A future task in good hands

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Differences of Current GMO to Gene Drive Organisms - Challenges for Risk Assessment

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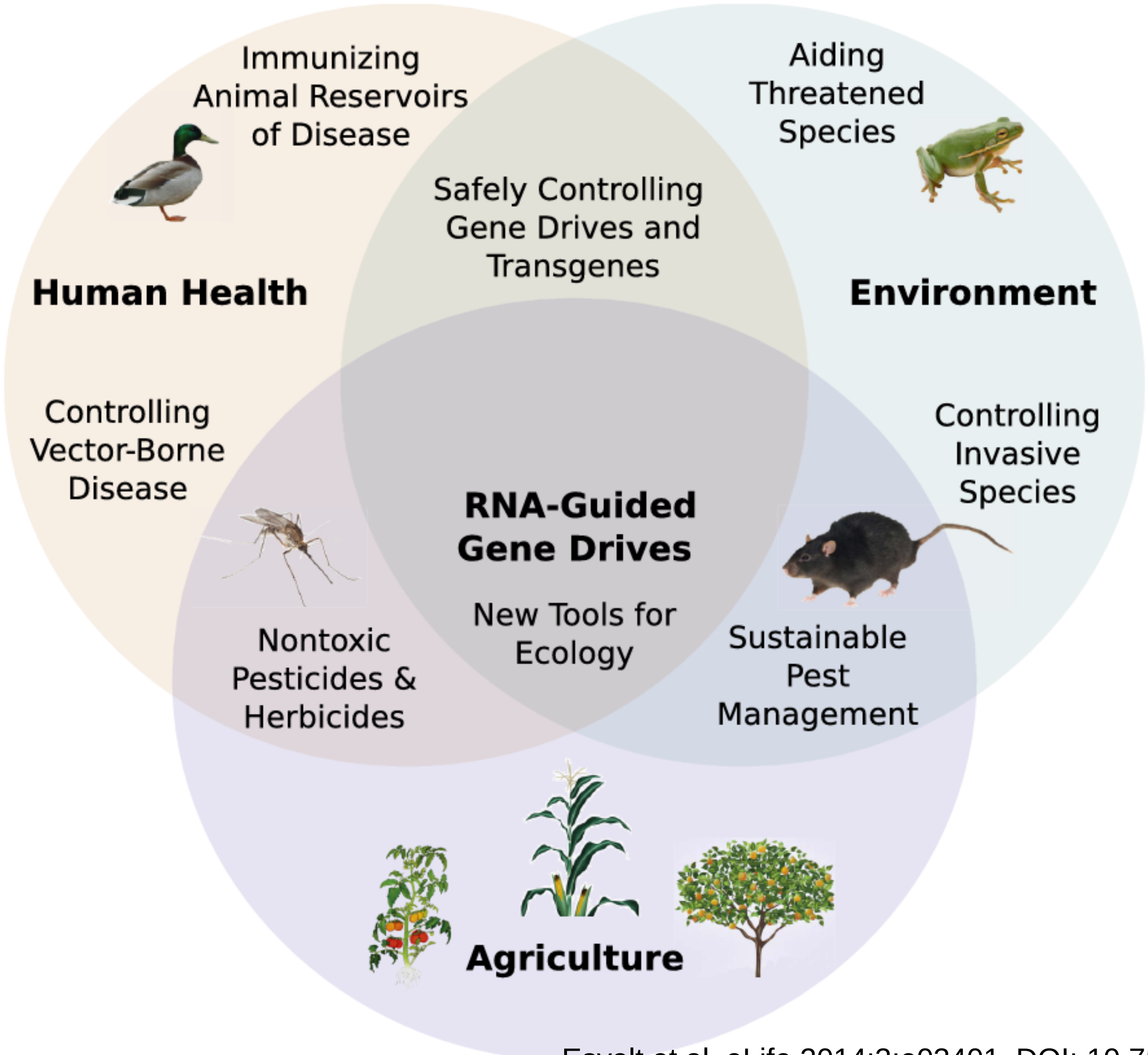
19.06.2018, Bremen

Potential applications of gene drives



Esvelt et al. eLife 2014;3:e03401. DOI: 10.7554/eLife.03401

Gene drives to protect biodiversity?

- Piaggio *et al.* (2017) call for an engagement of both gene drive developers and conservation biologists to enable "Synthetic Biodiversity Conservation"
- Webber *et al.* (2015) recognized significant risks early on:
  - "Are we willing to risk **the global loss of a species** as a result of unintended dispersal of modified individuals back to their native range"
- Esvelt and Gemmell (2017) are warning against global gene drives for conservation biology
  - "…making a standard, self-propagating CRISPR-based gene drive system is likely equivalent to **creating a new, highly invasive species…**"

Piaggio *et al.* (2017) doi: 10.1016/j.tree.2016.10.016

Webber *et al.* (2015) doi: 10.1073/pnas.1514258112

Esvelt and Gemmell (2017) doi: 10.1371/journal.pbio.2003850

Crucial differences between GMO and gene drive organisms (GDO)

Published online: April 12, 2018

Science & Society

OPEN ACCESS

EMBO reports

Synthetic gene drive: between continuity and novelty

Crucial differences between gene drive and genetically modified organisms require an adapted risk assessment for their use

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DOI 10.15252/embr.201845760

Crucial differences: From indirect protection to direct action

- Current strategies protect GM crops *from* a stressor
  - Bt-toxins protect GM-crops from a pest, herbicide resistance provides protection against a specific herbicide
- GDO are expected to work *against* a stressor
  - Population suppression of agricultural pests
- This idea has started with SIT, but GDO are much more powerful
- With gene drives GMO applications are moving directly from crop plants to modifying wild species
  - Major consequences on semi-natural and natural ecosystems are expected

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Crucial differences: public good

- GMO can become public goods but marketing strategies and patent rights so far prevented their development
- GDO could create public goods
  - Protecting Biodiversity
  - lowering malaria burden
- GDO can also have economic interests
  - Agricultural pest control using a local gene drive
- Public goods have to be evaluated against the public burden from ecological and socioeconomic impacts

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Crucial differences: outcrossing and spread of transgenes

- Spread of the transgene is a required prerequisite for GDO
- Gene drive alleles additionally have a higher chance of becoming established if they cross into closely related individuals
- GDO target genetically much more complex populations compared to genetically uniform GM-crops
- The release of some individuals carrying a global GD might be considered a full release already – problems with stepwise testing

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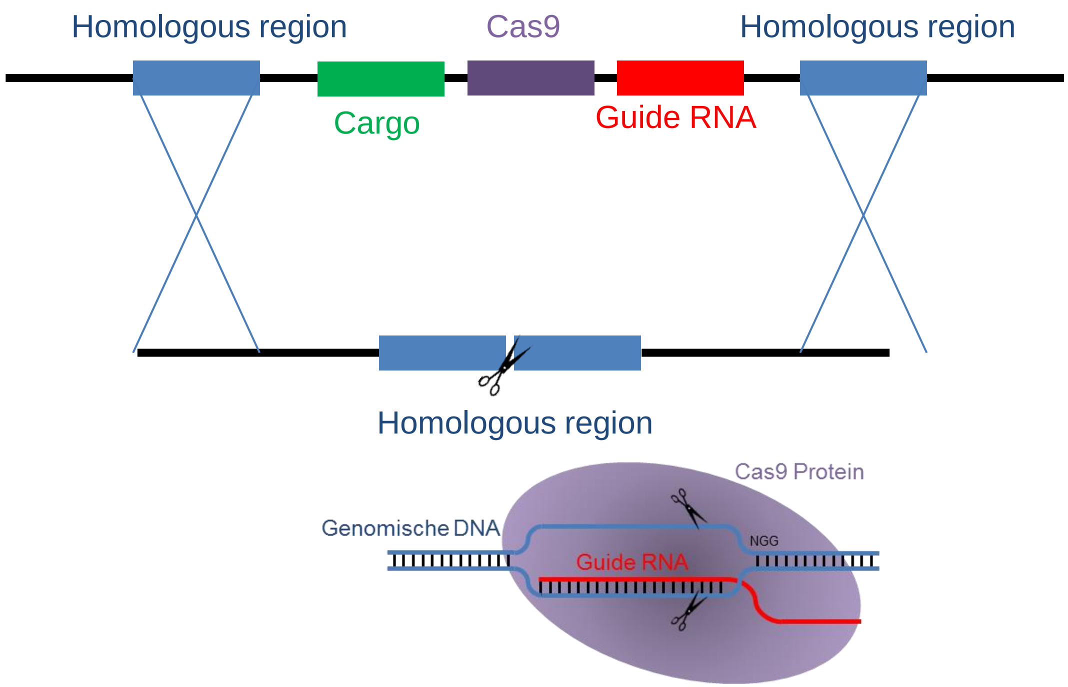
Crucial differences: the lab in the field

- The biotechnological tool is inherited in GDO (e.g. CRISPR/Cas)
  - The genetic modification is generated every generation new



Crucial differences: the lab in the field

- The biotechnological tool is inherited in GDO (e.g. CRISPR/Cas)
  - The genetic modification is generated every generation new

- The genetic modification in the case of CRISPR gene drives becomes an adjustable tool
  - Multiple applications of different gene drives in single species are being developed (immunizing drives, antagonizing drives)

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Modelling of gene drive effects

- Stepwise testing approach not possible for global gene drives
  - Modelling and scenarios will become more important

- Data requirements to model the efficiency of a gene drive
  - Molecular Data, population genetics, genetic diversity…

- Modelling the ecological impact
  - Biology and Ecology of species
  - Ecosystem function / variability of receiving environments
  - …

- Effect thresholds (limits of concern) to be defined

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Amendment of risk assessment

The potential risks of GDO require a wider societal perspective; e.g. on thresholds, necessities, acceptable uncertainties and common goals

We suggest a technology assessment approach:

- Is the technology appropriate for the goal?
- Incorporation of social, economic and cultural impacts

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Thank You!