fermentation processes were discovered, such as the use of lactic acid bacteria to make yoghurt and moulds to produce cheese, and the use of fermentation to make vinegar and wine.
1300 AD	Aztecs harvested algae from lakes as a food source.
1673	Francesco Redi used an experiment to compare two competing ideas that sought to explain why maggots appear on rotting meat. He observed that meat covered to exclude flies did not develop maggots, while uncovered meat did. This is regarded as the first disproof of 'spontaneous generation', and was also one of the first uses of a controlled experiment.
1724	Anton van Leeuwenhoek (1632 - 1723) used his microscopes to make discoveries in microbiology. He was the first scientist to describe protozoa and bacteria and to recognise that microorganisms might play a role in fermentation.
1852	Cross-fertilisation in corn was discovered.
1863	Paris hosted an international 'Corn Show', featuring corn varieties from many countries, including Syria, Portugal, Hungary and Algeria.
1871	Louis Pasteur invented the process of pasteurisation, heating wine sufficiently to inactivate microbes and prevent spoilage, but not ruining the flavour of the wine.
1871	Ernst Hoppe-Seyler discovered invertase, an enzyme that cuts the disaccharide (sugar made of two molecules) sucrose into glucose and fructose. The enzyme is still widely used today in making sweeteners.
1879	In the USA, William James Beal developed the first clinically-controlled crosses of corn in search of higher yields.
1884	Gregor Mendel died after spending 41 years studying the 'heredity' factors of pea plants. Having received no scientific acclaim during his lifetime, he said not long before his death, 'My time will come'.
1897	Eduard Buchner demonstrated that fermentation can occur with an extract of yeast in the absence of intact yeast cells. This is a founding moment in biochemistry and enzymology.
1935	Andrei Nikolaevitch Belozersky isolated pure DNA for the first time.
1953	James Watson and Francis Crick proposed the double helix structure of DNA. This was published in *Nature*.
1962	Planting of high-yield wheat varieties (later known as 'Green Revolution' grains) began in Mexico.
1973	Scientists successfully transferred DNA from one organism into another for the first time, making a 'recombinant organism'. Viral DNA was added to a bacterium.
1980	Workers at Cetus Corporation invented the polymerase chain reaction (PCR), used to multiply DNA sequences.

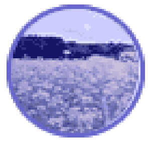
1982	Researcher Steven Lindow requested US Government permission to test genetically engineered bacteria to control frost damage to potatoes and strawberries.
1983	US patents were awarded to companies producing genetically engineered plants.
1985	The first deliberate release experiment was surreptitiously conducted by the firm Genetic Sciences - genetically engineered microbes were injected into trees growing on the company's roof.
1986	The US Environment Protection Authority approved the release of the first genetically engineered crop - genetically modified virus resistant tobacco plants.
1987	Calgene Inc. received patent for the tomato polygalacturonase DNA sequence, used to produce an 'anti-sense' RNA to extend the shelf-life of fruit (and eventually a similar construct was used to make the FlavrSavr tomato). Advanced Genetic Sciences Inc. conducted field trial of a recombinant organism, a frost inhibitor, on a strawberry patch in the USA.
1990	The first successful field trial of genetically engineered herbicide tolerant cotton was conducted in the USA.The first food products modified by biotechnology, an enzyme for cheese production and a yeast for baking, were approved in the USA and UK respectively. GenPharm International Inc. created the first genetically manipulated dairy cow. The cow was used to produce human milk proteins for infant formula.
1994	The first genetically engineered food product, the FlavrSavr tomato, received US Food and Drug Administration approval.
1995	GMAC allowed unrestricted, commercial release of a genetically modified blue carnation in Australia.
1996	INGARD® insect resistant (Bt) cotton was grown commercially in Australia.
1997	Researchers at Scotland's Roslin Institute reported they had cloned a sheep, named Dolly, from the cell of an adult ewe. Polly, the first sheep cloned by nuclear transfer technology bearing a human gene, appeared later.
1998	Scientists in Japan cloned eight identical calves using cells from a single adult cow. 40 million hectares of GM crops were planted globally, predominantly soy, cotton, canola and corn.
2000	The first entire plant genome was sequenced (*Arabadopsis thaliana*). 'Golden rice', a genetically manipulated variety with genes added that produce a vitamin A precursor, was created.
2001	The human genome was sequenced.
2005	Second generation of GM crops expected, with properties including: • elimination of allergens in food; • increased nutritional content; and • lower fat and oil levels.

2010	Third generation of GM crops expected, with properties including: • salt tolerance; • drought resistance; • drugs and vaccines in plants and food; and • plastic starter chemicals in plants.
Sources of information on the biotech timeline are: • What is Biotechnology? - BioteCanada http://www.biotech.ca/EN/what_history.html • Access Excellence - About Biotech - Biotech Chronicles www.accessexcellence.org/AB/BC/	

Herbicide tolerant canola







If you eat margarine and fish and chips you have probably eaten some canola oil. Canola oil, which is obtained from the seeds of the canola plant, is used in many food products and other products such as soap, creams and lotions.

Canola oil has a low level of saturated fat (7 per cent), a high level of mono - unsaturated fat (61 per cent) and a moderate level of polyunsaturated fat (22 per cent). Due to the low level of saturated fat, canola is regarded as a healthy oil to eat. Saturated fats contribute to health problems such as heart disease.

Issues facing scientists, food producers and the companies that sell seeds to farmers are:

- Weeds grow among the canola plants in paddocks. How can the weeds be removed without harming the canola plants?
- Canola oil is among the most healthy of edible oils. Can canola oil be made even more healthy?

Biotechnology may provide some answers to these questions. Gene technology is being used to produce canola plants that tolerate weed poisons. This allows an entire paddock to be sprayed, killing the weeds but not the canola crop plants. It is possible that gene technology could also be used to reduce the amount of saturated fat in the oil that the plants produce making canola oil even healthier to eat than it is now.

Better canola farming - the problem of weeds
Producing even healthier canola oil

Better canola farming - the problem of weeds

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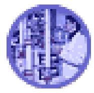
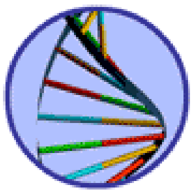


Weeds are plants growing where we do not want them to grow. They take up water and food from the soil so that the plants we want to grow have to compete for nutrients.

To get rid of weeds in a small garden we can pull the weeds out or dig them in. If the weeds are growing in a path we can use a plant poison called a herbicide.



Getting rid of weeds in crops is not so easy as they usually grow intermingled with the crop plants. It is very labour intensive but still common on small farms in Australia and developing countries. The most convenient solution is to spray weeds with a herbicide before the crop plants begin to grow. Spraying continues after the crop has grown to control weeds that grow at the same time. Usually the spraying is carried out using an aircraft or a boom sprayer pulled by a tractor. But there are problems.

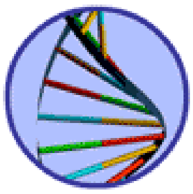
- If the wind conditions are not right it can be hard to control where the herbicide falls. It can drift onto houses, other valuable plants and into dams, creeks and rivers.
- It is often difficult to get the right weather conditions for spraying at exactly the right stage in the growth of the weeds and crops.
- The herbicide is required to kill the weeds but not harm the crop species.
- A single plant poison may not kill all species of weeds and a mixture of herbicides may be required.
- Generally a few individual weeds are not killed by a herbicide because they may be naturally resistant to the poison. These individuals may produce offspring that are also naturally resistant. This means that the number of weeds resistant to the herbicide used may increase from year to year.

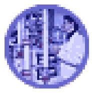
A herbicide
A biotechnology solution to weeds
Is canola that is tolerant to herbicides a good thing?
Tolerance to herbicides and the environment

Fat, cholesterol and your arteries

What people know about canola
All about weeds
How gene technology is carried out
What people know about genetically modified canola
Growing GM canola in Australia?

A herbicide





Glyphosate is a herbicide that kills almost any plant when it is sprayed onto the plant's leaves. The US-based company, Monsanto, sells glyphosate herbicide as Roundup® (for commercial and agricultural use) or as Zero® (for home use).

Glyphosate has some advantages over other herbicides. The spray does not dissolve well in water. This means that the spray that falls on the soil is not washed into river systems by rain. Because it sticks to soil particles and does not dissolve in the surrounding water it does not poison crops through the roots. Glyphosate is much less poisonous to animals (including humans) than many other herbicides. Also, it breaks down very quickly.

However, glyphosate can kill all the plants it falls on - both crops and weeds.

A number of other herbicides are also available to farmers. Farmers may spray their crops with at least two different herbicides because some weeds may be tolerant and survive the spraying with the first herbicide. Those weeds are often killed by the second or third spraying using a different herbicide.

A biotechnology solution to weeds

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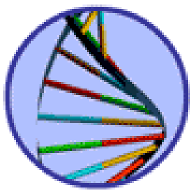

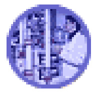

Some plants have a gene that makes them tolerant to a particular chemical herbicide. However, most of our crop plants do not naturally have herbicide resistance genes. But, in theory, we can put herbicide resistance genes into crop species.

There are three ways in which it is possible to develop crop plants that are not affected by a particular herbicide. These are the natural selection method, by conventional breeding and by using gene technology.

Herbicide tolerance created by natural selection

If a large population of a plant species is sprayed with herbicide, the few plants that survive will probably flower and produce seed. Some of these seeds will contain the genes that allow the plant to resist the herbicide. The herbicide resistance is passed on through generations of offspring and an increasing number of these plants will survive being sprayed by the herbicide.

If this process of allowing plants that survive exposure to the herbicide to develop and produce seed is carried out enough times, most seeds produced will be tolerant to the herbicide. The herbicide will no longer kill these plants.

Canola crops grown in Australia have some natural tolerance to herbicides. This natural tolerance has been enhanced by this method of selectively breeding herbicide resistant canola plants.

Glyphosate is a very effective herbicide. Only two grasses are known to have developed tolerance to glyphosate through natural selection. Developing herbicide tolerance in crop plants for this spray through natural selection is not likely to be easy.

Although instances of developing natural tolerance to herbicides are rare, it still presents the potential to cause problems. The crops may become weeds in the environment and, due to their tolerance of herbicides, it would be difficult to control them. Therefore caution is required in the use of herbicides.

Herbicide tolerance created using conventional breeding

Conventional breeding can also be used to create herbicide tolerant plants. By traditional cross breeding, favourable characteristics can be bred. This can accelerate the tolerance of a crop species to herbicides.

An example of a crop made using this technology is Clearfield® canola, marketed by Cynamid Agriculture with seed development company Pioneer Hi-Bred.

Varieties of Clearfield® canola have been bred, using traditional methods, to be resistant to imidazolinone herbicides, which include the marketed brand On Duty® . Use of such traditionally-bred herbicide tolerant canola varieties is widespread across Australia. Similar herbicide tolerance systems are also being developed for wheat and maize.

Creating glyphosate tolerance using gene technology

A gene, which causes a plant to be tolerant to the herbicide glyphosate, has been inserted into a strain of canola. The so-called 'Roundup Ready' seeds will grow into a crop that will not be affected when the weeds in the same paddock are killed by spraying with Roundup.

Is canola that is tolerant to herbicides a good thing?

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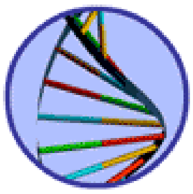

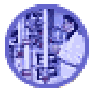

Many people say that herbicide tolerant canola is a good thing, others say that they are worried by this development. The people who say that Roundup Ready canola is a good thing say that it:

- is safe to eat;
- is better for the natural environment, because Roundup is less toxic than other herbicides and is not washed into waterways;
- helps to minimise tilling and soil degradation;
- enables farmers to have a choice on the weed control strategy they use;
- saves farmers some of the time and the labour costs of spraying;
- improves profits because farmers get better crop yields, since the crop is not competing with weeds;
- is better for company shareholders, because company profits are increased (although Monsanto is the company that most people associate with GM food, there are in fact more than 20 other companies currently producing GM seeds, such as Advanta, Novartis, Dow, Pioneer and Aventis); and
- is better for the seed merchants, because they can sell higher quality seeds at a higher price.

The people who are worried say that the Roundup Ready canola gene:

- may produce substances in the plants that are harmful to humans and farm animals;
- may cause the plant to produce oil that does not have as much food value as unmodified canola;
- may end up in other plants including weeds and make them herbicide tolerant too;
- may have unpredictable effects on other genes and the way they work;
- may not be good for farmers because the seeds tend to be more expensive to purchase than the traditionally used seed; and
- may encourage farmers to use more Roundup herbicide and so weeds may be more likely to develop resistance to this useful chemical.

A number of these points of view seem to be contradictory. We need to examine the evidence to decide whether or not each of these views, for or against the use of GM seeds, is valid.

For further points of view on these matters and some of the evidence that supports them, visit CSIRO at http://www.csiro.au/pubgenesite/faqs.htm and http://genetech.csiro.au/debate.htm

and The Australian Conservation Foundation at http://www.acfonline.org.au/campaigns/geneethics/briefings/food_table.htm and http://www.acfonline.org.au/campaigns/geneethics/briefings/infosheet.htm

Tolerance to herbicides and the environment

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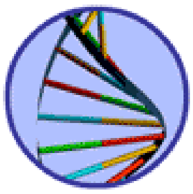

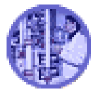

People who are concerned about using plants genetically modified for herbicide tolerance are generally worried that:

- the plants will 'escape' into the natural environment and grow and become a problem;
- the plants will interbreed with other plants in the environment and produce 'super-weeds' that are resistant to a number of herbicides; and
- there will be a transfer of the gene to non-GM and 'organic' crops.

Plants may 'escape' if their pollen or seeds are taken outside the paddock.

Pollen is carried by the wind, insects or other animals. Farmers have no control over where the pollen from their plants ends up. However it is possible to change the pollen-making genes in a plant so that the plant produces no pollen, or pollen that is not able to produce seeds. As a result the genetically modified plants cannot interbreed with other plants, and so make weeds that are difficult to control with herbicide.

The most commonly used crop plants are hybrids (crossbred) and such plants do not usually produce seed that is capable of germinating into the next generation of plants.

However, if the plants do 'escape', they will only survive and become a potential problem if they have properties that enable them to compete successfully with plants already in the natural environment. A ten - year study in Britain has shown that this is not the case for currently available GM strains of canola, corn, sugar beet and potatoes.

Producing even healthier canola oil

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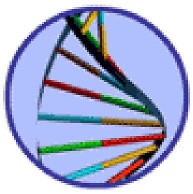

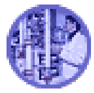

Some oil is good for our health. However, excessive intake of saturated fats in the oils and fats that we eat can cause health problems for our arteries and, in particular, our heart. This is due to the fact that the saturated fats cause build up of High Density Lipoproteins, sometimes called 'bad' cholesterol, in our bodies. In a healthy diet, most fats and oils eaten should be unsaturated (mono - unsaturated and polyunsaturated).

The amount of each of these fats produced by an animal or a plant is generally controlled by its genes. It might be possible for us to change these genes in canola plants so that they produce less saturated fats and more unsaturated fats, making canola even healthier to eat.

Canola crop

A canola crop in flower.

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Genetically modified soy

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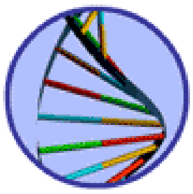
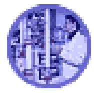
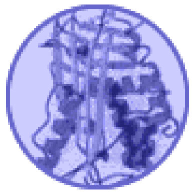






Soy is a very important ingredient in modern foods. Soy is eaten as tofu and soy beverages (such as soy milk). About two-thirds of all manufactured food products contain a soy-based ingredient. These include:

- oils (as vegetable oils and fats);
- soy flour;
- lecithin (an extract from soy); and
- soy protein.

Soy is one of the six main crops used worldwide for oil production. Others include canola, sunflowers, oil palm, cotton and peanuts. Soy proteins are thought to be able to reduce cholesterol levels in the body. Soy is also used as an ingredient in animal feed.

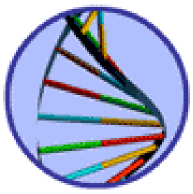
Soy is an important food ingredient because of its widespread use and nutritional qualities. Due to this, soy has been a focus for scientists working on genetic modification of plants.

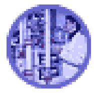
Improving the nutritional value of soy through gene technology
Nutritional content of herbicide tolerant soy

Ask the experts

Looking at labels
Looking at media views - GM foods
Organic farming

Improving the nutritional value of soy through gene technology





Genetic technology may change the nutritional value of soy.

Changing the protein content of soy

Researchers are looking at improving the protein content of soy varieties. This includes increasing the amount of:

- lysine – one of the amino acids which are the building blocks of proteins; or of
- glycinin – a storage protein.

There are no soy products with these modifications on the market yet.

Changing the types of oils in soy

After assessment by the Australia New Zealand Food Authority, Health Ministers have approved the sale of foods containing specific varieties of genetically modified (GM) soy, with an altered balance of oils in them. This type of soybean was first produced in the USA in 1996.

Unmodified soy beans are a source of polyunsaturated vegetable oils, similar to the types of oils found in margarine. Some GM soy varieties contain increased amounts of oleic acid (a mono-unsaturated fatty acid). These GM varieties of soy were created by adding extra copies of a ‘ desaturase’ gene – a gene which occurs naturally in soy plants.

The extra desaturase genes result in ‘ high oleic acid soy beans’ – the beans have a higher percentage of oleic acid than unmodified beans. The extra genes work by silencing an existing gene, and so reducing the conversion of mono-unsaturated oleic acid to polyunsaturated oils.

Benefits of these GM soy varieties

The main reason for making the change was to create a more versatile cooking oil. High oleic soy oils do not smoke when they are heated to high temperatures, and are better than unmodified soy for re-frying, and during refining and storage.

The change in the balance of the oils in the modified soy beans does not have any significant impact on the nutritional value of the oil. But if the improved cooking properties meant that soy oil replaced other (saturated) frying fats, this would contribute to improved nutrition.

Nutritional content of herbicide tolerant soy

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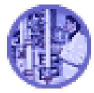
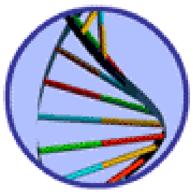
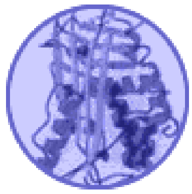


Soy is an important food ingredient because of its nutritional properties and its widespread use in processed foods. It is critical that the effects on the nutritional value of genetic modifications of soy are examined.

Comparing conventional with herbicide tolerant soy

Feeding studies in catfish, chickens, rats and dairy cattle have shown that their body weight and composition did not change when fed herbicide tolerant soy. In addition, the milk from dairy cattle fed the herbicide tolerant soy did not change its production levels or composition.

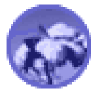




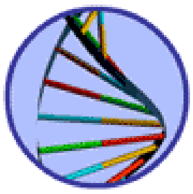
Studies of the plants themselves have not shown differences in composition between conventional soy and soy tolerant to glyphosate herbicide.

The Australia New Zealand Food Authority (ANZFA) has approved the soy from these herbicide tolerant plants for use in foods for human consumption.

Insect resistant cotton



Cultivated cotton plants grow to about 1 to 2 metres tall. The plant produces white flowers from a bud. When the bud has flowered, it turns pink and the petals fall off. Seeds that are then formed in a small green pod called the cotton boll. Huge numbers of seed hairs form around each seed and these white fibres become packed around the seed inside the boll. When the boll is mature, it bursts open, showing the soft cotton fibres, which exist to help the cotton seeds to be distributed. This is the cotton fibre that we harvest.



Cotton fibres are about 2 - 4 centimetres in length. They are made up of about 87 - 90 per cent cellulose. This is a tough carbohydrate molecule that makes up the cell wall of all plants. The fibres also contain 5 - 8 per cent water, and about 5 per cent other substances.

The length of the cotton fibre determines the quality, and therefore the price, of the cotton produced. The longest fibres are woven into the highest quality cotton fabric.

A major insect pest of the cotton plant is the cotton boll weevil. The US company Monsanto has developed a variety of cotton with built-in resistance to the boll weevil, and other scientists are researching the use of viruses and venoms to kill cotton pests.

A problem with insects

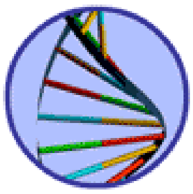
- PDF **Insects and cotton**
- PDF **Butterflies and Bt**
- PDF **How to engineer cotton**

- PDF **People do not agree about genetic engineering of crops**
- PDF **Looking at media views - GM crops**

A problem with insects

Australia's worst cotton pest is *Helicoverpa armigera*, a type of cotton bollworm.

Cotton is eaten by this grub or caterpillar, which is an insect larva. The adult is a moth that lays its eggs on cotton plants. When the larva hatches it starts eating the food that its mother has provided for it. The grub then burrows into the cotton seed pod (boll) to find more food, thus damaging the cotton. Because of this it is called the cotton bollworm or cotton boll weevil.

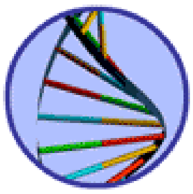


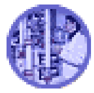
When the larvae have grown, they crawl down the stem of the plant into the soil. Here they turn into pupae, inside a hard case. The pupae metamorphose (change) into the adult moth stage in the soil. Four or five generations of these moths can be produced each year.

Cotton is also attacked by several hundred other species of insects apart from the boll weevil. The cotton leafworm, cotton fleahopper, cotton aphid, rapid plant bug, conchuela, southern green stinkbug, spider mites (red spiders), grasshoppers, thrips, and tarnished plant bugs all feed on various parts of cotton plants.

Killing the cotton pests - insecticide sprays
Current research into killing cotton pests using viruses and venoms
Killing a cotton pest using biotechnology
Natural selection at work - insecticide resistance
Natural selection and insecticides in GM plants

Killing the cotton pests - insecticide sprays





Damage caused by some of the insects that attack cotton can be limited by planting crops at a time of the year when the insect concerned is not in its feeding stage. Some varieties of cotton are naturally resistant to insect attack. Up until the last few years the most effective way of dealing with crop pests has been the use of chemical sprays.

Australian cotton farmers spend $125 million each year on insecticides to protect their cotton. This use of insecticides raises a number of concerns.

- Insects can rapidly become resistant to insecticides.
- Insecticides can kill other types of insects as well as the pest species.
- Insecticides often kill other beneficial insects that prey on the pest species, thus destroying a natural way of controlling the pest.
- Birds that eat insects killed by the chemicals can become sick, causing some bird species to become endangered.
- Some insecticides are dangerous to people living and working in the cotton growing areas.

Although today's chemical insecticides are much safer than in the past, there are still problems with using them.

Current research into killing cotton pests using viruses and venoms

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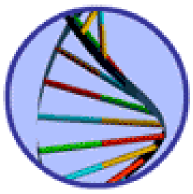
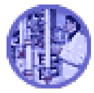




All living things have to contend with viruses, bacteria and fungi that may cause illness or death. For example, humans get colds and flu caused by types of viruses that grow in the cells of the nose and throat.

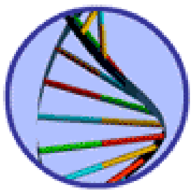
Baculoviruses are a group of viruses that specialise in infecting the caterpillars of many moth and butterfly species.

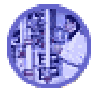
Scientists in the USA have genetically engineered a baculovirus that is intended to control cotton caterpillars. Scientists in Australia are considering importing these experimental baculoviruses for laboratory trials.

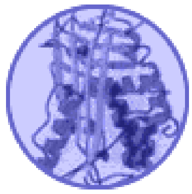
The genetically modified baculoviruses contain a gene for a scorpion venom. When the baculovirus infects the caterpillar, it invades the caterpillar's cells. The cells take up the gene for scorpion venom and begin to produce it. The venom paralyses the caterpillar, in the same way that a scorpion sting would do. The caterpillar dies within 36 hours.

The Australian research is being done in laboratories that will not allow the baculovirus to escape into the environment. Scientists will need to find out how the baculovirus behaves in Australian conditions, whether it infects non-target insects and if it competes with Australian baculoviruses before its release here.

Killing a cotton pest using biotechnology







The bacterium *Bacillus thuringiensis*, or Bt, is a naturally occurring soil bacterium. It produces proteins that kill insects. Sprays containing Bt bacteria have been used as pesticides on farms, including organic, for many years.

By the early 1990s the cotton bollworm had developed resistance to most chemical pesticides. Scientists working for the US company Monsanto developed a gene they called INGARD® , which contains a Bt gene. When the gene is inserted into cotton plants a protein is produced that kills the bollworm caterpillars. The poison stays in the leaves and does no harm until the bollworm eats the leaf tissue. It is very specific, that is, it only kills the bollworm caterpillars and very closely related species. It is said to be harmless to humans and other animals.

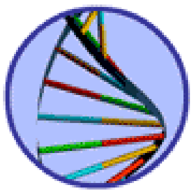
CSIRO plant industry scientists have worked with Monsanto and other companies to develop cotton varieties containing the INGARD® gene that are suitable for Australian conditions.

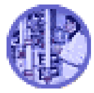
In 1999 about 40 million hectares of Bt genetically engineered cotton were planted worldwide. This area is increasing year by year. About one third of cotton crop grown in Australia (about 100 000 hectares) is Bt cotton.

Some bollworm caterpillars may be resistant to Bt. Therefore Bt cotton crops still need to be sprayed with insecticides to kill any surviving caterpillars, but the amount of insecticide spray used on cotton crops has greatly reduced since the introduction of INGARD® cotton.

You can find further information about Bt cotton by going to the CSIRO site at http://www.csiro.au and searching using the term 'Bt'.

Natural selection at work - insecticide resistance





Insects become resistant to chemical insecticides very rapidly. This can happen in as few as 5 generations.

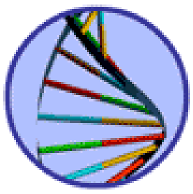
The problem is that an insecticide never kills all of its intended victims. If even a few survive they will reproduce. They will produce two types of young - those that are resistant to the spray and those that are not. The non-resistant ones will be killed by the next spraying but those that are left reproduce. At each generation, the number of naturally resistant insects in the population increases.

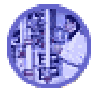
This means that an individual insect does not become resistant. It is born either resistant or non-resistant, but the population as a whole will gradually become resistant to the pesticide.

As this occurs a new pesticide must be developed. Over time populations of insects can become resistant to more and more pesticides. Humans are forced to produce different, generally stronger, pesticides.

Natural selection and insecticides in GM plants

Home > Food and agriculture > Insect resistant cotton > A problem with insects





One of the problems with any insecticide is that populations of insects soon become resistant to the poison. This applies to artificial and natural insecticides, as well as to those insecticides inserted into genetically modified plants.

Two solutions to this problem are being worked on.

One solution is the 'double and triple whammy'. This method involves adding two or three insecticide genes to the plant. This means that two or three poisons are produced. If the insects become resistant to one, the other may still kill them. The numbers of bollworms that survive three different genetically engineered pesticides will be very small.

The second solution involves refuges. These are areas of land near the crop that are planted with cotton that is not genetically engineered. Farmers are not allowed to spray the plants in the refuges.

The bollworm moths will be able to grow and breed safely in the refuges and the population of moths that are not resistant to any pesticide will remain high. These non-resistant moths will be able to breed with the moths that have grown from caterpillars that have eaten the genetically modified cotton and survived, that is, are resistant. The eggs and caterpillars that are produced will probably not be resistant to the insecticide. These caterpillars will be killed when they eat the genetically modified cotton. Meanwhile, moths mating and living in the refuges where they will be safe to grow will lay some of the eggs. This will ensure that the numbers of moths that are non-resistant remains high.

The current regulations in Australia prescribe that only 30 per cent of total cotton crops can be Bt cotton and refuges must be used around all of these crops, to prevent the emergence of Bt resistance in cotton bollworms.

A problem with insects

Home > Food and agriculture > Insect resistant cotton

Helicoverpa is a pest for cotton and some other plants.

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Cotton plant

Home > Food and agriculture

Mature cotton bolls showing the cotton fibres.

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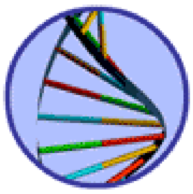
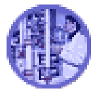
Regulation of the sale of GM foods





In Australia, the Australia New Zealand Food Authority (ANZFA) is responsible for carrying out safety assessment of foods including genetically modified foods.

Foods are only permitted for sale in Australia and New Zealand if they:

- have been assessed by ANZFA;
- are considered to be safe; and
- have been approved by the Health Ministers of the two National and eight State and Territory Governments as members of the Australia New Zealand Food Standards Council (ANZFSC).

All food sold in Australia must pass a thorough and rigorous safety assessment by ANZFA to gain approval for use. No other foods require the same level of testing and safety assurances as those derived from genetically modified crops. The safety assessments are based on all currently available data and if any safety concerns arise, the food will not be permitted in the food supply. ANZFA will only recommend approval for genetically modified foods if they are as safe as their conventional counterparts, with no change in nutritional value.

The Australia New Zealand Food Authority's safety assessment process for genetically modified foods is based on principles developed by the World Health Organization (WHO), the Food and Agriculture Organization (FAO) of the United Nations, and the Organization for Economic Co-operation and Development (OECD).

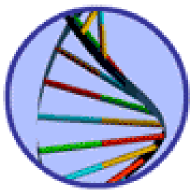
These principles require the cautious use of scientific, risk-based assessment methods and assessments on a case-by-case basis. The principles also require consideration of introduced genetic material and proteins to the food and the intended and unintended effects of the genetic modification, such as changes to levels of nutrients. They also require comparisons with any conventionally produced, unmodified version of an individual GM food, to look for changed characteristics.

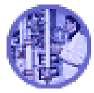
For more detailed information on ANZFA and food regulation visit the ANZFA web site at: http://www.anzfa.gov.au/

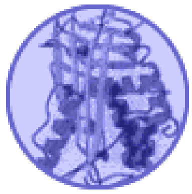
Ensuring your food, including GM food, is safe
GM food safety
GM food labeling

Getting the right stamp

Ensuring your food, including GM food, is safe







It is the role of the Australia New Zealand Food Authority (ANZFA) to ensure that all food, including genetically modified food, is safe and ANZFA's safety guidelines are based on world best-practice standards.

All companies, both from Australia and overseas, must, by law, comply with Australian regulations before they can sell genetically modified products in Australia. Using ANZFA guidelines, information supplied by companies, and world scientific literature, ANZFA's experts assess the characteristics of genetically modified foods to determine if they have been changed in any way which might make them unsafe.

There are five steps in the approval process for genetically modified food.

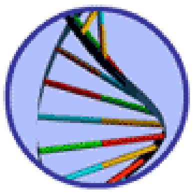
1. An initial safety assessment is made by ANZFA experts, with public comment invited.
2. A review of all the findings is undertaken.
3. A full safety assessment is conducted by ANZFA experts.
4. Final public comment on the proposed genetically modified food is invited.
5. A recommendation for approval or rejection is made to the Australia New Zealand Food Standards Council (consisting of the Health Ministers of Australia and New Zealand).

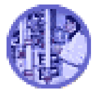
The full process can take up to 12 months. Each State and Territory Government is responsible for administering the enforcement of the food standards.

ANZFA
Australia New Zealand Food Authority

Data required to assess GM food safety
Scientific data used to assess GM food safety
Classification of food or food ingredients

Data required to assess GM food safety





Producers of all future GM foods - both domestically produced and imported - must apply to ANZFA to seek approval for the food to enter the food supply in Australia and New Zealand. A large amount of scientific information must be supplied with every application for food safety assessment by ANZFA. All scientific data obtained from the applicant must be generated according to international standards of Good Laboratory Practice in laboratories which are independently audited.

ANZFA supplements this data with information obtained from a variety of other sources, such as peer-reviewed scientific literature, general technical information, independent scientists, other regulator agencies, international bodies and the general community.

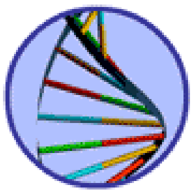
The general data requirements needed for a food safety assessment are:

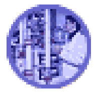
1. data on donor and host organisms and vectors;
2. food product information;
3. dietary intake;
4. nutritional data; and
5. toxicological data.

Click here for more detailed information on the scientific data used by ANZFA to assess the safety of GM food.

ANZFA Australia New Zealand Food Authority

Scientific data used to assess GM food safety



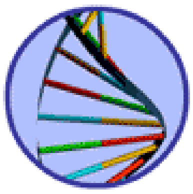
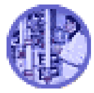


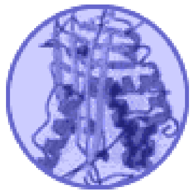
To make a safety assessment on GM foods ANZFA requires information on:

1. The identity of host and donor organisms.
2. Any known pathogenicity in host or donor organisms.
3. The previous use of host and donor organisms in food production.
4. The new genetic material that has been introduced through genetic modification:
   - origin, nature, purpose, function
   - method of introduction into the host organism.
5. The new genetic material in the GM organism:
   - number of complete or incomplete copies present
   - stability.
6. The new protein in the GM organism:
   - purpose, physical and biological characteristics
   - expression profile (which tissues the protein is found in and when the protein is present).
7. Potential adverse effects of the new protein, such as allergenicity and toxicity :
   - similarity of new protein to known allergens or toxins
   - physical features that are characteristic of allergens
   - acute toxicity (animal studies).
8. Composition compared to conventional counterpart - levels of nutrients, anti-nutrients, natural allergens and toxins.
9. Impact on human health from potential transfer of new genetic material to cells in the human digestive tract.
10. End uses of the food, including any requirement for processing prior to consumption.
11. If required, ability of the food to promote typical growth and well being (animal feeding studies).
12. Any other relevant information.

ANZFA
Australia New Zealand Food Authority

Classification of food or food ingredients



Foods or food ingredients produced using gene technology can generally be divided into five classes for the purpose of safety assessment.

Each class possesses distinctive properties allowing a separate safety assessment approach. This assessment scheme provides a general guide only. In practice, the type and extent of the safety assessment will largely depend on the nature of the food being considered in an application.

Group A consists of chemically defined substances such as food additives, processing aids, and agricultural and veterinary chemicals.

Examples:

- enzymes such as a-amylase (breaks down starches), chymosin (used in cheese); and
- veterinary chemicals such as porcine somatotropin (growth hormone), bovine somatotropin (growth hormone).

Group B consists of less well defined substances such as oils, fats, starch and protein where the composition may or may not be slightly altered.

Examples:

- vegetable oil from pesticide-resistant seed plants;
- sugar from insect-resistant sugar cane;
- starch from insect-resistant maize;
- vegetable oils with a modified fat composition from modified seed plants; and
- mycoprotein (fungal protein) from genetically modified yeast.

Group C consists of foods produced using GMOs (generally microorganisms) where the GMO has been removed from the final product, such as beer and wine.

Examples:

- beer produced using yeast modified to ferment at a colder temperature; and
- wine or beer produced using yeast modified to result in an altered flavour profile.

Group D consists of transgenic plants or animals, i.e. plants or animals which contain new or altered genetic material.

Examples:

- tomatoes containing the gene for Bt toxin;
- soybeans containing a gene which confers herbicide resistance;
- potatoes in which genes have been altered to result in higher protein content;
- pigs with altered growth characteristics; and
- sheep resistant to blowfly strike.

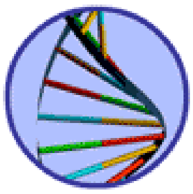
Group E consists of foods such as yoghurt where the genetically modified fermentation microorganism remains in the food.

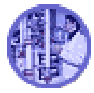
Examples:

- yoghurt containing a fermentation organism with increased phage (bacterial virus) resistance; and
- yoghurt containing a modified fermentation organism which leads to increased vitamin content.

GM food safety

Home > Food and agriculture > Regulation of sale





Some concerns about the safety of GM foods are driving a world-wide debate about the safety of foods from GM plant or animal sources and about the labeling of foods that may contain such GM products.

The approval procedures of the Australian New Zealand Food Authority (ANZFA) ensure that any new foods released onto the market are assessed for safety by answering questions such as:

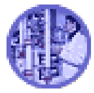
- Is the genetic material transferred the same as in its source and does it work in the same way in its new location?
- Is any of this genetic material present in the food product derived from the genetically modified plant or animal?
- Could any of this genetic material cause harm if it was transferred to human cells?
- Are new proteins produced in the plant as a result of genetic modification?
- Are these proteins present in the food product derived from the genetically modified plant or animal?
- Are any new proteins in the food product likely to be poisonous or cause allergies?
- Is the composition of the food product derived from the genetically modified plant or animal different from the non-GM form of the food?

Because the safety assessment process undertaken for GM foods is a more thorough process than that undertaken for all other foods, the level of safety associated with GM foods is at least as high as that of all other available foods. To find out more about ANZFA's safety assessment process for genetically modified foods refer to their publication, 'GM foods and the consumer', which is also available at: http://www.anzfa.gov.au/Documents/pub02_00.pdf

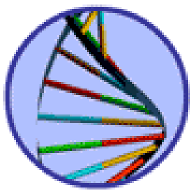
ANZFA
Australia New Zealand Food Authority

Conference on science and health of GM foods

Conference on science and health of GM foods



An OECD conference in Edinburgh concluded that 'many consumers already eat GM foods, though they do not necessarily know they are doing so. No peer-reviewed scientific article has yet appeared which reports adverse effects on human health as a consequence of eating GM food'. The 400 participants - from more than 40 and countries representing governments, industry and civil society organisations, including Greenpeace International, Friends of the Earth and GeneWatch - also highlighted some areas for improvement, such as the phasing out of antibiotic resistance genes in GM food crops and the role of labelling in giving the consumer choice.

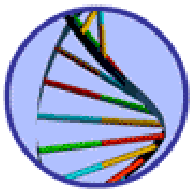


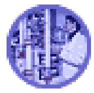
Hosted by the UK government, the conference formed part of an ongoing program of work at the OECD on biotechnology. The OECD conference provided an arena for international groups to meet and discuss issues on the science of biotechnology plus the broader issues of economic, trade and sustainable development.

Conclusions from the Edinburgh conference were fed into a meeting of the Group of Eight industrial countries meeting in Okinawa, Japan, in July 2000.

For more information visit the OECD web site.
http://www.oecd.org/subject/biotech/edinburgh.htm

GM food labeling





Because there is debate about the safety of GM food products and about ethical issues related to the use of gene technology, some people would like to know if any food product they are purchasing is from a GM source. In response to this, on 28 July 2000, the Australia New Zealand Food Standards Council (ANZFSC) agreed to new labeling rules for genetically modified foods or food containing such food products.

The new food labeling standard will require the labeling of food and food ingredients where new DNA and/or new protein is present in the final food or where the food has altered characteristics.

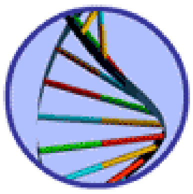
To give food manufacturers and importers time to revise their labels where necessary, the new standard will take effect in late 2001.

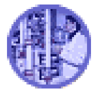
However, consumers will notice the introduction of labels on food containing GM ingredients progressively during the twelve months before this time.

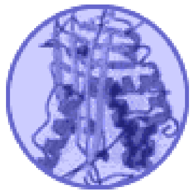
Some manufacturers may decide to introduce negative labeling in that period, indicating that food ingredients have been obtained from non-GM sources.

ANZFA
Australia New Zealand Food Authority

Regulation of research in Australia







Since 1975 Australia has had a voluntary system of controls over genetically modified organisms (GMOs). Australia was, in fact, one of the first countries in the world to set up a system that assesses the risks involved with dealing with GMOs, whether in the laboratory, through farming trials, or for general release.

The voluntary system revolves around an independent scientific committee. This committee assesses all work involving genetic manipulation to ensure that it does not pose unacceptable risks to the environment or to people.

The committee is currently called the Genetic Manipulation Advisory Committee (GMAC). The GMAC is a non-statutory advisory committee, which provides expert biosafety advice on the use of novel genetic manipulation techniques in Australia.

The need for regulation

While the GMAC has provided reliable scientific advice about the risks posed by gene technology, and how to manage those risks, the system is not backed up by legislation. This means there is no legally enforceable way to audit or monitor the use of gene technology or penalise breaches.

The Interim Office of the Gene Technology Regulator (IOGTR) was established as a branch of the Therapeutic Goods Administration within the Commonwealth Department of Health and Aged Care in May 1999.

The IOGTR has two primary functions:

- to work with State and Territory Governments, other Commonwealth agencies, and non-government organisations to develop and implement a new national regulatory system for GMOs; and
- pending the establishment of this new system, to provide support and direction to the current voluntary administrative arrangements for GMOs.

The Gene Technology Act 2000

Throughout 1999 and 2000 the States, Territories and the Commonwealth worked together with interested parties, to develop the Gene Technology Act 2000. The Act was passed by the Federal Government in December 2000. The legislation is the Commonwealth's component of a new national scheme for the regulation of GMOs, which will include legislation in every Australian State and Territory.

The Act is to take effect from 21 June 2001. Until 21 June 2001, GMAC will continue to provide advice on environmental and human risks associated with genetically modified organisms.

The objective of the Act is to protect the health and safety of people and to protect the environment by identifying risks posed by or as a result of gene technology and by managing those risks. It does this by creating laws for certain dealings (or activities) with GMOs.

Details about the regulatory framework for gene technology in Australia (including information on the Act and Regulations) can be found at the IOGTR Internet site http://www.health.gov.au/tga/genetech.htm

A scientific, ethical and precautionary approach

The Gene Technology Act 2000 establishes three key advisory groups to assist the Gene Technology Regulator assess the biosafety of GMOs:

- the Gene Technology Technical Advisory Committee (replacing GMAC) to advise on the science;
- the Gene Technology Ethics Committee to advise on ethical matters; and
- The Gene Technology Consultative Community Committee, to advise on community concerns regarding gene technology.

The object of the Act is also to be achieved through the application of the *precautionary principle*. The *precautionary principle* means that, *where there are threats of serious or irreversible environmental damage, a lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation*.

International arrangements

Working on international forums is one way Australia can encourage other countries to take up comprehensive arrangements to ensure the protection of people and the environment in the development of gene technology.

We need to ensure Australians and other nations act responsibly when exporting or transporting genetic material internationally. Likewise we need to ensure that people importing or transporting genetic material across Australian boundaries act appropriately. Through participation and agreement in an international treaty, countries can develop internationally consistent laws that bind each participating country to a common global approach to a global issue.

Convention on Biological Diversity

Australia is signatory to the Convention on Biological Diversity (CBD) and a member of the Intergovernmental Committee on the Cartagena Protocol on Biosafety. In response to the CBD, an international biosafety protocol is currently being negotiated through this committee. The protocol will govern the 'transboundary movement' (i.e. movement across international borders) of living modified organisms resulting from modern biotechnology, which may have an adverse effect on the conservation and sustainable use of biodiversity.

You can find evidence about the safety of genetically modified products around the world by examining the different regulatory arrangements around the world and the outcomes of other countries' research. While many countries are developing or have just established arrangements for regulating GMOs, some countries rely on self-regulation by industry and scientists. The Australian arrangements under the new Gene Technology Act 2000 set an international benchmark for managing the risks associated with GMOs.

The regulations in practice

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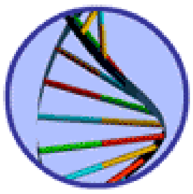

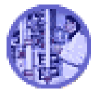

The following is a case study, under the voluntary system, from the CSIRO media release by Dr Jim Peacock on 7 September 1999.

Genetically modified plants are first developed in the laboratory, and when scientists are satisfied with the results they run glasshouse trials. From there, if the scientist is satisfied with the results, they move to small field trials, about the size of a suburban backyard, and from there to larger field trials.

Currently, a GM plant needs to be approved for trial by the Genetic Manipulation Advisory Committee (GMAC) and the Federal Government's Interim Office of the Gene Technology Regulator (IOGTR). These bodies oversee the release of all genetically modified organisms. If the plant is being used in a food it also needs to be approved by the Australia New Zealand Food Authority (ANZFA), which regulates food safety and is responsible for labeling of foods. An example of the process of regulation of GM plants was the INGARD® , also known as Bt, cotton. The crop was developed by CSIRO and its commercial partners to contain a new gene to protect it against insect attacks.

Using INGARD® cotton, growers have been able to cut pesticide use by up to 70 per cent. But before it was approved for use the plants had to go through many regulatory and testing stages to assess possible risks.

The CSIRO had to prove that the modified cotton couldn't breed with any Australian native plants which are related to cotton, so the gene couldn't 'escape'. They also had to show that they had strategies in place to prevent insects developing resistance to Bt, the protein that protected the plants from their attack.

And since the oil from the seeds of the modified cotton is used in cooking and to make margarine, ANZFA had to test it to make sure there was no health risk even though the cotton oil doesn't actually contain any genes or protein.

Biotechnology glossary

1080 poison
Sodium fluoroacetate, a highly poisonous substance used to control animal pests.

adult stem cells
Undifferentiated cells in a tissue. These cells can grow into any of the types of specialised cells in that tissue.

anaemia
A condition that is due to a reduced number of red blood cells or reduced amounts of haemoglobin within them. This results in reduced oxygen carrying capacity and reduced aerobic activity in body cells.

antibodies
Proteins produced by humans and higher animals in response to the presence of a specific antigen.

anticoagulant
Substance that prevents blood from clotting.

Bacillus thuringiensis
A species of soil bacterium that possesses a gene for a group of insecticides, the Bt toxins. Different strains of the bacterium produce different Bt toxins. The gene has been genetically engineered into cotton plants so that the plants produce the insecticide.

bacteria
A large group of organisms that do not have organelles enclosed in cell membranes and have DNA in both a chromosome and circular plasmids. They have a protein and complex carbohydrate cell wall over a plasma membrane.

base sequence
The order of the chemical units (bases) adenine, thymine, cytosine and guanine in DNA, that codes for a protein and so forms the genetic code.

biological control
The control of a population of an organism by another organism. Generally the controlling organism is a predator or disease-causing organism of a species that is a pest.

bioremediation
A natural process in which environmental problems are solved by the use of bacteria or other microorganisms that break down a problem substance, such as oil, into harmless molecules.

biotechnologists
Scientists who develop useful products using biological processes.

biotechnology
A broad term generally used to describe the use of biology in industrial processes such as agriculture, brewing and baking. Recently, the word has come to refer more to the production of genetically modified organisms or the manufacture of products from genetically modified organisms.

biotreatment
The treatment of a waste or hazardous substance using organisms such as bacteria, fungi and protozoa.

Bt
An abbreviation of the name of *Bacillus thuringiensis*.

calicivirus
The virus that causes Rabbit Calicivirus Disease, RCD, in rabbits. It is spread by mosquitoes and fleas.

carriers
Substances or particles that can transfer genes into a cell. These include viruses, liposomes (fat globules) and artificial chromosomes (sequences of DNA created in a laboratory) that can transport large amounts of DNA.

cellulose
A long-chain, branched polysaccharide that forms the cell walls of plants.

chemotherapy
The application of chemicals (drugs) to control the growth of cells that form a cancer.

cholesterol
A long chain molecule that is absorbed from food in the intestine or produced in the liver. It is needed as a part of blood plasma and of cell membranes.

chromosome
A threadlike component in cells that contains DNA and proteins. Genes are carried on the chromosomes.

clone
A group of genes, cells or organisms derived from a common ancestor. The members of the clone are genetically identical.

cloning
The process of production of a group of genes, cells or organisms that are genetically identical, from a common ancestor.

congenital hypothyroidism
An inherited trait that results in reduced activity of the thyroid gland, generally due to reduced production of thyroid stimulating hormone. The trait results in a reduced base rate of the body's chemical reactions, tissue swelling and weight gain. It can cause dwarfism in children.

CSIRO
Acronym for the Commonwealth Scientific and Industrial Research Organisation. This is a government-funded organisation that carries out research in science, industry and agriculture.

cystic fibrosis
An inherited disease that results in abnormal mucus secretion that produces severe respiratory problems, incomplete digestion and abnormal sweating.

diabetes
There are several forms of diabetes. It is a common condition in which the amount of glucose (sugar) in the blood is too high because the body is unable to use it properly. Normally, a hormone called insulin removes excess glucose from the blood.

DNA
Acronym for deoxyribonucleic Acid. A molecule of DNA consists of a long chain of deoxyribose, a 5-carbon sugar, and phosphate groups with the bases adenine, thymine, cytosine and guanine. DNA contains the genetic code that controls the production of proteins in living things.

double helix
Twin, parallel spirals. The handrails of a spiral staircase form a double helix. Alternating sugar and phosphate groups form a double helix in DNA.

Down's syndrome
An inherited condition due to extra chromosome 21 either as a third chromosome 21 or attached to chromosome 13, 14 or 15. Also called trisomy 21.

electrophoresis
The process whereby an electric charge is used to separate charged molecules in a mixture according to charge and size. It is routinely used to separate fragments of DNA.

embryonic stem cells
Undifferentiated cells in an embryo that are able to multiply and become differentiated into any sort of cell in the body.

endangered
A category of organisms with such low numbers in a population that the population is in danger of extinction.

erythropoietin
A hormone released from the kidneys and the liver in response to low oxygen concentrations in the blood. It controls the rate of

red blood cell production.

factor IX
A soluble blood protein that forms part of the cascade of the 12 reactions of blood clotting.

feral
A type of domestic animal that lives in wild conditions.

fertilisation
The process of union of male and female reproductive cells (gametes), during the process of sexual reproduction, to form a cell called a zygote.

gene bank
A collection of cells or artificial chromosomes containing known genetic information.

gene testing
Methods that identify the presence or absence of a particular gene in an individual.

gene therapy
The process of replacement of a defective gene in an organism suffering from a genetic disease. Recombinant DNA techniques are used to isolate the functioning gene and insert it into cells.

gene
A segment of a chromosome. Some genes direct the synthesis of proteins, while others have regulatory functions.

genetic disorder
A condition that results from a defective gene or chromosome.

genetic engineering
A technology used to alter the genetic material of living cells in order to make them capable of producing new substances or performing new functions.

genetic screening
The testing of a population for the presence of particular genes.

haemoglobin
The protein found in the blood of most vertebrates and some invertebrates that carries oxygen and small amounts of carbon dioxide.

haemophilia
An inherited disease that is due to a deficiency or lack of certain compounds in the blood. This results in impaired blood clotting and therefore excessive internal or external bleeding.

hazardous
Dangerous.

herbicide
A substance that kills plants. Herbicides are used in agriculture, horticulture and gardening to control unwanted plants. Herbicides can be selective, and kill selected species, or non-selective (broad spectrum), and kill all plants.

hormones
Substances in the blood that are produced by cells of an endocrine gland or by nerve cells in response to a specific nervous or chemical stimulus. They affect the metabolic function of those cells that have the appropriate receptor for the hormone.

Human Genome Project
The project that has identified and located all of the genes in human DNA, determined the sequences of the chemical bases that make up human DNA, and will store this information in databases.

human serum albumin
Soluble blood proteins that make up about 55% of plasma proteins. They are involved in maintaining fluid balance in the blood and plasma volume.

Huntington's disease
An inherited disease due to a defective gene on the short arm of chromosome 4. It results in loss of motor control and mental deterioration. The symptoms do not appear until the person is in the 30s or 40s, generally after the most common reproductive age.

immune system
The cells, biological substances (such as antibodies), and cellular activities that work together to provide resistance to disease.

immunocontraception
A method of reducing fertility of a pest species by controlling or preventing conception and pregnancy. Used in rabbits, it depends on the insertion of genes using the myxoma virus.

***in vitro* fertilisation (IVF)**
Methods of carrying out fertilisation outside the body, usually in a glass container such as a covered laboratory dish.

inherited disorders
Conditions that are due to changes in individual genes, or groups of genes or in sections of chromosomes or whole chromosomes. These changes may be passed from parents to offspring.

inorganic
Substances that are not organic, that is, are not manufactured in living things.

insecticide
A substance that kills insects.

insulin
A hormone of vertebrates and invertebrates that promotes the conversion of glucose to glycogen.

karyotypes
A description or display of the number and types of chromosomes of an individual.

lactoferrin
A protein in breast milk that promotes infant growth.

mammalian
Describes the group of vertebrates that have internal development of the embryo, mammary glands that can produce milk, live - born young, a body covering of hair or fur, a four-chambered heart, a well developed cerebral cortex, the ability to maintain a constant body temperature, and, in most adults, a permanent set of teeth.

marsupial
A mammal whose distinguishing features include the birth of young at an early foetal stage of development, and generally, a pouch (marsupium) in which further development of the foetus occurs.

microorganisms
Organisms that can be seen only with the aid of a microscope. They are also known as microbes.

mono-unsaturated
Refers to molecules, such as fats, that have one double bond only. Mono-unsaturated fats can lower blood cholesterol levels. Some oils and margarines, avocados, olives, nuts and seeds contain mostly mono-unsaturated fats.

muscular dystrophy
An inherited condition that is due a gene on the X chromosome. It is therefore called a sex-linked gene. It results in the inability to produce a vital muscle chemical resulting in muscle wastage, stumbling, then inability to walk and death by the age of about 20.

mutation
A change in the base sequence of a gene so it does not perform its normal task in the cell.

myxoma
The name of the virus that causes myxomatosis in rabbits. It is carried by mosquitos and fleas.

myxomatosis
A disease of rabbits caused by the myxoma virus. It results in streaming eyes, swelling of the head, difficulty in breathing and eventually death.

native
Refers to organisms that have not been recently introduced into an ecosystem.

nuclear transfer
The process that involves the removal of the nucleus of a cell followed by the transfer of a nucleus from another cell into it.

nuclei
Plural of nucleus, the structure within the cell that contains the chromosomes.

nucleotide
The sub-unit of nucleic acids, DNA and RNA, that consists of a 5-carbon sugar, a phosphate group and a nitrogenous base. The bases are adenine, thymine, guanine and cytosine in DNA and are adenine, uracil, guanine and cytosine in RNA.

organism
A living thing. The term includes anything that has DNA, from bacteria to vertebrates.

parasite
Organism that lives in or on another organism and uses it as a source of food and shelter, so that the host is damaged.

permafrost
An area that is subject to permanent ice and snow.

pesticide
A substance that kills pests.

pharming
The process of farming genetically engineered animals to be used as living pharmaceutical factories The practice has used cows, sheep, pigs, goats, rabbits and mice to produced large amounts of human proteins in their milk.

phenylketonuria (PKU)
An inherited disorder that results in reduced production of phenylalanine hydroxylase. This substance is involved in the breakdown of phneylalanine in food to tyrosine. In children this condition can result in mental retardation.

pigments
Chemicals that are coloured.

plasmid
A piece of DNA found in bacteria and yeasts that is able to replicate independently of the chromosome. Plasmids are usually circular.

polymerase chain reaction (PCR)
The process whereby a segment of DNA is cloned so that its sequence is multiplied many times in a laboratory.

polyunsaturated fat
A fat that has more than one double bond in the molecule.

predator
Animal that kills another animal for food.

protein
A long-chain molecule consisting of amino acids. The type and order of the amino acids in a protein is specified by the DNA in the cell that produces them.

rabies
A viral disease of wild animals that can be transmitted to humans through the bite of an infected animal. The disease has not yet been detected in Australia.

recombinant DNA
The DNA formed by combining segments of DNA from different types of organisms.

saturated fat
A fat that has only single bonds in the molecule.

social hierarchies
An arrangement within a group of animals, such as rabbits, where some individuals are dominant over others. The more dominant an animal, the more likely it is to have preferred access to mates and sources of food.

somatic cells
Body cells, that is cells other than sperm or eggs.

species specific
Refers to something that applies only to members of one species. A poison that is species specific affects only one species.

staple length
The length of the individual fibres of cotton. The length of the fibres affects the quality of the fabric that is made from it.

Tay-Sachs disease
An inherited disease that results in a build up of a substance called ganglioside in the brain. This causes brain damage.

thalassaemia
An inherited disease that results in reduced production of either alpha or beta haemoglobin. Symptoms range from mild to severe anaemia , stunted growth and bone deformities.

tissue culture
The process that involves the separation of cells from each other and their growth in a container of liquid nutrients.

toxic
Poisonous

trait
A feature that is genetically controlled.

transgenic
Refers to an organism with one or more genes that have been transferred to it from another organism.

vaccine
A preparation that contains either whole disease-causing organisms (killed or weakened), or parts of such organisms, used to confer immunity against the disease that the organisms cause. Vaccine preparations can be natural, synthetic or derived by recombinant DNA technology.

vector
A molecule of DNA, usually found in bacteria, that is used to carry foreign DNA into a host cell.

viruses
A group of particles that do not have a cellular structure and that consist of a molecule of DNA or RNA surrounded by a protein coat.