Sculpting evolution with gene drives

By Huib de Vriend[1]

Late November 2015, a group of scientists from the University of California announced their plans in Proceedings of the National Academy of Sciences to use gene drive technology to engineer a whole population of the mosquito that normally carry the malaria parasite. They claim that strains based on this technology could sustain control and elimination as part of the malaria eradication agenda. The debate about the governance of this technology and fears about uncontrolled spread of potentially harmful genetis traits in wild populations has already started.

Gene drive

During normal sexual reproduction, each of the parent's two versions of a given gene has a 50 percent chance of being inherited by a particular offspring. Gene drives are genetic systems that circumvent these tradional rules: they greatly increase the odds that the drive will be passed on to offspring. This can allow the gene drive to spread to all members of a population. The powerful genome editing tool called CRISPR/Cas9[2] has made the idea of engineered gene drives feasible.Gene drives can now be used to spread genetic alterations through wil populations over many generations.

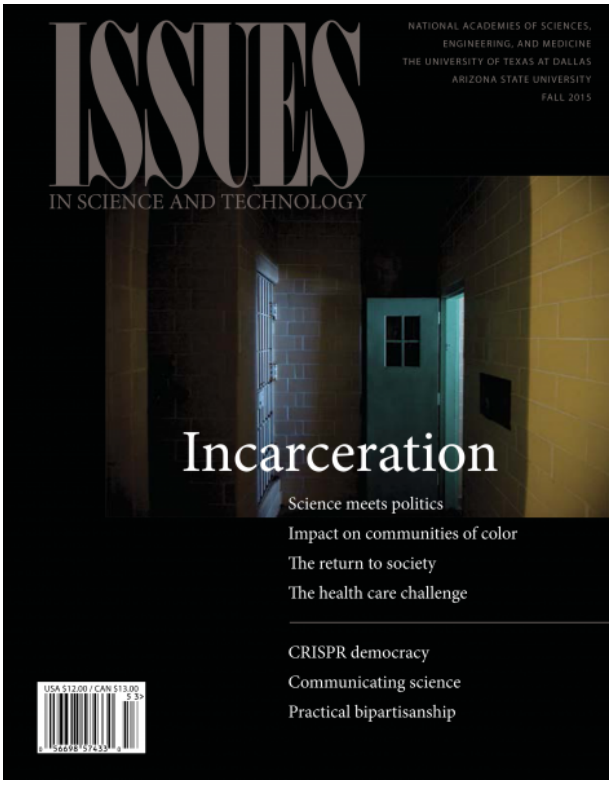
Because of their capacity to alter the traits of entire populations of organisms, they are considered a powerful tool for the management of ecosystems, for instance to eliminate diseases such as malaria, dengue, West Nile, yellow fever, and Lyme, to eradicate invasive species, or to reverse pesticide and herbidicide resistance in pests and weeds.

Responsible scientists

Mid November 2015 a group of scientists from Harvard University published safety protocols—ways to prevent or reverse a released gene drive—using the yeast *Saccharomyces cerevisia*. One technique genetically separates the components necessary to create a gene drive, putting one half directly in the yeast genome and the other half on an external strand of DNA. The researchers also developed a method that uses one gene drive to overwrite the effects of another. Heidi Ledford, who writes about biology and medicine for Nature on a regular basis, thinks this approach may calm some fears about the technology. She quotes Kevin Esvelt, an evolutionary engineer and coauthor on the paper: "We have a responsibility to keep our experiments confined to the laboratory..... The basic lesson is: if you don't have to build a gene drive that can spread through a wild population, then don't." Esvelt told *Nature* that he hopes the scientific community will thoughtfully evaluate gene drives rather than dismiss them. "Should we use gene drive to eliminate malaria? Should we use it to replace broadly toxic insecticides? These questions all have to be considered separately," he told *Nature*. "This

paper is really about making sure we don't blow it in the meantime and obviate the chance to talk about all of this."

Need for inclusive future deliberations



Against the backdrop of the call of a group of scientists for a worldwide moratorium on altering the human genome to produce changes that could be passed on to future generations in March 2015, Sheila Jasanoff, Ben Hurlbut and Krishanu Saha published a paper in the Fall 2015 edition of *Issues in Science and Technology* in which they warn for an uncritical application of the Asilomar model to gene editing. This model implies that geneticists have a right to "push research to its limits" and that restraint is warranted only where the research entails technically defined risks like "endangering public health." The authors point at the controversy on genetically modified crops and stem cell research which demonstrates the shortcomings of the approach taken at Asilomar: "In retrospect, one can see the long, at times tragic controversy over GM crops..... as a reopening of the debate by global citizens of all the dimensions of genetic engineering that Asilomar had excluded."

The authors advocate future deliberations (on CRISPR) to actively rethink the relationship between science and democracy. Rather than limiting deliberations to scientifically defined risks Jasanoff, Hurlbut and Saha suggest to take note of four themes that would help steer study and deliberation in more democratic directions: envisioning futures, distribution, trust, and provisionality." These themes also apply to applications in animals, plants and microorganisms, and the domain of the bioeconomy.

- Envisioning futures: The emergence of a far-reaching technology is a time when society takes stock of inaginable futures and decides which ones are worth pursuing and which ones shoud be regulated, or even prevented;
- Distribution: These days it is expected that public funded discoveries with economic potential should be commercialxed: science, in this view, best serves the public good by bringing goods to the market. But people will benefit from those goods only if they cover their needs and they have adequate access;
- Trust and inclusiveness: Trust is a crucial factor in acceptance of new technologies. Laisser faire approaches do not sufficiently produce trust. A scientific community demonstrating social and ethical responsibility is a good start, oversight is a must;

- Provisionality: „Revolutionary moments do not reveal the future with map-like certainty ..... The challenge for democracy and governance ist o confront the unscripted future presented by technological advances and to guide it in ways that synchronize with democratically articulated visions oft he good. This demands thoughtful conversations about alternatives for as long as it takes to build new norms fort he

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Image: Centers for Disease Control and Prevention

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[2] CRISPR/Cas9 is an enzyme that recognizes and cuts a DNA strand at a particular site. When the cell repairs that break, errors can occur to generate a knockout of that gene or additional modifications can be introduced.