New Zealand Biotechnology

animal biotechnologies

plant biotechnologies

agritechnologies

medical science

foods and health

processing natural ingredients

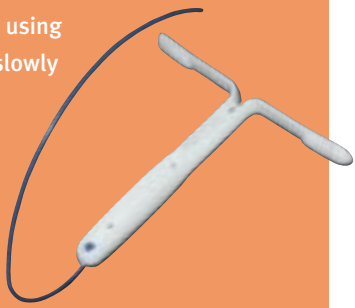
environment protection & remediation

Sore throats are often caused by bacterial infections, particularly in children. A lozenge that contains friendly oral bacteria that have been shown to help maintain oral health has been developed and commercialised in New Zealand. It capitalises on the fact that in nature, bacteria fight each other. The bacteria contained in the lozenge produce proteins that help inhibit the growth of bacteria that tend to infect throats. It is one of a range of products aimed at maintaining health and reducing the need to take antibiotics for common ailments.

Photo courtesy of BLIS Technologies, Dunedin

Possums represent one of the greatest threats to our natural environment, so researchers are developing a form of possum contraception. Proteins that coat the possum's egg cells will be introduced to the possum – either by a bait or possum-specific virus or worm – so that the possum makes antibodies that attack its own egg cells and it becomes infertile. This will slow the rate at which populations rebuild after poisoning.

Photo courtesy of Keven Drew, Landcare Research



Cows, sheep, pigs, deer and goats can be brought into oestrus using this insert, which is placed in the vagina for several days and slowly releases the hormone progesterone. Upon withdrawal of the insert, the animal's body responds by releasing eggs and becoming sexually receptive. The device was developed in New Zealand and is sold around the world. Farmers use it to bring non-cycling animals into oestrus, and to bring numbers of animals into oestrus at the same time to increase the chance of pregnancy following short-term exposure to males or artificial insemination.

Photo courtesy of DEC International, Hamilton

Oxygen starvation causes brain injury that develops into permanent brain damage. This can happen during events such as cardiac surgery or motor vehicle accidents, and to babies during the birth process. This machine, which was developed in New Zealand, is a world-first in being able to detect the injury before it turns into permanent damage. It does this by reading brainwaves at the patient's bedside. Traditional methods of detection, such as brain scans, only reveal the damage once it has become permanent. The very early warning that this monitor provides opens opportunities to prevent the damage becoming permanent. The monitor is being trialled internationally.

Photo courtesy of Tru-Test Ltd, Auckland

Strong history, powerful future

Making a living from technologies that use living things... it's old news for New Zealanders. Biotechnology has been in New Zealand for a century and a half.

Meat and dairy exports have formed the backbone of our economy for over a century, and plantation forests cover seven percent of our land. In order to achieve these things, we've had to develop and apply biological knowledge – experimenting with the right fertilisers and pasture crops, for example, and suitable sites, soils and tree species.

We've bred some of the most productive livestock in existence – our sheep farmers have left the rest of the world behind in the last 15 years by doubling lamb exports while nearly halving sheep numbers. We are the world's biggest producer of lamb meat, and the largest exporter of internationally traded dairy products. The international brewing industry respects us as the homeland of the novel 'continuous fermentation' process, and wine connoisseurs know we make some of the world's best wines. The 1960s and 70s saw our medical researchers leading the world in replacing faulty heart valves and saving premature babies.

Today, our biology-based enterprises are being combined with new scientific knowledge, particularly that based on genetics, to create new industries and opportunities. The uniqueness of the new frontiers being breached stems partly from our historical strengths - in agriculture, horticulture, medical research and the environment – and partly due to scientific excellence, a new commercial awareness, and a continuing pioneering drive.

This pamphlet gives an overview of the areas of science based on biotechnology (defined as technologies based on knowledge of living things) that are being pursued in New Zealand, and what we are good at. Our country is well placed to prosper in the biotechnology revolution going on around the world.

Harnessing genes

New Zealand has taken a strong genomics approach. Research institutions and companies have constructed genetic libraries that describe many of the genes of some of our key agricultural and horticultural species. They lead the world in this bank of knowledge for sheep, deer, forage crops, apples, kiwifruit, berries, radiata pine and eucalyptus.

Using genomic information, breeders can capitalise on natural variation in animals and plants, and breed future generations with targeted characteristics. When deciding which animals or plants to breed from, screening simple blood or tissue samples can reveal which organisms possess a gene or genes of interest. Such genes may increase meat tenderness, fertility, fruit flavour or disease resistance, for example – or reduce methane emissions. Conventional breeding procedures are then used to breed from specimens with those genes. This marker-assisted breeding can speed up by decades the advances that breeding without knowledge of the genomes could achieve.

The careful stud records and regular herd testing done by the New Zealand dairy and sheep industry provide an invaluable database to use in the process of identifying genes responsible for desirable characteristics.

Desirable gene variants, once identified, can also be artificially inserted into the genome of animals and plants through genetic modification to produce characteristics that are not possible with conventional breeding. Animal and plant scientists are trying to increase the precision of where new genes are inserted into a genome, as well as rates of gene uptake, in order to make the process more effective and efficient.

Cloning

Animals with desirable characteristics can be produced even more precisely by cloning. In this process, the nucleus is taken from a cell from an animal that is to be cloned and inserted into an egg that has had its nucleus removed. Egg development is switched on with chemicals that mimic the effect of a sperm entering it, and after a few days of growing in a culture medium, the embryo is implanted in a surrogate mother. Scientists around the world are working to improve the development and survival of these eggs, and cattle cloning is one area in which New Zealand researchers excel internationally.

Biopharming

Both plants and animals can be used to produce pharmaceuticals such as high value therapeutic proteins and antibacterial compounds. The term biopharming is generally applied to systems where a gene or genes are inserted for the purpose of making an animal or plant produce valuable compounds that it would not naturally produce.

In animals, the cloning procedure can be used, with the extra step of inserting a new gene that codes for the compound into the donor cell before cloning. The compounds are then harvested and purified from fluids such as milk. In plants, the gene is inserted into plant cells which are initially grown in a culture medium and then produce the compounds in chosen tissues, such as tubers, seeds, leaves or fruit.

New Zealand's farming system is well suited to biopharming because of its lack of serious livestock disease – we are arguably the 'cleanest' country in the world in this sense. Strict regulatory processes, and excellent veterinary care and husbandry systems, combine with very capable farmers and non-intensive outdoor farming systems to protect this advantage. Biopharming from plants, while in its infancy in New Zealand, has the particular advantage of producing pharmaceuticals from a non-animal source.

Plant Products

New knowledge about the way genes control a myriad of plant traits is making existing New Zealand industries stronger, and opening potential new ones. Discovering what switches genes on and off within plants is crucial to being able to manipulate many commercial traits.

- The way that plants branch and flower strongly affects the productivity of all of New Zealand's key economic plants. Flowers and low branches are undesirable for forest crops, and plant architecture dictates factors such as fruit quality and ease of harvesting in orchards. The search is on for genes that influence branching and flowering and when these are activated during the plant's development.

- Goals in forage crops, such as ryegrass and clover, include tolerance to heat and drought, reduced flowering, increased nutritional value and delivery of compounds to enhance the health of grazing livestock. The potential to include desirable grass genes in other crop plants such as cereals is also being explored, with the aim of enhancing traits such as disease resistance in the cereals.
- Non-traditional products from food crops are also being developed. Fruit flavours and aromas, sought after by food and perfume industries, are one such example. Their production in fruit can be increased using gene marker assisted breeding, and the valuable compounds extracted after harvest.
- For nearly three decades, propagation of plants in culture from tiny tissue nodules has been a niche business in New Zealand. The same technology has improved our food quality: every seed potato in the country, for example, is disease free as a result, and New Zealand was one of the first countries in the world to instigate this method of potato production.

Foods & Health

A large number of health-promoting compounds that are naturally present in foods are being investigated as high-value ingredients in their own right. New Zealand's excellent climate and fertile soils, combined with agricultural and horticultural expertise, means that it is well placed to expand production from traditional foods to include these highly marketable 'nutraceuticals'.

Plants contain many chemicals which can fight against challenges our bodies face, such as oxidation, inflammation, bacteria and cancer. Research into other foods has revealed a number of bioactive food components; milk, for example, contains bone-building compounds and natural antibiotics to control bacterial infections. Commercially focussed research is identifying these valuable bioactive compounds, enhancing their production, and designing systems to best extract them from fruit, vegetables, seafood, meat or milk. By drawing in medical researchers, the health effects of some of these compounds are being established in humans.

'Nutrigenomics' is an emerging field in New Zealand, which focuses on how a person's gene expression and diet interact. Capitalising on ever-increasing knowledge of the human genome, researchers are beginning to explore the way different genes affect how people break down, digest, store and excrete different foods. The goal of this research is to produce foods that are tailored towards different groups of people – for example, people with a high risk of heart disease - in order to enhance their health more specifically.

Agriculture to Biomedicine

The huge significance of pastoral industries to New Zealand's economy and our history of livestock research have resulted in a wealth of knowledge about agricultural animals. The country stands poised to make human biomedical advances as a result of combining this knowledge with advances in genomics.

- Groundbreaking new understanding of ovulation control has come from the discovery of a super-fertile ewe: more fertile ewes, and new human and animal fertility medicines and contraceptives, are expected to follow.
- Potential therapies for muscle wasting may stem from the breakthrough finding by New Zealand scientists of a naturally occurring gene mutation that leads to double muscling in cattle.
- New Zealand's dairy industry has added another string to its bow by searching for novel components in milk. Promising leads include growth factors and compounds to treat respiratory and immune conditions. Products are expected to range from functional foods to pharmaceuticals.
- The New Zealand-based discovery of the three dimensional structure of a valuable milk protein, lactoferrin, has helped build a strong research programme in structural biology. By deducing the structure of proteins produced by the genomes of organisms – such as that which causes tuberculosis – new drugs can be designed to combat major diseases. This technology is being applied both to human diseases and agricultural issues such as pest control, the regulation of plant growth and disease resistance.
- Research into vaccine production in sheep has led to their use in studies of the mechanisms of immune responses occurring at mucous surfaces such as the intestinal tract. This information is vital for the development of safe and effective vaccines for both humans and animals, and provides unique insights into immune responses to infectious disease and responses that lead to allergies such as asthma and eczema.
- Many of these research breakthroughs rely on knowledge of sheep physiology. These animals make excellent models of human systems.

Biomedical Science

New Zealand researchers have in-depth knowledge in the areas of neuroscience, cardiovascular disease, asthma, diabetes, cancer and osteoporosis. Understanding the relevant body systems – brain, heart, lungs, hormones, cells and bones – reveals ways to intervene in their disease states. In the last decade, 'blue skies' research has led to a range of treatments being patented and commercialised.

- The discovery that brain cells die hours or days after oxygen deprivation, rather than immediately, revealed a window of opportunity for treatments to prevent the progression to cell death and brain damage. New Zealand scientists are testing compounds based on the brain's own repair factors as potential drug treatments, and are also commercialising a novel bedside diagnostic device that detects brain injury shortly after it has occurred.
- Novel osteoporosis drugs have stemmed from the realisation that obese people tend to have dense bones. By examining hormones from the pancreas that rise naturally with obesity, researchers have identified several that exert bone-building effects. Fragments of these are being developed as sought-after drugs.
- A no-needle blood sampler has been developed in New Zealand, which uses ultrasound and a slight electric current to draw blood components up through the skin into a container for later analysis. It has been developed for use on high-performance athletes to correlate physiological measurements, such as hormone levels, with lifestyle factors and athletic performance.

Processing natural ingredients

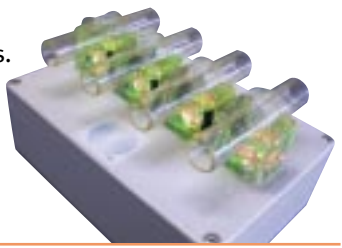
Historically, New Zealanders turned hops into beer, grapes into wine and milk into dairy products. Today, high value compounds are being identified in everything from milk and micro-organisms to fruit waste and fish skins. Once extracted and refined, using processes such as digestion, precipitation, filtration and separation of components, they are used in nutraceutical, pharmaceutical and food industries.

High value anti-cancer and other drugs are produced in New Zealand for companies in the United States and United Kingdom. This involves growing (via fermentation) the micro-organisms that produce the drug, then extracting it with solvents. This combination of fermentation and extraction expertise and facilities – along with following current good manufacturing practice – is rare and makes New Zealand attractive to international companies.

Sensors and diagnostics

Farmers have always strived for greater efficiency. From solar-powered electric fences to high-tech sensors for milk, kiwi farmers are fast to take advantage of new technology.

- Sensors that detect signs of blood or changes in conductivity indicative of tissue damage or infection in cows' milk have been developed in New Zealand, and are marketed internationally. These are placed inside milking machine tubes and relay data to a computer. In this way, bulk milk contamination can be avoided and cows treated promptly. The world's first computerised on-line sensor of milk somatic cell count – the international gold standard of udder health and mastitis status – is under development.
- Disease is a challenge to farmers, and solutions such as a slow-release zinc bolus that protects stock against facial eczema have been developed in New Zealand. A slow-release vitamin B12 injection to protect against deficiency in cattle and sheep originated locally, as did the world's only vaccine against toxoplasmosis and novel antibiotic-based mastitis treatments.



Environment

New Zealand is a fertile, productive island. Our resulting success at primary industry makes our environment and economy vulnerable to biosecurity threats and environmental contamination. Biotechnology offers ways to detect pests and diseases, and control and remediate damage already done.

- Contaminated soils such as those found at old orchards, waste dumps and mines could be cleaned up using trees that absorb toxic heavy metals. White rot fungi offer a new method of decontamination: they release an enzyme that rots wood. Many persistent organic pollutants – such as those prevalent at old sheep dip and timber treatment sites – are chemically similar to lignin, a primary component of wood, so the fungal enzyme also breaks these down.
- DNA and RNA-based techniques are opening new avenues to identify insect and plant pests at New Zealand's borders. Researchers are developing tests that will rapidly test the DNA or RNA of a suspect sample for a match with the sequences of known pests. This should enable simpler, faster and more accurate identification of pests, including insects that are in egg or larval forms, and allow border staff to act swiftly to intercept them. A long-term collection of many of the world's bacterial and fungal pests is proving to be a valuable resource for obtaining the DNA sequence information needed to develop these tests.
- Genomic techniques are helping researchers estimate how many possums (our major pest animal) survive after a culling operation: screening the DNA contained in collected droppings establishes how many animals produced the droppings.
- DNA sequencing is being used to assess and protect the diversity of our rare native species. By revealing the genetic differences and similarities between different populations of a species, the technique has revealed groups of freshwater fish, shorebirds, dolphins and reptiles that are genetically unique and therefore need special protection.

The Ministry of Research, Science and Technology
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Useful websites

www.biospherenz.com

Showcases New Zealand biotechnology businesses and highlights investment opportunities in the biotechnology sector. Provides key information on a comprehensive list of biotechnology companies and research institutes in New Zealand, and sector news.

www.biotenz.org.nz

Website of a group of New Zealand companies and institutions that focus on biotechnology, natural products, pharmaceutical and biological products and services. Provides information on members, lists of products and services, and sector news.

www.acri.cri.nz

Official website of the Association of Crown Research Institutes (CRIs). CRIs are science research businesses owned by the New Zealand Government. They undertake 'blue skies' and applied science and technology research and development, in many instances from the idea through to the commercial outcome. Contains links to each of the country's nine CRIs.

www.morst.govt.nz

Ministry of Research, Science and Technology – a New Zealand Government department which develops research and innovation policies and manages the publicly funded part of the research, science and technology system on behalf of the Government. It contracts other agencies such as the Foundation for Research, Science and Technology and the Health Research Council to manage the actual funding of projects.