Gene Editing (GE) in Aotearoa New Zealand 2025 and Beyond

Gene editing or engineering (GE), which falls under the umbrella term of gene technology, still seems something of a science fiction to many, even though the science in this area has been developing for more than fifty years.

Today, this technology is anything but sci-fi.

In the field of health, researchers and corporations are already using GE to find cures for many genetic disorders or the diseases caused by them. In other fields, gene editing has the potential for altering agricultural productivity and emissions, pest management, protecting endangered species, and producing novel and enhanced varieties of fruits and vegetables.

Through the improvement of laboratory research tools, it has now become possible to edit the genetic code of a plant or animal, including human beings. These tools can be used to read and compare genetic codes; to repair damage; and even to insert genetic code from other living things. The reasons for doing this are to provide the altered lifeform with advantages over its previous condition.

But is this always a good thing? Before we choose to use any technology, we have a responsibility to make sure we have thought about the consequences, good and bad.

What, precisely, are the benefits and risks involved? More importantly, how do we carry out a meaningful risk assessment when many of the risks are not easily measured or understood?

We cannot simply say that something is wrong, and therefore to be avoided, just because we do not understand it, or because it feels risky. This way of thinking could lead to us missing out on huge benefits for the future.

In the process of questioning the reason or purpose for using technology such as GE, the most effective way forward is to use ethical frameworks to weigh the risks against the benefits.

To begin with, we must understand our own ethical starting points. This is critical when there are contrasting and sometimes competing frameworks for assessing GE.

Even when a majority of people can agree on a framework or key principles, such as the 'precautionary principle', the 'common good', and/or 'human flourishing', the fact that people bring different interests to the GE debate means that we are likely to interpret and apply those principles differently.

For some people, their framework is shaped largely by the possibilities of economic benefits. For others, the need to protect the integrity of our natural environment means that they set a high bar in terms of what is deemed to be acceptable risk. For others, intergenerational responsibilities, social, cultural or religious values come to the fore.

A robust conversation needs all perspectives to be brought together. This reflects the reality that a rich understanding of human flourishing takes account of our physical, mental, social, cultural and spiritual dimensions, including our responsibilities for the integrity of the environment.

In other words, a genuine assessment of the use of gene technology needs to balance economic benefits and scientific progress with human well-being and the well-being of all life.

Ultimately, what is required is a robust regulatory process that all New Zealanders can have confidence in and that is transparent.

So why should you care about GE in particular?

Since governments have a significant stake in both the regulation and funding of GE applications, and because the likely consequences will affect all of us, as well as our children and grandchildren, the Government has a significant responsibility to consult widely and proceed cautiously for the sake of humans and the environment. Equally, as citizens, we all have an important stake in making sure we know who is doing what and having our say whenever laws and/or regulations are being reviewed, as is currently the case in Aotearoa New Zealand.

This resource is provided to give you a brief summary of some of the important things to know about GE and how it could affect us and the world we live in, including future generations.

A variety of reflection questions are offered throughout this document to stimulate individual and group exploration of the benefits and risks that might surround the many possible and potential uses of gene editing technology today and into the future.

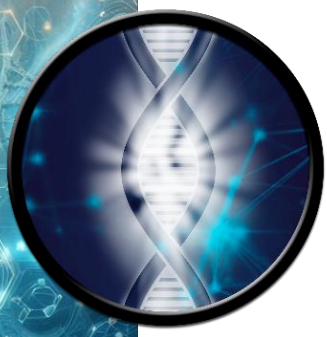
Understanding the issue

While there are common questions regarding GE technologies generally, there are also specific questions unique to Aotearoa New Zealand.

If your knowledge is broad enough to start exploring what an informed, ethical position might look like, you might like to go straight to the ICBC information article which has more information, references and discussion starter questions for you, your whānau and your community.

However, if gene editing is new to you, we hope reading this article will give you enough background information before reading the more in-depth ICBC material and the other resources that are provided.

What is a gene?



Every living thing, and each type of virus, has its own genetic code made up of DNA and its close relative RNA. This genetic code is a set of instructions that control how the living thing's chemistry and life processes work. Parts of the code that control a specific task or function are called genes. Every type of living thing has a unique set of genes and a unique number of genes. A human being is estimated to have about 35,000 protein coding genes. By contrast, an E coli bacteria has around 3,100; the common wasp (Vespula vulgaris) approximately 12,300; and cattle some 22,000 genes.

The information in a gene is used to make proteins that form structural components like bone or hair, and specialised cells and organs like blood cells and the liver or heart. The information in a gene also makes 'signal system' proteins, such as hormones and receptors, which act in different parts of each cell or body to carry out the jobs required to sustain life processes.

Genes can be controlled by internal or external chemical messages during the development of the living thing, right from when it is an embryo until its death. It is not only the genetic code of a living thing that determines physical development and health, but also when and how the genes are switched off and on, and in what combination. This area of genetics is called epigenetics, where genes are controlled differently in different cell types of a living thing, even though its cells have the same genetic code. This is how the cells of a living thing, all with the same DNA, can become specialised cells in different parts or organs of a living body.

Note that our genes are not changed by any genes or DNA in the plants or animals we eat as food, because food genes are broken down in our stomachs. (Similarly, any DNA or closely related RNA in vaccines do not change the genes of the injected human or animal as, after boosting the immune system, they are quickly broken down in the body and discarded.) However, what we eat does affect how well our body systems and metabolisms work, including the health of our genes.

What is gene editing?

Gene editing is a laboratory technique that scientists have copied from nature. It uses special proteins that act like scissors and glue to cut out sections of the genetic code and reattach the cut ends. This can also involve adding an altered section of genetic code to replace or add to an existing gene. Gene editing can be carried out in bacteria, viruses, plants and animals, including humans.

The best available technique for gene editing is called CRISPR-Cas9. CRISPR stands for Clustered Regularly Interspaced Short Palindromic Repeats and was first discovered operating in bacteria that use the process as a protection against virus attacks.

The Cas9 component is an enzyme which works like molecular scissors. The new gene sequence to be inserted is cut in the lab using Cas9 scissors which shape the ends in a way

that will match the cut ends to be made in the gene. Both this newly cut genetic sequence and the CRISPR component are then enclosed in a virus coat that can be easily taken up by their new host cells. Within the host cell, the new genetic sequence and its CRISPR component are guided by specific RNA to the targeted place in the genome. With the cut ends of the new gene sequence matching the cut ends of the gene inside the cells, they will successfully join. The normal cell machinery will then read the new code and make the corrected proteins.

What happens when you change genes in a living thing?

Any living thing (plant, animal or micro-organism) whose genetic makeup has been changed by gene editing is called a Genetically Modified Organism (GMO). A GMO will have the benefits of the new gene, or the benefit of having a faulty gene either fixed or removed. This helps the living thing to survive, be healthier, be more productive or resist predators or diseases.

It is important to note that genetic changes in animals are inherited only if the genetic changes are made in the reproductive egg and sperm cells. Gene editing in all other cell types in animals remain only with that specific animal and are not passed on to future generations.

Living things that can undergo asexual reproduction will pass on most GE changes to the next generations.

Currently, there are no countries that permit gene editing in humans to be passed on to future generations. Similarly, there currently exists a global ban on adding another species' genetic code into human genes.

How do we make good decisions about gene technologies?

Gene editing technology offers us the potential to improve our food productivity, ecology, and health outcomes. However, there are potential risks too.

We could be changing the genetic code of living things in ways that have unpredictable outcomes in the future. To avoid this, we need a well-informed discussion that first of all considers the science. But, in weighing up the pros and cons, we must also consider the social, cultural, ethical and spiritual viewpoints of New Zealanders. Following this, the implementation of new GE needs to follow guidelines that have been well thought out and account for as many 'unforeseen' problems as possible.

The environment in which we humans exist is an incredibly complex system. We do not exist independently from the living and non-living systems that support us. We are part of an inter-connected ecological array of relationships that sustain life. Biodiversity, conservation and restoration are important areas to consider when contemplating the application of gene technology moving forward. This is both in terms of the positive impact GE technologies can make in these areas and in the context of unintended consequences.

We human beings should not see ourselves as the centre of the natural world. Other living and non-living systems must be respected for their value and ability to exist without us. However, because of the power of technologies like GE, humans are uniquely placed to reshape relationships – human and non-human – within our own and other ecosystems for better and for worse. Faced with the possibility of using GE to implement changes that cannot be reversed, we need to give significant weight to the complex web of relationships that we are part of when undertaking the process of risk evaluation.

The HSNO Act which currently regulates GE in Aotearoa New Zealand makes specific mention of cultural, ethical and spiritual considerations. These were included following the 2001 Report issued by the Royal Commission on Genetic Modification which grouped the key values into three spheres: "cultural, ethical and spiritual; environmental and health; and economic and strategic." (p. 18) Thus, a robust evaluation of gene editing technologies would allow for critical interrogation via different cultural, ethical and spiritual worldviews, in particular that of tangata whenua. The intrinsic wisdom and value of these worldviews will only enhance our decision making. Achieving this requires a broad range of conversations.

The alternative to this is that GE and environmental decision making in Aotearoa New Zealand would be dominated by purely scientific and economic worldviews.

It is important to independently evaluate every GE application for all possible consequences. Specific benefits in one area might, unintentionally, create risks for others, and vice versa. The potential for unintended irreversible consequences for future generations places a unique and weighty responsibility on our generation to consider and regulate well.

We explore some potential applications and consequences of GE for Aotearoa New Zealand in the sections below.

How might the cultural, ethical, social and spiritual perspectives regarding the use of GE in NZ be adequately accounted for?

What is at risk if these views are not included in discussions about new GE technology regulations?

How might GE be used ethically for the wellbeing of: all people; the Aotearoa New Zealand environment; our economy; and the world?

What are the potential benefits of GE?

One area of considerable benefit for GE is agricultural production. By using gene editing it is possible for animals to produce more and/or better products (like meat, wool, eggs, and milk e.g. A2 milk); to grow faster; and/or to be more resistant to pests, poor soil, or wetter or drier conditions. Plants and microbes can be gene edited to grow faster and produce better crops; to be more pest resistant; and to reduce greenhouse gases which are known to be a major contributor to climate change (e.g. methanotrophic bacteria).

For conservation, protecting endangered animals and plants could be assisted by giving them genes to help them survive the changing environment in which they live; to make the pests that attack them unable to have offspring; or to make them resistant to diseases or unable to be eaten by pests. Gene editing could also be used to help reduce the number of pests by making it difficult for pests such as the Brushtail Possum to reproduce. Additionally, gene drive technology could be used to speed–up the spread of a GE change through a pest population such as wasps or possums.

In human healthcare, we are already able to genetically modify bacteria, plants and animals to produce medicines or products that boost our health or replace those that our bodies don't make enough of, such as insulin. Viruses can be modified to help our immune cells target cancer cells, or to carry chemicals that kill only the cancerous cells.

This same process of virus delivery can be applied to delivering medically active proteins that are specifically helpful to an individual, further advancing our capabilities in making personalised medicines that perfectly fit the metabolism controlled by an individual's genetic code. A simple GE CRISPR patch or injection could allow doctors to treat an illness very specifically and precisely, using the patient's own body to provide the cure. Already, in the UK and US, CRISPR has been used successfully to medically treat patients with beta thalassemia and sickle cell disease, both of which are caused by faulty gene sequences. In NZ, clinical trials are underway using genetically edited CAR T-cells to treat cancer patients uniquely and effectively.

What are the potential risks of GE

As far as we know, gene editing is not easily reversible, especially if genes or their analogues have 'leaked' into the environment. This 'leaking' is termed *horizontal gene transfer* and could happen as a result of bacteria doing what they are good at – picking up GE genes from decaying things or body wastes and then sharing them with bacteria and other living things in another locality. In this way, a gene edit could possibly spread in the same or other species and could be difficult or impossible to reverse, resulting in unintended consequences that could then irreversibly negatively impact the natural environment.

While we are still learning how the human body works at all stages of life, we do not yet know for sure what effects gene editing could have, long-term, on the normal function of a person throughout their lifetime. Therefore, any epigenetic effects from treatments may only become apparent in the future, as would be the results of any gene edits made in error, or any unauthorised gene editing. The 'forever' impact of irreversible genetic modification requires a process of careful consideration and weighing of benefits with these risks.

In the area of agricultural production, faster growing stock and production could also have significant negative impacts on an environment's waterways and atmosphere. And, with the success of GMO crops and stock, farmers may feel pressured, economically, to buy specific GMO seeds or animals. This could reduce, rather than enrich, biodiversity; put some of our taonga species at risk; and, ultimately, lead to less choice and independence for farmers, including loss of food production and sovereignty for tangata whenua

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Who should determine what is an acceptable level of risk when weighing up the pros and cons of GE, and how should they weigh up that risk?

Conclusion

What is decided now, whether related to primary production, conservation or medical treatments, will affect not only us but also future generations. There is a responsibility to consider all possible outcomes for GE in NZ, pros and cons, including their cultural, social, ethical and spiritual impacts. The 'forever' impact of permanent genetic modification means our responsibility to future generations and to the eco-system as a whole must be adequately considered as part of the process of implementing, monitoring and regulating gene technology.

How might the needs of future generations be robustly and adequately considered when we cannot get their consent?

How might an approval and accountability process that is not unduly burdensome for researchers and developers be created without ignoring the voices of others?

Further resources for understanding the issues

ICBC-resource-Gene-Editing-in-NZ-for-2024-and-beyond.pdf
A resource article with background information, references and discussion starters.

https://www.royalsociety.org.nz/major-issues-and-projects/gene-editing-in-aotearoa/
NZ Royal Society information on possible GE in the NZ context.

https://www.pmcsa.ac.nz/topics/gene-editing/
Information from Prof. Dame Juliet Gerrard, PM's Chief Science Advisor (to mid 2024).

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