Technology

Innovative Genomics Institute

# CRISPR-Cas9-based gene drive architecture for control of agricultural pests

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## What are we doing?

### Big Picture

- One potential application of CRISPR-Cas9 gene editing technology is gene drive systems capable of spreading desirable genes into populations or suppressing populations.
- Between 10-16% of potential global food production is lost to insect pests every year.
- Hence, agricultural applications of gene drive could provide significant societal benefits by enhancing food security and reducing reliance on environmentally destructive insecticides.

### Project Goals

- We have identified a variety of crop pests of interest to which this technology may apply.
- Our goal for each of these species is to use mathematical models to determine optimal CRISPR-Cas9-based gene drive architectures that could be successful in controlling their agricultural impact while ensuring biosafety through the ability to remediate them from the environment in the event of negative consequences or a change in public opinion.

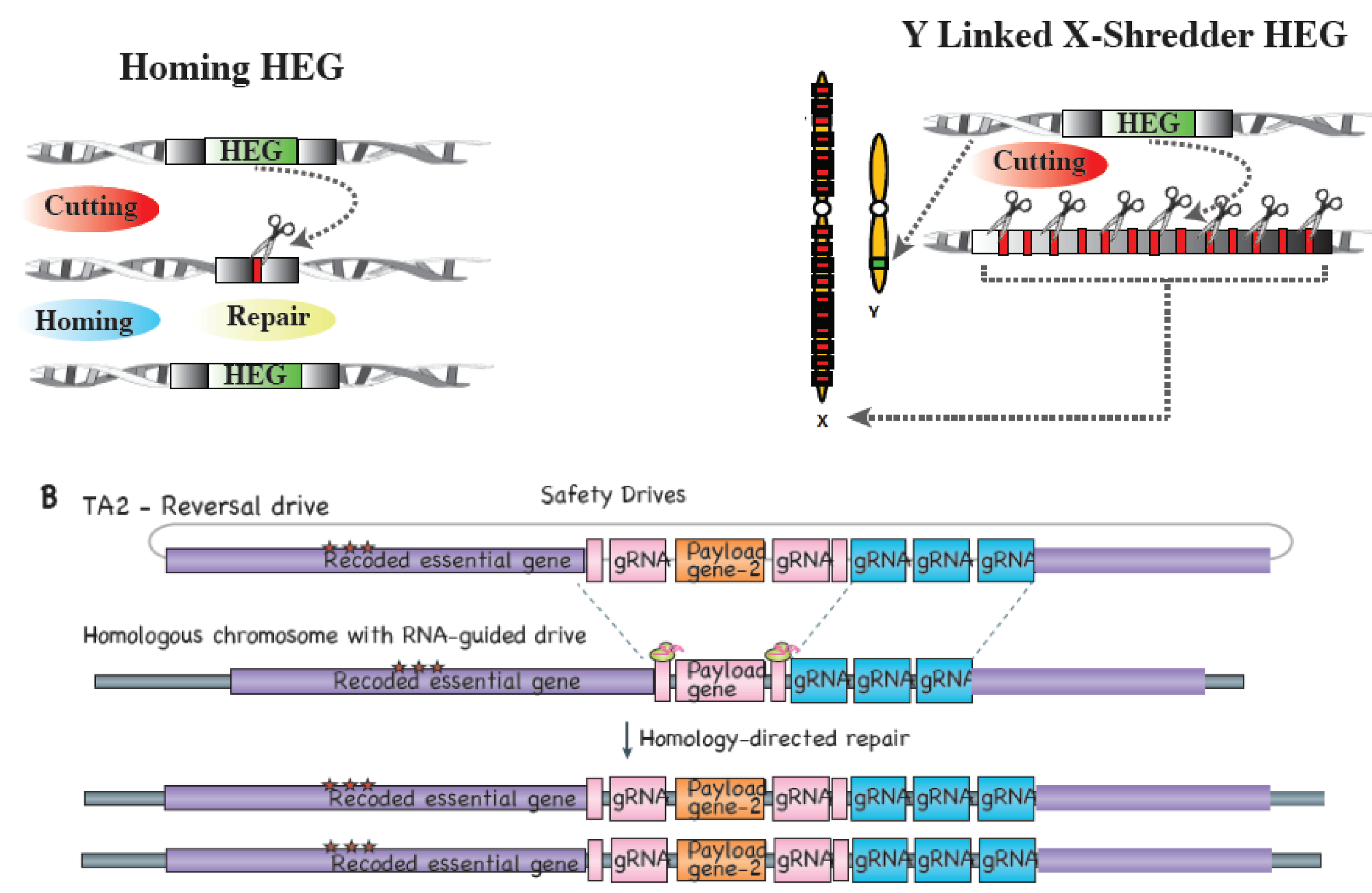
## Why?

- The following crop pests have a substabtial impact on agricultural production, but differ in terms of their ecology and means of impact:

**Table 1: Current insect pest species of interest:**

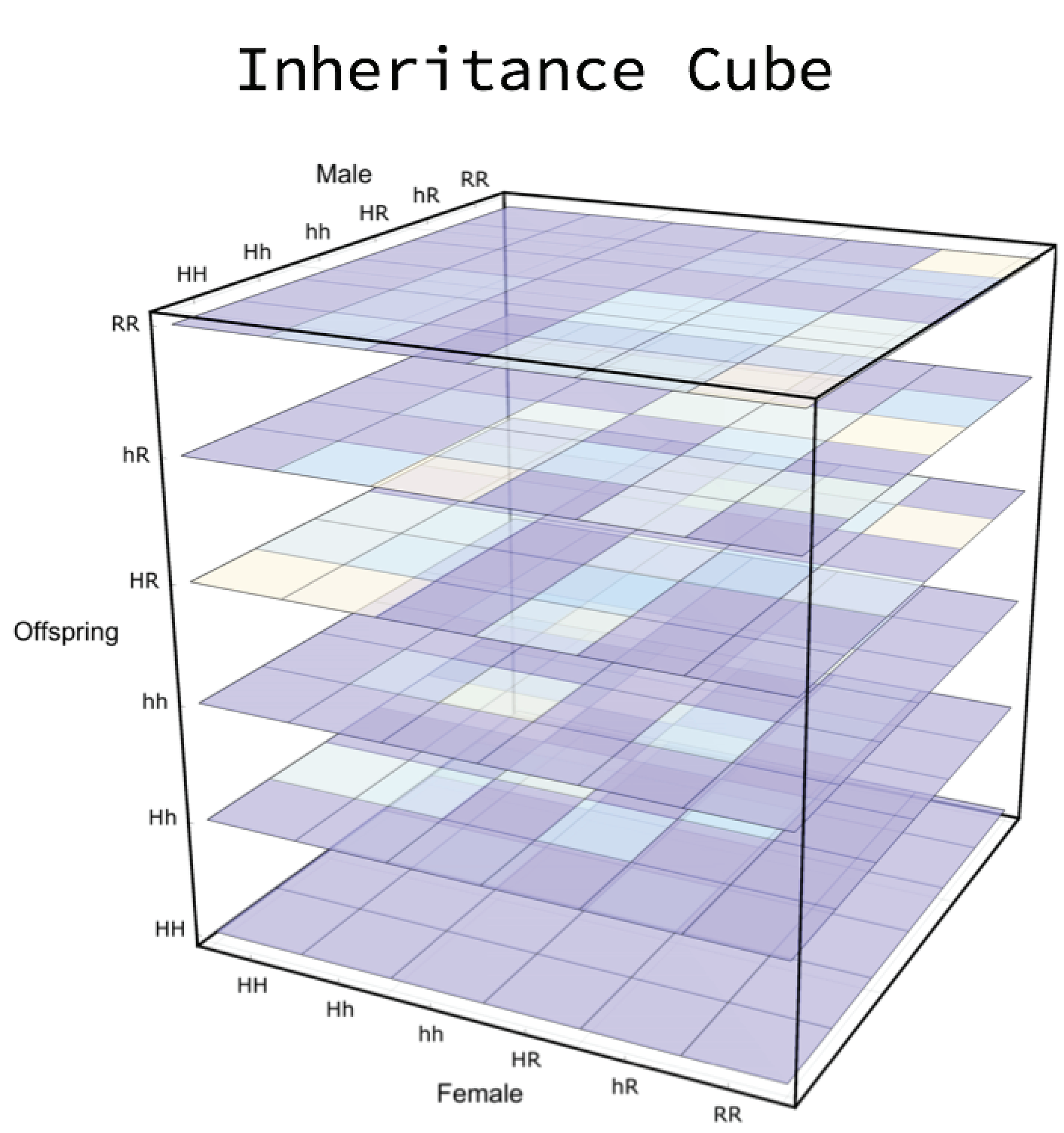
| Species: | Geographic distribution: | Agricultural impact: | Transgenesis: |
|---|---|---|---|
| *Drosophila suzukii* (spotted wing Drosophila) | Widespread in Europe and North America. Present in Asia, Central and South America. | Infests fruit during ripening phase. Responsible for > $500 million / year in crop losses in the western US. | Gene drive system developed |
| *Ceratitis capitata* (medfly) | Endemic in Europe, Middle East, Africa, Hawaii and South America. Eradicated from North America and Australia. | Larvae develop inside and dig out of fruit. Responsible for > $14.5 billion / year in crop losses in Europe, North Africa and the Middle East. | Transgenic strains created |
| *Diaphorina citri* (Asian citrus psyllid) | Endemic in Asia. Found in the Middle East, Central and South America, North America (California, Texas and Florida) and the Caribbean. | Vector of citrus huanglongbing virus. Nymphs cause damage to new shoots of citrus trees. Potential for ~$23 billion / year in global crop losses. | Currently being attempted |
| *Pectinophora gossypiella* (pink bollworm) | Native to Asia. Present in most of the world's cotton growing areas. Major pest in the southern US. | Responsible for more than $250 million / year in global crop losses. | Transgenic strains created |

- The following are a few of the gene drive and remediation systems that could be used to control these pests. Mathematical models can help to determine which system is most appropriate for each species:

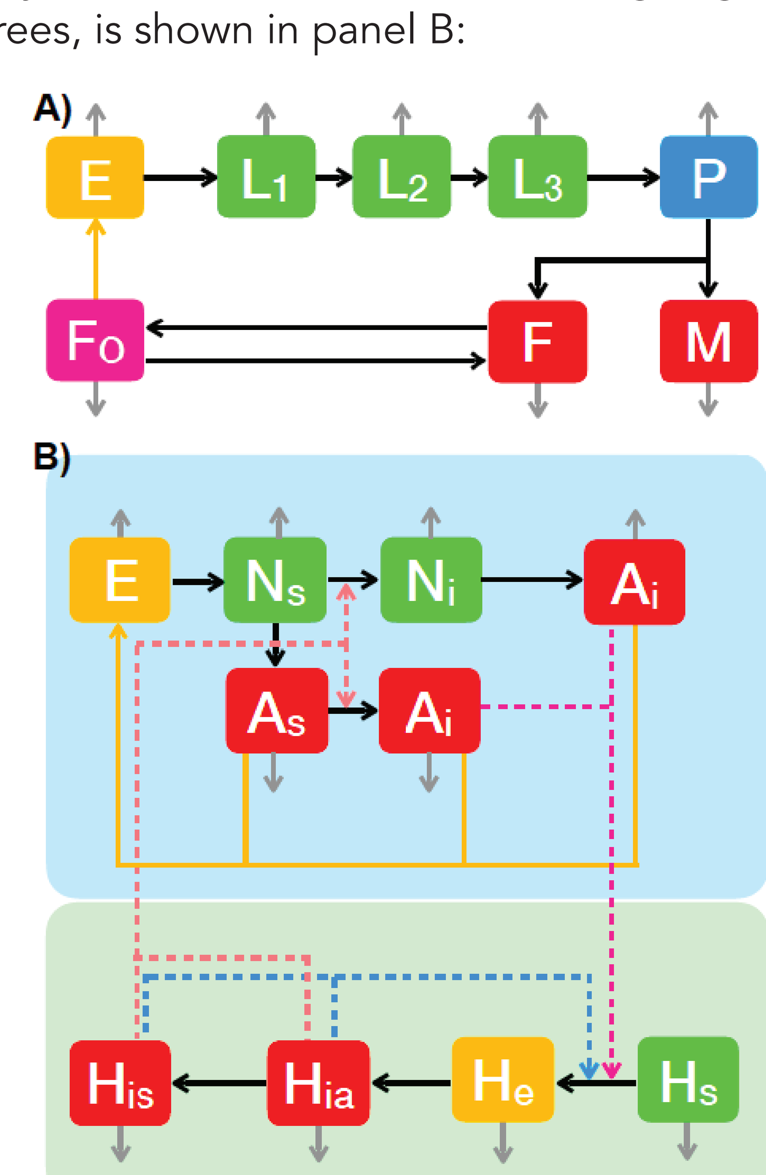



## How?

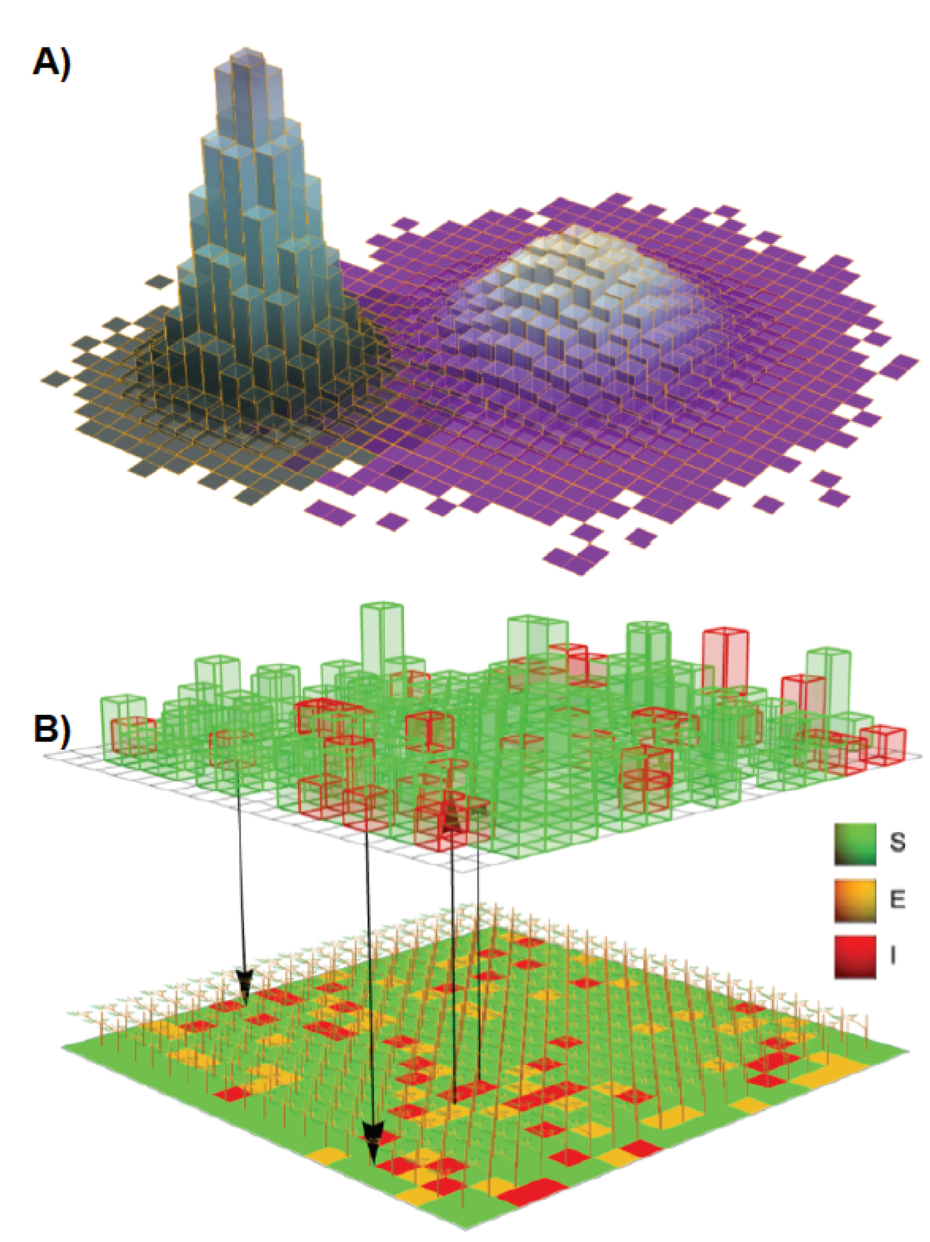
- We will develop population genetic and dynamic models of gene drive and remediation systems in species of interest.
- The models will incorporate the inheritance patterns of the gene drive and remediation systems:




- The models will also incorporate the ecology and life cycle of the insect pest species of interest.
- Here, the medfly is shown in panel A, and the Asian citrus psyllid, which transmits citrus huanglongbing to citrus trees, is shown in panel B:




- The models will also incoporate the dispersal of the pest species (panel A) and relevant features of the landscape into which transgenic varieties could be released (panel B):




**Feedback:** Ideas, suggestions, comments