ARRIGE
Association for Responsible Research and Innovation in Genome Editing

newsletter n°2

Editorial

Hervé Chneiweiss
ARRIGE Vice-President

Genome editing at the top of the international agenda

September 2020 was a month of intense activity at the international level on genome editing. Let's present here an overview.

Initially announced as the work of an International Commission resulting from 17 national academies from all around the world, the report "Heritable Human Genome Editing (**HHGE**)" was presented on 3rd Sept 2020 as "the report of an international commission of the U.S. National Academy of Medicine, U.S. National Academy of Sciences, and the U.K.'s Royal Society" (**International Commission**). This report "considers potential benefits, harms, and uncertainties associated with genome editing technologies and defines a translational pathway from rigorous preclinical research to initial clinical uses, should a country decide to permit such uses.". The report remains essentially technical, focusing on "stringent preclinical and clinical requirements for establishing safety and efficacy, and for undertaking long-term monitoring of outcomes". The good thing is that the report clearly states that the science is not ready and describes the many uncertainties making HHGE a matter of scientific research in the a long term. Rather disappointing, governance was clearly not in the remit of this commission and their recommendations are vague, suggesting two international committees, one to inform on scientific advances, the second with unclear missions. But the main bias of this report is that it seems to consider genome editing of human embryos as a simple technical matter, without questioning its feasibility (it seems to say that even if not ready today, all problems will be solved tomorrow), usefulness or the values that would or would not lead to its implementation. On the contrary, it considers as a given that the reproductive choice of parents is a compelling need. Once again, the debate on ethical values is called for, but the great forgotten questions remain: who, where, how?

Calls for inclusive participation are common among those concerned with the technology and its governance, when it comes to applications in humans, food, agriculture, and environmental conservation. The WHO's Expert Advisory Committee on Developing Global Standards for Governance and Oversight of Human Gene Editing (the **Committee**) also had a working session 2nd-4th September, and also virtually due to COVID-19 instead of the exciting session the Committee had previously (Feb. 2020) in Cape Town, South Africa, allowing for many local actors to meet. Many of ARRIGE members remember the preliminary meetings we had in Buenos Aires (2016), New Delhi (2017) or Brazzaville (2018) and how important it is to encounter the real diversity of our world. The Committee is exploring public engagement at various scales, from the initial step of education through dissemination of scientific findings translated into many languages, with an engagement step taken by consultation with a broad range of stakeholders from around the world through videoconference seminars or web-based dialogue, and collaboration with other international organizations and nongovernmental organizations (NGOs). On September 2nd the committee had the opportunity to discuss with leading members of the International Commission. We can only regret the lack of previous consultation between the two committees that could have enabled an

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agreement/consensus to be reached that would have made an opinion more robust in the eyes of the international community.

Additionally, the question of how the public debate on the uses of genome editing is framed was central to the kick-off meeting of the Global Observatory (**GO**) on September 10th-11th entitled "Genome Editing and Human Dignity: Comparative Perspectives". More than 30 experts gathered virtually due to the COVID-19 crisis to analyze how to open a genuine dialogue at an international level. ARRIGE welcomes such a proposal since one of our main goals is to bring civil society into the discussion. However, at this stage, GO remains at the expert level with intentions to create an infrastructure for a global dialogue. I happily heard Sheila Jasonoff say that they were "sponges" and open. Thus, ARRIGE is ready for as many interactions as possible to move from words to actions.

Finally, in the 17th Sept 2020 issue of *Science*, an international group including several ARRIGE members, proposed a citizens' assembly model that would at a minimum be composed of 100 people recruited throughout the world. Their report "would be a first draft of informed global public opinion regarding genome editing". Such an assembly should allow for legitimacy decisions in global governance, since "public confidence in technologies and their application can be secured by public participation in decisions ..." The citizen assembly should also break with current public views on genome editing that are mainly owing to the novelty and highly technical nature of the issues involved. Finally, the citizen assembly should bring "input into governmental decisions, about detailed applications no less than broad questions about whether or not to pursue the technology". As written in the article "…evidence shows that a well-designed process involving lay citizens can bring reflective judgment to bear in a way that stakeholders, activists, and politicians may not (because they are too invested in advocacy)".

Following an eventful month of September, GE continues to be at the center of attention on the international scale with the **Nobel Prize in Chemistry** awarded in October to E. Charpentier and J. A. Doudna for "the development of a method for genome editing" using CRIPSR/Cas9, now referred to as "a tool for rewriting the code of life".

More than ever, ARRIGE missions to mitigate excessive hype and concern among citizens, and its effort towards the mobilization of the various stakeholders through a global governance of genome editing, are of paramount importance, and your involvement is essential.

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Latest News

Next ARRIGE annual meeting

Due to the current sanitary crisis, we have decided to hold this Assembly on line either via ZOOM or TEAMS or GOTOMEETING.

SATURDAY NOVEMBER 14th (2-6pm CET, Paris time*)

*ARRIGE General Assembly (only for ARRIGE members) **2pm-3pm CET**

Position of ARRIGE Scientific Committee on Gene Drive

Gene drive technology: State of the question on science and ethics.

This document was first discussed and written by the ARRIGE Gene Drive group with Christian Siatka and Gaëtan Bugio as a chair, Ayola Adegnika, Mylene Botbol, Martina Crispo, Tony Nolan, Jerome Singh and Bruce Whitelaw. We thank the members of the ARRIGE Scientific Council for their feedback, which has considerably improved the quality of the document. It was a slow process largely due to COVID19. Authors had a great discussion over Zoom. It was possible to have this conversation over 4 continents and 5 different time zones and we received some great feedback.

The development of gene editing technologies over the last few years has considerably improved our understanding of biological processes by being able to change the genetic material of many organisms with versatility and ease and examine the effects of these changes. This understanding improves our prospects for the control of disease - either directly, by introducing genetic modifications that prevent and treat disease, or indirectly, by understanding the genetic causes of disease and allowing targeted therapies that specifically affect these processes. They also have a scientific and cultural impact on our representations of what is human and modify the extent of our ethical responsibilities and require a dialogue between social sciences and STEM disciplines.

Gene drive: a powerful technology to potentially control pests or vector borne diseases

'Gene drive' refers to a phenomenon that occurs in nature but can also be synthetically generated. It describes the behaviour of genetic elements - also referred to as gene drive elements - that are able to bias their own inheritance when a sexually reproducing organism produces its gametes (sperm or eggs). Ordinarily, one copy of a gene has a 50% chance of being included in any gamete but gene drives can be present in a higher fraction of gametes because they either make extra copies of themselves prior to gamete formation, or because they gametes containing a gene drive outcompete gametes not containing it'. Individuals containing a gene drive therefore produce a much higher proportion of the offspring in each generation - up to 100% - compared to 50% for classical genetic inheritance. Because of this behaviour, gene drives can spread rapidly in a given population, transforming it such that potentially all individuals contain the gene drive. It is theoretically possible to design an engineered gene drive to spread a genetic modification of choice into a population in order to change it. The new genome editing technologies, including CRISPR-Cas, make this more feasible and designs have been inspired by existing natural versions of gene drive.

Synthetic gene drives are particularly suited to organisms that have short generation times and they have the advantage of being both species-specific and self-sustaining: the release of a relatively low number of individuals containing the gene drive can be sufficient to seek out and mate with the local population, spreading the gene drive as they do so. Depending on the specific gene drive design, it is possible to moderate both the strength of its ability to invade a population and the

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threshold number of organisms that needs to be released.
A lot of recent research has looked at developing gene drives for the control of invasive rodent pests and insects that transmit disease. This follows decades of research in controlling vector borne diseases or invasive species using conventional methods such as insecticides and rodenticides; artificial habitat clearing; introduction of predators etc. that have not yet been applied in every needed environment. To date, most success in the laboratory has centred on the development of gene drives in mosquito species that transmit a range of pathogens, including malaria parasites, dengue and yellow fever viruses. By contrast this same type of gene drive has not proven successful in rodents to date, highlighting some of the unknowns in the general applicability of gene drive. Two approaches are being followed: spread a gene drive that also contains an engineered genetic construct that modifies the mosquito's ability to harbour the pathogen; spread a gene drive that negatively affects the ability of female mosquitoes to reproduce, thereby debilitating the population as it spreads. Both types of gene drive have shown promise and spread rapidly when released into laboratory populations. These successes notwithstanding, there remain a number of technical issues to be resolved, not least the possibility of genetic resistance arising in the population.

Regulating gene drive release
At a regulation level, there are considerable efforts to establish local and international guidelines for the use of gene drive from the WHO, the African Union, the CDC - Africa, the European Union, NASEM in the USA or the Royal Society of New Zealand, and different governments across the endemic areas for vector borne diseases and invasive pest control. While there is still a need for improvement to implement a regulation on gene drive in many countries, an important issue with the gene drive approach is the potential for crossing the boundaries of multiple countries.
A regional implementation of the regulation will enable better management of the release of any gene drive organisms and should minimise the risks such as trans-boundary movements of the gene drive organism. As scientists, our role is to inform and discuss with regulatory agencies and stakeholders the benefits and the risks of the technology, in order to help develop ethical guidelines and regulations for its implementation and to coordinate a safe risk management of the gene drive approach that is consistent with the Cartagena protocol on biosafety.

Ethical concerns regarding the use of gene drive
The idea that gene drives could modify evolutionary trajectory and cause the extinction of certain species, be it mosquitoes or pest, is a disruptive idea among the public. It confronts us with the fact that the Anthropocene is not just an idea but is a possibility and a responsibility of humans to replace a defective "natural gene" with a synthetic one in organisms targeted for gene drive Moreover, it cannot perfectly control the implied outcomes of these experiments and cannot therefore establish a governance of shared anticipated risks. When gene drive is viewed as continuity rather than a rupture with nature, gene drive can be described as a form of enhancement of existing gene drive functions found in Nature itself.
The discourse of promise and hype is often advanced but cannot be verified. For instance, it claims that we could suppress nuisance species such as malaria-causing mosquitoes, but researchers in the field are still working hard to determine the broader ecological and environmental impacts of using gene drive, which strongly suggests the need to evaluate its consequences, beyond the risk/benefit utilitarian model. In terms of responsible science, it requires one to clearly describe the shared risks and to anticipate and determine the supposed benefits for whom and what.
Would the application of this technology in a given circumstance be accessible, in terms of distributive justice or access to health, facilitating compliance from the

most exposed populations? At stake is the social contract of science, to share a responsibility to alter the polysemic cultural concept of "Nature" across cultures, to avoid conflict of interpretations and thus conflicts of interests.

Sociologically, this matter requires a certain amount of scientific knowledge, not equally distributed on the planet and still a privilege of affluent countries, but it is also a cultural model per se, that cannot be considered universal a priori. It challenges the classical Darwinian model of evolution, as a tree of life at the very moment its mutation, becoming more complex than simply leading to evolution or extinction. Moreover some countries or traditional cultures are still thinking in a fixist creationist frame, which cannot accept the idea of humans acting on gene alteration or construction of a synthetic organism that has an impact on natural process. Some defend a teleological idea of nature that is preeminent to culture and requires a difference between instrumental and intrinsic values of living organisms. This divide exists also in the so-called "Northern countries" and creates ideological tensions around the design of a common reference frame of ethical responsibility that could be pluralistic without falling into cultural relativism. It requires one to rethink the necessity raised by gene drive technology and any human intervention, to differentiate between nature values and human interests. This cultural divide confronts lay persons with representation dilemmas that cannot be reduced to ignorance and rely on cultural representations that evolve in a very different time frame. The idea that living organisms can be artefacts, tailored to human design, not only does something to how we value non-human nature but risks having knock-on effects upon the way we value human life according to environmentalists, since it blurs the distinction between animal and machine that is the core of Cartesian discourse.

We are facing a change of paradigm that must lead us to be responsible for altered inheritance and the hybridization between artefacts, considered as natural or artificial, at the very moment when this division itself is blurred by the engineering capacity to act on mutations, without knowing in advance the possibly adverse, short or long term, side effects, on the manipulated and other connected species. It raises the following questions. Would the technology affect the environment, such as protected species in the ecosystem, do the animals deserve the right to be protected? Are native species, close to the invading ones, valued by the local community? We have to be clear on the definition of artefacts that synthetic biology creates. Synthetic biologists create artificial organisms but they do not create an alternative "Nature". It will require public involvement in finding a lingua franca between evolving scientific discourse and cultural representation adaptations without presupposing enhancement, which is still associated with some forms of eugenism.

Engaging with the community and stakeholders

Regarding issues in the control of vector borne diseases and invasive pests, it is important to take into consideration the community's point of view. Through clear engagement and provision of information to allow community consent to the risks and benefits of the use of gene drive technology. The community living in the areas where there is an important need are particularly vulnerable and prone to suffer from misconduct or mis-implementation of the new technology even though it is for their own interest.

Governments in many countries may need further assistance from stakeholders to allow the implementation of a gene drive in their communities, considering the global environmental impact and consequences on individuals. Existing data based on this technology is limited to laboratory-based settings. There is no community-based data on safety nor the long-term effect of the gene drive. Therefore, while much progress has been made, it will be more than crucial to develop a model in the Western community with evidence-based safety data before moving to the endemic developing countries, for

example with vector-borne diseases where there is a need. A legal framework for capturing these concerns on community acceptance has been developed for implementation following four principles. Firstly, do existing research ethics guidance frameworks such as the Helsinki declaration apply to gene drive research? Is it necessary to obtain individual informed consent for field release of GM vectors? Is there a precedent in other research fields for not soliciting individual informed consent? Is there a precedent for community engagement approaches that would be appropriate for gene drive? The development of a local community program where anyone can be involved and informed regarding the benefits and potential risks of this technology is a must. This program should include the participation of the local community, researchers, regulatory agencies and the Ministries of Health, Environment and Livestock and Agriculture in the case of pest control. A deep discussion would help to engage all the actors and have success in the implementation of gene drive technology. Also, the possibility to repopulate a given population, if drastic changes arise due to its eradication, should exist, in the form of frozen germplasm material that can be resurrected and released again. This can help to give peace of mind to the general public and have a backup plan in such a case. Anyhow, it is expected that benefits in terms of public health and economic gain are considerably higher than the potential risks.

How could ARRIGE play a role on gene drives?

The role of ARRIGE, beyond the explanation of concepts and a form of democratization of knowledge, must also be to promote confidence in some controlled mode of genetic engineering, while taking seriously into account the social and cultural aspects of persons or indigenous groups possibly impacted by the effects of this new engineering technique and its effect on the environment.

Some concrete examples

We consider the capability to share knowledge as the condition of democratic science at the service of human life.

Gene drives concern mostly animal species for the moment. We will concentrate on what exists and speak of vector-borne disease and pest control.

*In Nantucket (Massachussetts, USA), local councils accepted transgenic mice as a capacitating tool to fight tick-borne Lyme disease. It stages for us the capacity of a plurality of populations to re-appropriate new technologies, beyond the discourse of dual use, through a hierarchisation of values and interests.

*In New Zealand, an attempt to use genome editing to eradicate rats has been proposed to local populations, which was refused. We will have to analyze there the dominating science narrative.

*In Burkina Faso, an experiment releasing genetically modified mosquitoes, as a first step as part of a larger program to control mosquito numbers, led to the acquisition new skills and exploration of new local resources, which raised the question of scientific knowledge, financial and logistic capabilities of local vulnerable populations facing the transfer of gene editing technology.

Acceptance of a potentially feared technology, and eventual transfer/adoption of the technology depends on good communication and participative and relational ethics discussions. The lack of information leads some to perceive innovative technologies as a new form of cultural domination leading to eradication of local cultures. This dismissal should be taken seriously and resolved in terms of convergence of interests.

Future perspectives

The ethical issues for ARRIGE will be to develop a shared hierarchy of values to analyze the impact of technology transfer as an enhancement or destruction of species, both in the South and the North. The ethical justification of gene drive must be addressed in terms of limiting vulnerabilities and enhancing capabilities in a 'bottom up' approach,

taking seriously into account plural representations. Confidence in scientific advances depends upon the will of the scientific community to be at the service of humanity while considering its interdependence with living beings at large. In addition to the wider ethical concerns regarding their use, a number of technical questions remain and are the subject of ongoing research. These include questions such as how to counter the development of potential arising genetic resistance and how to predict the dynamics of spread and the resulting effects of the population control.

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Free Commentaries

Aaron Roberts[+], Katherine Littler[++], Claudia Emerson[+]
[+]McMaster University, Canada, [++]WHO

Principles for gene drive research: Articulating guiding norms and stimulating growth of a community of practice

Context and Motivation

In 2016, the CRISPR-Cas9 based gene drive had recently been developed and had been shown capable of producing desired results more precisely, economically, and quickly than any previously explored gene drive technique. In response, the US National Academies of Sciences, Engineering, and Medicine (NASEM) published a report titled, "Gene Drives on the Horizon: Advancing Science, Navigating Uncertainty, and Aligning Research with Public Values". The preface to this report stated, "If the current pace of change in general genetics is thrilling, the pace of change in gene drive research is breathtaking." Indeed, the speed of gene drive development was so rapid that it created concerns about the ability of policy and regulation to keep abreast. Thus, in the NASEM report and elsewhere, scientists, ethicists, and policy makers were calling for the development of guidance and regulation for gene drive research.

While it would ultimately be necessary to develop and put in place formal policies and regulation for gene drive research, doing so would require time. And yet, gene drive research appeared to be progressing at astonishing speed. It was in this context that on March 22, 2017, the first convening of what would become the Gene Drive Research Forum was held in Washington, D.C., co-hosted by the Bill & Melinda Gates Foundation, the Foundation for the National Institutes of Health (FNIH), and the Wellcome Trust. Present were scientists, ethicists, regulators, and representatives of research funding organizations. The participants recognized that guidance was needed more immediately than formal regulation could be delivered and, therefore, decided to create an accessible guidance document which was in line with, and responded directly to, recommendations in the NASEM report. The document would provide a center of normative gravity around which they hoped a community of shared best practice would form.

For a few reasons, the authors drafted the document so it would speak directly to sponsors and supporters. Firstly, a large portion – 13 out of 32 – of the recommendations laid out in the NASEM report centered on funders, providing an opportunity for robust alignment with the NASEM report; already a widely respected document. Second, though it was growing fast, the gene drive research space was still in relative infancy and research does not proceed without funding, so if they could articulate some broad, yet robust, standards and persuade a critical mass of major funders to sign on to them, they could contribute meaningfully to the generation of effective research norms. Finally, the shape of research itself inevitably forms around the priorities, boundaries, and expectations of funding bodies. Thus, if funders were willing to voluntarily and transparently commit themselves and the work they would fund to alignment with articulated shared norms of best practice, those norms would naturally spread into the research space itself.

Principles for gene drive research

On December 1st, 2017, "Principles for gene drive research" (**https://science.sciencemag.org/content/358/6367/1135.full**), was published in Science. By the time of its publishing, the Principles had garnered 13 founding signatories. Among them were some of the largest organizations funding gene drive research, including

several national research funding agencies, the Bill & Melinda Gates Foundation, Wellcome Trust, and Tata Trust. Since being published, three additional organizations have become signatories to the Principles putting the current total at 16 signatories. The invitation to become a signatory remains open, granting the Principles an ability to grow greater normative gravity with each additional organization committing to alignment with them. The Principles are published and freely available to all, but in brief they are comprised of the following:

Advance quality science to promote the public good

Promote stewardship, safety, and good governance

Demonstrate transparency and accountability

Engage thoughtfully with affected communities, stakeholders, and publics

Foster opportunities to strengthen capacity and education

For further exposition of each of the Principles, references to the specific NASEM report recommendations each principle responds to, and a current list of signatories, readers are invited to follow this link (**https://fnih.org/news/announcements/guiding-principles-for-sponsors-supporters-gene-drive-research**).

What has grown out of the Principles?

Following publication of the Principles, much effort and commitment has gone into their implementation. What started out as a small group of funders that came together out of their collective concern and interest in supporting responsible research has grown into a larger, broader group of stakeholders highly committed to supporting a community of practice. On Dec 7th, 2017, immediately following the December 1st, 2017 publication of the principles, the Gene Drive Research Forum officially convened for the first time in London, hosted by the FNIH and Wellcome Trust – each being signatories and leaders of the Principles – to initiate conversation with other funders and stakeholders about how to set the task of implementation.

The Gene Drive Research Forum brings together representatives from research, government, private sector, and not-for-profit organizations, as well as other parties with an interest in safe and ethical conduct of gene drive research for applications in public health, conservation and agriculture. The Forum has met annually since 2017, gathering stakeholders to undertake activities and initiatives that instantiate the Principles. Each meeting has focused on a topic corresponding to a Principle (e.g. data sharing, transparency, community engagement, etc.). Additionally, Forum Working Groups were convened and met between general meetings to drive implementation forward. Readers who are interested can learn more about the topics discussed, and read agendas and summary reports for each of the Forum general meetings by following this link (**https://fnih.org/what-we-do/geneconvene/working-with-geneconvene/research-forum**).

New initiatives

The formation and ongoing activities of the Forum demonstrate that the Principles have had the kind of impact intended; to call out the gene drive research community and create a community of ethical practice.

Encouragingly, the momentum and impact of the Forum's activities continue to grow and evolve. Recently launched, the GeneConvene Global Collaborative is the latest initiative to support the community of practice for gene drive research. In addition to hosting an online virtual institute, GeneConvene serves as the secretariat for the Forum. In this capacity GeneConvene works with participants to co-organize and co-host Forum meetings and workshops and facilitate Working Groups that are focused on the issues the Principles address: data sharing, research transparency, community engagement, and technical and regulatory capacity strengthening. These issues have been quite predominant in gene drive discourse and we expect that work in these areas will continue.

Your participation is welcome!
The developers and signatories of the Guiding Principles are committed to mobilizing and facilitating progress in gene drive research by supporting efforts of the highest scientific and ethical quality, inspiring a transparent approach, and backing biosafety measures. Please reach out here (**https://fnih.org/what-we-do/geneconvene/contact-geneconvene**) if your organization would like to become a signatory to the Principles and/or to participate in upcoming Forum activities.

Stephanie James and Michael Santos
Foundation for the National Institutes of Health, Bethesda, MD USA

The GeneConvene Global Collaborative: An Initiative for Advancing Responsible Research and Development of Gene Drive Technologies for Public Health

The GeneConvene Global Collaborative (GeneConvene), a program of the Foundation for the National Institutes of Health (FNIH), advances best practices and informed decision making for development of genetic biocontrol technologies to improve public health (**https://fnih.org/what-we-do/geneconvene**). GeneConvene offers technical information, advice, training and coordination for research on gene drive and other genetic biocontrol technologies. We believe that responsible exploration of genetic biocontrol technologies is crucial to unlocking the potential of these tools to address malaria and other urgent public health needs.

Gene drive for public health
Gene drive approaches carry certain highly attractive theoretical advantages for control of mosquito-borne diseases. Since the control mechanism is carried by the mosquitoes themselves, everyone living in the treated region should be protected regardless of financial resources or access to medical facilities, and people will not be required to change their behavior to benefit from the effect (as is the case, for example, with insecticide-treated bed nets). The modified mosquitoes also should be able to reach remote mosquito breeding sites and outdoor mosquito populations not adequately targeted by current vector control tools. Because gene drive approaches require productive mating to spread, their effects should be limited only to interbreeding populations, and thus less of a concern for biodiversity than broad spectrum insecticides.

While research is ongoing in other mosquito vectors, the most advanced potential application of gene drive currently is for control of Anopheles gambiae mosquitoes that transmit malaria in Africa. Control of malaria in Africa is arguably where the initial use of gene drive-modified mosquitoes might be most beneficial. However, the characteristics of persistence and spread of the introduced trait(s) that make gene drive a theoretically attractive tool to prevent and eliminate malaria transmission also have generated speculation about the potential for irreversible harm to biodiversity and human or animal health. Concerns additionally have been raised about the adequacy of current regulatory and governance mechanisms to deal with gene drive technologies. Such concerns must be acknowledged and addressed for each proposed use of gene drive approaches.

The GeneConvene Global Collaborative
In 2018, an international group of experts contemplating the development pathway for gene drive-modified mosquitoes as a biocontrol tool for malaria elimination in Sub-Saharan Africa recommended that a neutral body be established to (1) manage high level coordination among the various stakeholders, and (2) organize centralized responses to the diverse challenges that will arise in the

development and evaluation of gene drive-modified mosquitoes as public health tools (James et al., 2018). In 2020, the FNIH launched the GeneConvene Global Collaborative to respond to that need. FNIH is a not-for-profit charitable organization that creates and leads alliances and public-private partnerships to advance breakthrough biomedical discoveries that improve the quality of people's lives **(https://fnih.org/about)**.
GeneConvene builds on over 10 years of experience at FNIH working on genetic biocontrol approaches for public health **(https://fnih.org/what-we-do/geneconvene/impact)**.

GeneConvene aims to contribute to an environment in which gene drive and other genetic biocontrol technologies for public health can be safely, ethically and rigorously studied, developed, tested, and, if authorized by appropriate decision makers, responsibly implemented at appropriate scale to have a positive health impact. In this role, we work with diverse stakeholders to identify emerging issues and respond proactively to develop fact-based, consensus-driven recommendations and best practices guidance. We review legislation and policies governing genetic biocontrol and interpret these for scientific stakeholders, to help them better understand and comply with oversight mechanisms relevant to their research. We work to promote broader understanding about the wide range of potential genetic biocontrol technologies for public health and their advantages and challenges. And we distribute timely and accurate information to help all stakeholders make informed and responsible decisions.

As a neutral body, GeneConvene does not conduct or fund research to develop or implement gene drive or other genetic biocontrol products, exert oversight over research and development programs, or advocate for specific genetic biocontrol products.

GeneConvene programs relevant to the wider genome editing community
Two of GeneConvene's programs may be of particular interest to the wider ARRIGE audience. These programs encompass activities beyond a strictly public health perspective. GeneConvene conducts these activities to promote mutual learning, with the understanding that challenges and responsibilities will be similar across the many possible applications of gene drive and genetic biocontrol.

The GeneConvene Virtual Institute **(https://www.geneconvenevi.org/)** is an online knowledge hub that makes information about scientific, technical, policy and regulatory aspects of genetic biocontrol technologies and closely related fields widely available, to enable audiences to understand and stay current with the research.

The Gene Drive Research Forum (**https://fnih.org/what-we-do/geneconvene/working-with-geneconvene/research-forum)** brings together parties with an interest in safe and ethical conduct of gene drive research to discuss cross-cutting issues for potential applications in public health, agriculture and conservation.

Invitation
GeneConvene serves as a resource for all those who seek to understand and advance the safe, ethical and rigorous exploration of gene drive and other genetic biocontrol technologies. We invite interested ARRIGE members to contact us **(https://fnih.org/what-we-do/geneconvene/contact-geneconvene)** for more information about any of the activities described here.

Community Contributions

Publications

N.R. Faber et al. Novel combination of CRISPR-based gene drives eliminates resistance and localises spread.
bioRxiv Aug 27, 2020
https://doi.org/10.1101/2020.08.27.266155

D.J. Dankel, S.N. Dankel. Gene editing – a collective responsibility
Norwegian Journal of Medicine. Sept 2020
https://tidsskriftet.no/en/2019/11/leder/gene-editing-collective-responsibility

Global Forum on Bioethics in Research (GFBR)
Genome editing for human benefit: ethics, engagement and governance
https://wellcomeopenresearch.org/collections/gfbr19

A. Deplazes-Zemp, et al. (2020) Gene drives: benefits, risks, and possible applications.
Swiss Academies Factsheets 15 (4)
https://naturalsciences.ch/organisations/geneticresearch/125988-gene-drives-benefits-risks-and-possible-applications?_ga=2.220843675.2001843394.1599481750-1935097342.1597052916
Available in English, German and French

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The CRISPR Journal, 3(1), 3–4.
https://doi.org/10.1089/crispr.2020.29083.sso

E. Kleiderman, V. Ravitsky & B.M. Knoppers. "The 'serious' factor in germline modification".
Journal of Medical Ethics. 45: 508-513. 20 July 2019.
https://jme.bmj.com/content/45/8/508

V. López Del Amo et al. Small-Molecule Control of Super-Mendelian Inheritance in Gene Drives.
Cell Reports 31, 107841, June 30, 2020.
https://doi.org/10.1016/j.celrep.2020.107841

Webinar given by the University of KwaZulu-Natal's School of Law, South Africa: 'African philosophy, genetics and genomics'
https://law.ukzn.ac.za/colloquium-series-on-african-philosophy-genetics-and-genomics/

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