Gene Drives Information Sheet

TE TIRA WHAKAMĀTAKI

What is it?

Naturally, during the reproductive process of animals, and some plants, two parents will combine their DNA to create offspring that has a mix of traits from both parents. In humans, traits may look like brown or blue eyes, and in some cases, it is more likely for the child to have one trait than it is to have the other. Gene drives work to change this normal inheritance, they ensure that modified or selected versions of a gene from that parent are always passed on to an offspring, making them spread faster throughout a population. This genetic phenomenon, discovered in the early 2000s, allows scientists to engineer organisms, with help from tools like CRISPR, so that the traits they want are more likely to be passed on. This technique holds promise for addressing challenges such as controlling pests by offering a hands-off, poison-free approach. Specifically, gene drives could be used to make genes which reduce fertility spread through a population, making the species have less and less children every generation, removing the need for intensive trapping and poisons.

How it works

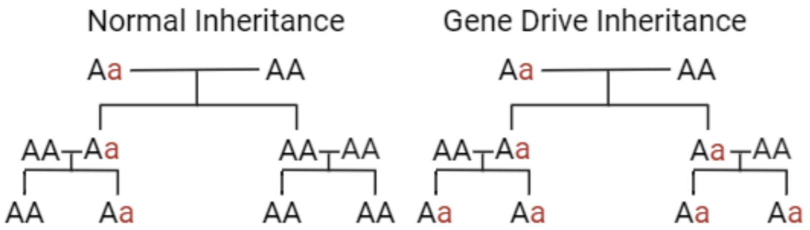
Imagine that the genes in an organism are a deck of cards and each card represents a different trait like eye colour, deafness or infertility. Normally, the decks of two parents are shuffled together randomly to give the combination of cards that a child will inherit. Gene-drives work like a magician doing a card trick. **With a genetic sleight of hand, they ensure that a certain card gets picked, or in this case, a certain gene is guaranteed to get passed on to offspring.** This is comparable to how scientists use gene drives to ensure that desired traits are passed down through generations, like infertility in pests.

Does it change the DNA?

Yes, inserting a gene drive requires scientists to modify the DNA of the organism to make the changes necessary. This lab modification is passed on through generations.

Normal vs Gene Drive Inheritance

In the diagram to the right, it shows how gene drive can be used to promote certain traits through the generations. Outlined in **red**, the desired trait (like infertility) represented as the small **a**, would normally only be passed on to some offspring. Through gene drive, it could theoretically be passed on to **all offspring**.



Has it ever been used?

Sort of, it has been done in lab populations of mosquito species which are carriers of malaria, but large-scale releases have not yet happened.

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How could this be used in Aotearoa?

Let's apply gene drives to a conservation challenge in Aotearoa, like controlling invasive mustelids (ferrets, stoats and weasels) that threaten our taonga species. What makes mustelids a perfect candidate for a gene drive is that they're spread throughout Aotearoa, including hard to reach areas like Fiordland. Due to the rugged and remote terrain, pest control with trapping is difficult. Much of stoat control therefore is undertaken with aerial 1080 drops. **Gene drives could have a more hands-off and specific control (i.e. no off-target impacts) method to meaningfully reduce pest numbers.** If scientists could identify a gene in stoats that, when an individual ends up inheriting two modified copies, reduces their ability to reproduce. This would leave most stoats healthy, and able to pass on the selected gene to future offspring. Eventually though, the whole population will inherit the modified copy. They will then be unable to have as many pups and the total population will gradually decrease.

This approach is targeted and species specific, minimising harm to other species. It may still be decades before a gene drive is developed for mammals and it will take decades after a gene drive is released into the wild to have a useful effect on the population. It is also likely that after its release, the trapping and baiting effort currently undertaken across Aotearoa would have to stop or lower significantly so that the stoats with the gene drive survive and breed.

Why should you care?

Gene drives are currently under development overseas for control of mosquitoes that transmit diseases like malaria and zika virus. The development of a mammal gene drive is still in the experimental stage, but many are looking to it as a key player to meet the predator free 2050 goal. Because this tool would be hands-off and cost effective, it would allow for us to focus our resources on protecting taonga species in other ways. But considering the difficulty with development, implementation and its long time frame, perhaps it shouldn't be looked at as the silver bullet. There are also concerns about containing a gene drive to populations of mammals within Aotearoa - if it 'escaped' overseas where these species are native, it could lead to widespread ecosystem and cultural damage. There is ongoing research in how to stop gene drives after they are released, which could help prevent this from occurring.

References and Additional Information

Ethical dilemma: Should we get rid of mosquitoes? - TED Talk

The potential for the use of gene drives for pest control in New Zealand: A perspective - Academic Article

Gene Drives Could Fight Malaria and Other Global Killers but Might Have Unintended Consequences - Article

Editing Our Genes: Pest Control - Article

Disclaimer: While we are committed to being a part of these conversations regarding Aotearoa New Zealand's future in synthetic biology, Te Tira Whakamātaki are neither for nor against the use of synthetic biology technologies for environmental protection purposes. The purpose of this information sheets is to inform and educate and to break down and explain some of the different terms and tools.This tools has been selected because it is frequently in the media and mentioned to us often, not because we hold any opinion on them.