About Gene Drives

Gene drive is a naturally occurring phenomenon that happens when a gene is inherited more often than normal, which allows it to spread through a population even if it reduces the likelihood that each organism will reproduce. There are many examples in nature, including some that always make offspring male, which in some cases have caused populations to severely decline.

Thanks to the discovery of CRISPR gene editing, we can mimic the gene drives found in nature.

Because gene drives can be very powerful, our group is focused on developing safeguards and local versions of these systems to give communities the ability to solve problems affecting only their own ecosystems without risking unintentional spread to other areas.

Our group is developing several types of **local drive systems** in the lab:

Daisy drive: In a “daisy drive,” the gene drive is designed to lose some genetic fuel (which we call "daisy elements") over each generation. Adding more daisy elements ensures the drive continues for more generations, adding fewer means the drive will run out faster. When the drive runs out, the genes are no longer inherited more than 50% of the time and will eventually be lost in the population due to natural selection.

Threshold dependence: We can duplicate a naturally occurring phenomenon in which two distinct populations cannot easily produce offspring together. In this case, mating between edited and wild organisms will only produce half as many offspring as either can with their own kind. Whichever population is in the minority in an area will eventually decline. This design ensures that edited genes will eventually be eliminated no matter what happens.

Safeguards

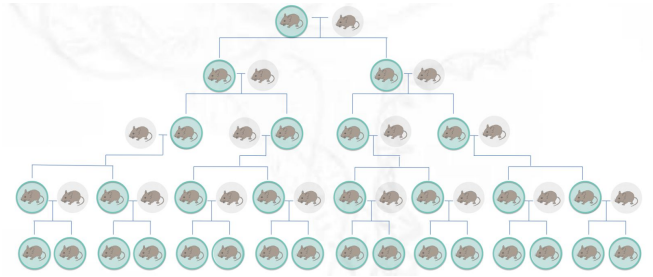
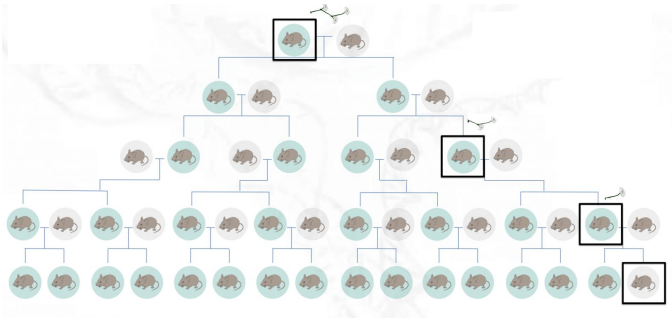
Predictability: We are testing gene drives in populations of nematodes to see how such drives evolve over hundreds of generations and billions of organisms.

Reversibility: Although it is better to ensure that edits will be lost on their own, we are also developing a “reversal drive” system in worms to restore any edited population to the original wild-type genetics if needed.

We are currently developing proof-of-principle experiments to illustrate how Daisy Drive works in mice. We hope our next steps will lead to field trials in the U.S. on islands off the coast of Massachusetts, where we live.

Contact Information

Kevin Esvelt, Principal Investigator of the Sculpting Evolution Group: esvelt@media.mit.edu
Devora Najjar, Graduate Research Assistant: devora@media.mit.edu
Ashton Strait, Graduate Research Assistant: astrait@media.mit.edu

Types of gene drive systems, how they spread, and possible applications:	
Type of Drive System	**How it Spreads**
Self-Propagating 	Can spread through any ecosystem that has the target species, even if very few engineered organisms are introduced. ***Our group does <u>NOT</u> develop self-propagating gene drives.***
Threshold-Dependent	Can spread temporarily within a local population if enough organisms are released.
Self-Exhausting (Daisy) 	Can spread temporarily within a local ecosystem for a set amount of time, based on the number of organisms released and how the drive is designed.

<u>Who We Are</u>

As scientists, we hold ourselves morally responsible for the consequences of our research. Because gene drive technologies have the potential to alter the shared environment, we will only develop applications in partnership with communities who are strongly supportive of such interventions and are committed to actively guiding development.

We invite you to share any comments, questions, or concerns you have; and we promise to listen, and respond as best we can.

<u>Further Information and Resources</u>

https://www.responsivescience.org/
sculptingevolution.org/