Agricultural Biotechnology Council of Australia

Biotechnology: the science

Biotechnology is the use of biological systems — living things — to make or change products. It has been used for centuries in traditional activities like baking bread and cheese and yoghurt making.

Traditional biotechnology involved for example, developing a new wheat variety with early ripening characteristics by cross-breeding different types of wheat and then backcrossing until the desired characteristics were present in the new wheat variety.

Agriculture itself can be regarded as a form of biotechnology because over thousands of years humans have selected animals and plants with useful qualities and gradually transformed them into today's familiar, highly productive crops and farm animals.

Today, biotechnology is indispensable to our health and wellbeing. Every society on earth uses and depends on it in one form or another. The treatment of sewage, production of antibiotics and the generation of food flavourings are all examples of the applications of biotechnology.

Since the 1950s scientists have learned that DNA is like a plan that is passed from one generation to another. **DNA** contains **genes** — messages coded with information that give living things their particular characteristics like eye colour. Scientists also discovered that all living things use the same type of code.

Modern biotechnology includes the discovery of genes (**genomics**), understanding gene functions and interactions (**functional genomics**), the use of **DNA markers** and genetic modification, which includes controlling gene activity, modifying genes and transferring genes to new hosts.

Gene technology is a key aspect of biotechnology. It includes a range of techniques used by scientists to switch genes off or move them between two unrelated species. Using gene technology, scientists aim to introduce, enhance or delete particular characteristics, depending on whether they are considered desirable or undesirable. Gene technology makes only small, precise changes to a species' genetic plan — usually only to one or two genes of the 50,000 or so a plant or animal possesses.

There is no need to make radical changes to plants, animals and beneficial microbes that are already well adapted to their environment. Quite subtle genetic editing can produce changes of great potential agronomic, environmental or human health benefit.

A genetically modified organism (**GMO**) is a living thing that has been genetically modified using gene technology.

Gene technology: benefits and risks

Everything in life has its benefits and risks. Gene technology is no exception.

In Australia, no genetically modified (GM) product can be released into the environment, or used in industry, until the regulatory body, the Office of the Gene Technology Regulator (OGTR), has approved the product, after reviewing its potential environmental and health impacts. Other regulatory agencies are also involved, depending on the type of GM product.

Like any new technology, there is no iron-clad guarantee that gene technology is completely safe, nor can all its health, environmental, economic or social consequences be predicted — good or bad. However, GM crops and foods have been grown, traded and consumed globally for 15 years with no adverse effects.

According to the World Health Organization, 'GM foods currently available on the international market have passed risk assessments and are not likely to present risks for human health. In addition, no effects on human health have been shown as a result of the consumption of such foods by the general population in the countries where they have been approved.'

It is critical in assessing GM products that the science and its applications are reviewed on a case-by-case basis, and the potential risks weighed up against the potential benefits.

How plant breeding works

Agriculture as we know it today relies on the use of crop plants (and animals) selected over thousands of years. These plants have been selected for many reasons, ranging from their resistance to pests and disease, their health properties, and the way they perform in the paddock.

The selection of these plants began as early as 12,000 years ago, when people first started to farm. Plants that were easy to grow and provided good food were chosen over those that did not grow well. This selection process continues.

In the last 200 years plant cultivation moved towards the active crossing of like plants to create new and improved plants.

What was not known until recently was how this operated at the genetic level. Each plant cross, be it in the wild, as in the case of wheat, or through deliberate plant breeding, involves the mixing of genetic material. In other words our ancestors moved genes between plants to enhance the beneficial qualities of food without understanding how this worked.

Modern plant breeding

Modern plant breeding aims to develop new varieties from an original plant, combining its qualities with an improved feature that is present in another plant. This feature may be resistance to a particular pest or disease, or tolerance to climatic conditions.

Traditional and new processes of plant breeding are illustrated at the end of this information paper. The new feature to be introduced is identified in another plant of the same species or in related plants. The original plant does not carry this feature. The original plant is crossed, through breeding with the plant that has the new feature. The resulting offspring should have the new feature, while maintaining the best qualities of the original.

The individual characteristic is present and controlled by a specific gene or a number of genes. As a result, traditional plant breeding mixes up all the genes in both plants. This means that thousands of genes can be involved in the one cross. The success of this process is determined by how well the desired characteristic combines with other desirable characteristics in the new plant. However, other characteristics that alter the plant for the worse can also be transferred. As a result there is no control over the transfer of these genes during the traditional breeding process, resulting both in wanted and unwanted characteristics.

Plant breeding and biotechnology

Biotechnology applications are helping to accelerate and refine crop plant breeding. Traditional breeding takes, on average, 12–15 years to produce a new variety. Many potential benefits are lost along the way, as plants that fail to demonstrate the introduced characteristic are discarded. As a result the process is slow and can be hit and miss.

Biotechnology has provided a far greater understanding of how biological systems of plants work. Many advances in plant breeding have resulted.

These advances allow the breeding process to be refined. It is possible to identify the genetic structure responsible for a single characteristic and its location in a plant. As a result, a desired specific characteristic can be introduced to a new plant quickly and efficiently. The speed of crop plant breeding has been accelerated through the use of these technologies and this has resulted not only in GM crops, but has also allowed new knowledge of gene function to accelerate conventional breeding programs.

New varieties of plants

Biotechnology has resulted in new varieties of insect resistant, herbicide tolerant and virus resistant crops that are under commercial cultivation globally. Genetically modified varieties of soybean, corn, cotton, canola, carnations, papaya, lucerne (alfalfa), sugar beet, roses and petunias are available in various countries around the world, while Australia grows cotton, canola and carnations commercially.

The development of crops that can tolerate climatic and soil stresses, such as drought, salinity and frost, resulting in more consistent production and less seasonal fluctuations are in the pipeline. Other research is looking at the development of foods with consumer benefits such as increased vitamin content or healthier oil profiles.

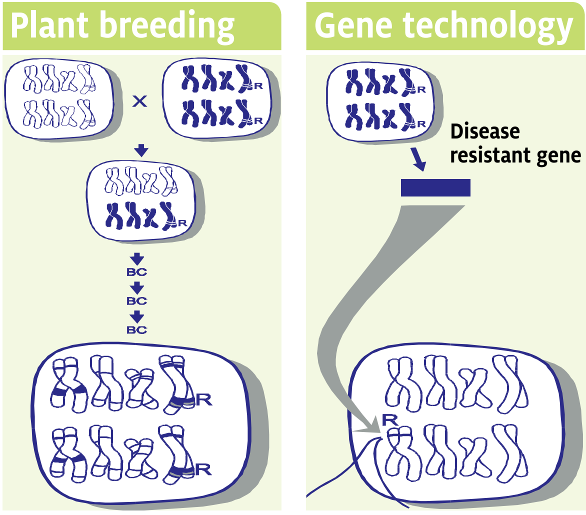
Impact of the new crops

The use of GM insect-resistant cotton varieties since 1996 in Australia has resulted in dramatic pesticide reductions. The latest insect resistant varieties available require about 80 per cent less insecticide than conventional cotton. It is important to recognise that the current commercially-available GM crops are not a universal solution to pest and weed problems in agriculture but are a part of an ongoing integrated strategy for sustainable agricultural production.

Australia's future prosperity

Australia's future prosperity is still strongly linked to the success of agriculture. Biotechnology, used responsibly and carefully, offers Australia the potential to maintain, and add to its variety of commodities/crops. Most commodity sectors in Australia are investing in gene technology and biotechnology research in order to remain globally competitive into the future.

Plant breeding: comparing conventional breeding and gene technology



Hundreds of extra genes together with disease resistance (r) gene

Single resistance gene

Source: CSIRO

Using gene technology, researchers can select a single gene of interest (such as a rust resistance gene) and insert it directly into a plant. Previously, two plants were crossed (one containing the gene of interest), and the resulting offspring had to be back-crossed (BC) both to eliminate unwanted features and to achieve the desired outcome.

For more information:

Cotton Australia www.cottonaustralia.com.au/cotton-library/fact-sheets/cotton-fact-file-biotechnology

CSIRO www.csiro.au/Organisation-Structure/Divisions/Plant-Industry/Gene-technology-information-kit.aspx

The International Service for the Acquisition of Agri-Biotech Crops (ISAAA) www.isaaa.org

World Health Organization www.who.int/foodsafety/publications/biotech/20questions/en/