Supplementary Materials for

Core commitments for field trials of gene drive organisms


*Corresponding author. Email: oakbari@ucsd.edu

Published 18 December 2020, Science 370, 1417 (2020)
DOI: 10.1126/science.abd1908

This PDF file includes:
Author affiliations
Disclosure statements
Table 1 with full references
Author affiliations


1 Herbert Wertheim School of Public Health and Human Longevity Science, University of California San Diego, La Jolla, CA 92093, USA
2 Arthropod Genetics Group, The Pirbright Institute, Pirbright, Woking, GU24 0NF, UK
3 Department of Health Law, Policy and Management, Boston University School of Public Health, Boston, MA 02118
4 T. Denny Sanford Institute for Empathy and Compassion, University of California San Diego, La Jolla, CA 92093, USA
5 Island Conservation, Puerto Ayora, Galápagos Islands, Ecuador; School of Agriculture and Food Sciences, The University of Queensland, Gatton, Australia
6 Department of Computational Biology, Cornell University, Ithaca, NY 14853, USA
7 National Institute of Infectious Diseases and Vaccinology, National Health Research Institutes, Miaoli, Taiwan
8 Chemical Biology and Therapeutics Science, Broad Institute of MIT and Harvard, Cambridge, MA 02142, USA
9 Department of Medicine, Harvard Medical School, Boston, MA 02115, USA
10 Divisions of Renal Medicine and Engineering, Brigham and Women’s Hospital, Boston, MA 02115, USA
11 Wyss Institute for Biologically Inspired Engineering, Harvard University, Boston, MA 02115, USA
12 School of Life Sciences, Arizona State University, Tempe, AZ 85287, USA
13 Division of Biological Sciences, Section of Cell and Developmental Biology, University of California, San Diego, La Jolla, CA 92093, USA
14 Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC 27695, USA
15 Genetic Engineering and Society Center, North Carolina State University, Raleigh NC, USA 27695, USA
16 Commonwealth Scientific and Industrial Research Organization, Perth, WA 6014, Australia
17 McMaster University, Institute on Ethics & Policy for Innovation, Department of Philosophy, Hamilton, ON L8S 4L8, Canada
18 Media Laboratory, Massachusetts Institute of Technology, Cambridge, MA 02139, USA
19 Program on Science, Technology and Society, Harvard University, Cambridge, MA 02138, USA
20 J. Craig Venter Institute, La Jolla, CA 92037, USA
21 Department of Entomology and Plant Pathology, North Carolina State University, Raleigh NC, USA 27695, USA
22 Department of Science, Innovation, Technology and Entrepreneurship, University of Exeter Business School, Exeter, UK
23 Program in Ethics in Science and Medicine, University of Texas Southwestern, Dallas, TX 75390, USA
24 John D. Bower School of Population Health, University of Mississippi Medical Center, Jackson, MS 39216, USA
25 Liverpool School of Tropical Medicine, Pembroke Place, Liverpool L3 5QA, UK
26 Center for Medical Entomology, The Jikei University School of Medicine, Tokyo, Japan
27 School of Public and International Affairs, North Carolina State University, Raleigh NC, USA
28 Hubert Department of Global Health, Rollins School of Public Health and Center for Ethics, Emory University, Atlanta, GA 30322, USA
29 Florida Medical Entomology Laboratory, University of Florida, Vero Beach, FL 32962, USA
30 Department of Global Health and Social Medicine, Harvard Center for Bioethics, Harvard Medical School, Boston, MA02115, USA
31 Department of Genetics, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands
32 Division of Epidemiology & Biostatistics, School of Public Health, University of California, Berkeley, CA 94720, USA
Neuroscience Research Institute and Department of Molecular, Cellular and Developmental Biology, University of California Santa Barbara, Santa Barbara, CA, 93106, USA
Center for International Studies, Massachusetts Institute of Technology, Cambridge, MA 02139, USA
Department of Bioengineering, Stanford University, Stanford, CA 94305, USA
Department of Entomology, Robert H. Smith Faculty of Agriculture, Food and Environment, Hebrew University of Jerusalem, Rehovot 7610001, Israel
CSIRO Health and Biosecurity, Australian Centre for Disease Preparedness, Geelong, VIC 3220, Australia
United States Department of Agriculture, Animal Plant Health Inspection Services, Wildlife Services, National Wildlife Research Center, Fort Collins, CO, 80521, USA
Department of Entomology, The Center for Infectious Disease Dynamics, and the Huck Institutes of the Life Sciences, The Pennsylvania State University, W127 Millennium Science Complex, University Park, PA 16802, USA
Mosquito Control Laboratory, QIMR Berghofer Medical Research Institute, Herston, QLD 4006, Australia
Program on Emerging Technologies, Massachusetts Institute of Technology, Cambridge, MA, USA
University of Hawaii at Hilo, Hilo, HI 96720, USA
United States Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, HI 96850, USA

† To whom correspondence should be addressed: Omar S. Akbari, Division of Biological Sciences, Section of Cell and Developmental Biology, University of California, San Diego, La Jolla, CA 92093, USA, Ph: 858-246-0640, Email: oakbari@ucsd.edu
Disclosure statements

A Defense Advanced Research Projects Agency (DARPA) Safe Genes Program Grant (HR0011-17-2-0047) was awarded to O.S.A. and supports the work of K.C.L. O.S.A is a founder of Agragene, Inc., has an equity interest, and serves on the company’s Scientific Advisory Board. L.A. is supported by the Bill & Melinda Gates Foundation (INV-00007033 and BBS/E/I/00007034). C.B. is a member of NIH Novel and Exceptional Technology and Research Advisory Committee (NExTRAC) and Co-Chair of the NExTRAC Gene Drives in Biomedical Research Working Group. K.L.C. is a member of the Scientific Advisory Board for Synbal, Inc. C.I.E. is supported by a grant from the Bill & Melinda Gates Foundation, and the funders had no role or decision in C.I.E.’s authorship. K.E. is the author of patents on diverse gene drive technologies with Harvard University and MIT. S.W.E received funding from the Schmidt Futures Foundation and sits on an advisory panel for the DARPA program that funded K.C.L. and O.S.A., but did not directly receive funding from DARPA. V.M.G. is a founder of and has equity interests in Synbal, Inc. and Agragene, Inc., companies that may potentially benefit from the research results. V.M.G. also serves on both the company’s Scientific Advisory Board and the Board of Directors of Synbal, Inc. The terms of this arrangement have been reviewed and approved by the University of California, San Diego, in accordance with its conflict-of-interest policies. S.H. is funded by British Academy grants KF400306 and KF2\100179. E.H. is funded by USDA grant “Gene Drive Applications to Agriculture in Texas: Knowledge, Perceptions, and Values” (USDA Project # 2018-67023-27676), but this publication is not directly related to the work supported by that funding; and is an ad hoc member the NExTRAC Gene Drives in Biomedical Research Working Group. M.J.P. received research funding support from the Open Philanthropy Project and the Smith Richardson Foundation on related topics, but this funding did not directly support her participation in this paper; received honoraria from the Nuclear Threat Initiative Biosecurity Innovation and Risk Reduction Initiative and Ginkgo Bioworks; and serves in various unpaid/volunteer roles at Revive & Restore, Engineering Biology Research Consortium, International Genetically Engineered Machine (iGEM) Competition, run by the iGEM Foundation, World Economic Forum Global Future Council on Synthetic Biology, NSF Center for Cellular Construction, Synthetic Biology Program at the Joint Genomics Institute, Biosecurity Task Force of the American Biosafety Association, and Research and Health Department of the World Health Organization Science Division. L.R. is co-founder of BioPolicy Solutions; there are no financial conflicts of interest associated with this work. R.S. coordinates the Genetic Biocontrol of Invasive Rodents Program, contributes to the Outreach Network for Gene Drive Research and World Health Organization Global Outbreak and Alert Response Network, participated in the 2019 NIH Gene Drive Research Forum, has contributed to work by Revive & Restore, and owns a consulting company Health Preparedness and Crisis Management and mutual funds with S&P500 holdings; there are no known conflicts of interest associated with these activities.
Table 1 with full references

<table>
<thead>
<tr>
<th>Approach</th>
<th>Examples</th>
<th>Temporal Dynamics</th>
<th>Geographic Reach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gene Drives</strong></td>
<td>Linked-homing(^1)((2, 4, 16–21)), Medea ((22–24)), CleaveR((25, 26)), TARE/TADE(^2)((27, 28))</td>
<td>Self-propagating (low threshold)</td>
<td>Non-localized</td>
</tr>
<tr>
<td></td>
<td>Translocations((29, 30)), Underdominance(^3)((31)), UD(^{MEL})*((32)), Tethered Homing ((33))</td>
<td>Majority wins* (high threshold)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Daisy(^4)((34)), split-homing(^5)((1, 3, 35–37)), Homer ((38, 39)), killer rescue ((40, 41))</td>
<td>Self-limiting (temporally limited)</td>
<td>Localized</td>
</tr>
<tr>
<td><strong>Non-Drives</strong></td>
<td>SIT(^<em>)((42)), RIDL(^</em>)((43)), fsRIDL(^<em>)((44)), pgSIT(^</em>)((45))</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Characteristics and examples of engineered population control technologies. Two broad types of engineered approaches exist to modify populations—one requires gene drive and the other relies on non-drive technologies. Multiple examples of these types of systems exist, which can have varied temporal dynamics including: Self-propagating with a low threshold (predicted to spread from a small release), to majority wins with a high threshold (predicted to spread into a population only when the transgene is present at >50%), to self-limiting which are temporally limited (can only spread or persist in population for a short period). These systems can fall under two broad categories from non-localized (predicted to spread beyond boundaries) to localized (predicted to spread within a localized population). For more details on the various examples and terminology see associated references.

\(^\#\)Can be used for population suppression in some forms. *While UD\(^{MEL}\) does have a high threshold it does not always fall under “majority wins” temporal dynamics. Abbreviations: Medea, maternal effect dominant embryonic arrest; TARE/TADE, toxin-antidote recessive embryo/toxin-antidote dominant embryo; CleaveR, Cleve and Rescue; UD\(^{MEL}\), maternal effect lethal underdominance; SIT, sterile insect technique; RIDL, release of insects carrying a dominant lethal; fsRIDL, female-specific release of insects carrying a dominant lethal; pgSIT, precision-guided sterile insect technique.

Main references


Supplemental references


