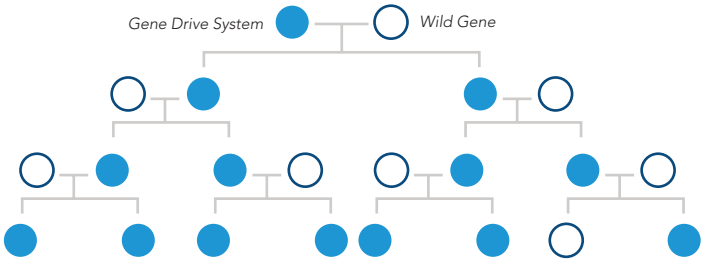
FACTS ABOUT GENE DRIVE

GENE DRIVE RESEARCH FOR THE PUBLIC GOOD

WHAT'S A 'GENE DRIVE'?

Gene drive is a genetic phenomenon that occurs in nature and causes a selected trait to spread rapidly through a species via sexual reproduction over several generations. Gene drive works by increasing the likelihood that a modified gene will be inherited by its offspring. Normally, genes have a 50/50 chance of being inherited, but gene drive systems could increase that chance to upwards of 99 percent. This means that over the course of several generations, a selected trait could become increasingly common within a specific species.

Figure 1: ***Gene Drive Inheritance***



GENE DRIVE APPLICATIONS FOR PUBLIC HEALTH AND CONSERVATION

Researchers have been studying if it is possible and appropriate to harness gene drives to solve some of society's most intractable problems. Public health and biodiversity and ecosystem conservation are two of the main areas where research has focused. In the field of public health, several proposals have been made which would use gene drive to limit the spread of diseases, particularly those spread by insect vectors, which affect several hundred millions of people a year. This could be done by spreading a trait which makes the vector organism unable to host the pathogen, or one which affects the local population dynamics of the host organism. Gene drive technologies could also be used to control organisms that serve as a reservoir of diseases, such as rodents.

Additionally, gene drives approaches are currently being explored for conservation. Potential applications of gene drive in this field could enable the elimination of introduced, damaging invasive species which threaten native ecosystems or that carry infectious diseases that put the survival of other species at risk. This is for example being considered to manage rat populations on islands, where, as an invasive species, they undermine the survival of many local animals and birds.

GENE DRIVE FOR VECTOR CONTROL

One potential application of gene drive is to reduce the burden of vector-borne diseases such as malaria or dengue. Vector-borne diseases account for more than 17% of all infectious diseases and cause more than 700000 deaths annually[1]. The human and economic cost of these diseases is tremendous: malaria alone is estimated to cost African countries USD $12 billion a year.[2]

The Global Burden of Malaria

- Despite recent progress against the disease, in 2019, there were an estimated 409 000 deaths from malaria globally — the majority of them children in sub-Saharan Africa.[3]
- Today, half the world's population — about 3.3 billion people in over 87 countries — is at risk for malaria[4].
- Reducing global malaria incidence and mortality rates by at least 90% by 2030 could save more than 10 million lives and generate over US$ 4 trillion of additional economic output[5].

[1]*World Health Organisation, https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases, March 2020*
[2]*UNICEF "Fact sheet: malaria, a global crisis", August 2004, https://www.unicef.org/media/media_20475.html*
[3]*World Health Organisation, "World Malaria Report 2020", November 2020*
[4]*World Health Organisation, UNICEF "Achieving the malaria MDG target: reversing the incidence of malaria 2000-2015" September 2015*
[5]*Bill & Melinda Gates Foundation, Office of the UN Secretary-General's Special Envoy for Financing the Health MDGs for Malaria, Malaria No More "From aspiration to action: what will it take to end malaria?" September 2015*
[6]*For more reference on data in the box see https://www.islandconservation.org/why-islands/*


©Target Malaria

For a disease like malaria, a gene drive system could be introduced into a mosquito species. By modifying genes required for adult mosquito survival or parasite transmission, gene drive could significantly reduce the capacity of mosquitoes to transmit malaria. Although any application of gene drive is many years out, gene drive could one day complement existing approaches for malaria control. Because it would be inherited over successive mosquito generations, a gene drive system could potentially be a cost-effective and sustainable malaria control strategy that requires few repeat investments, particularly in communities where existing tools maybe costly and difficult to implement. Other applications of gene drive for other mosquito-borne diseases could also be considered, for example for dengue.

Gene drive for the eradication of invasive rodents from islands:

Another potential application of gene drive is to help protect biodiversity by reducing populations of invasive species on islands. Invasive species are the second greatest cause of plant and animal species loss globally. The cost of their impact and control efforts is an estimated five percent of the world's annual economy. Islands are particularly affected as they represent the highest concentration of both biodiversity and species extinctions.

Island communities, plants and animals are highly impacted by introduced, damaging (invasive) rodents which have invaded 80% of the world's islands and are a leading cause of extinctions on islands.

Currently, rodenticides are the best available tool that conservationists have to eliminate rodents on islands. Though highly effective, these operations are complicated and costly to implement due to the needs to avoid, minimize, and mitigate non-target risks. Gene drive methods of rodent eradication offer an alternative to rodenticides that has the potential to be more species-specific, more humane, and more biologically safe. The ongoing research aims at using a gene drive approach in mice to facilitate a bias of subsequent rodent generations to all be a single sex. The expected result is the creation of a final generation of mice unable to reproduce.

Why Islands?

80% of the world's island[6] groups have introduced invasive rodents.

40% of all highly threatened terrestrial vertebrate live on islands.

86% of extinctions of island species since 1500 AD are due to invasive species.

76% of mammals, birds, reptiles and amphibians' extinctions happen on islands.

[6]*For more reference on data in the box see www.islandconservation.org/why-islands/*

RESEARCH TIMELINE

Current research on gene drive is at an early stage. Although many applications have been proposed, there has not yet been field tests or environmental releases of gene-drive modified organisms. According to the current development pathway for a tool to control malaria-carrying mosquito populations, the earliest a gene-drive based tool could be presented for regulatory approval for evaluation is 2025, with several more years of testing before it could be considered for use. Invasive mice investigations are on similar time frames.