



**Potential security implications of genome  
editing technology**  
**Outcomes from an international  
workshop**

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**Assessing the security implications of genome  
editing technology**

- Genome editing is the deliberate alteration of a selected DNA sequence in a cell using a site-specific enzymes. It allows greater precision than previous technologies.
  - International workshop, Herrenhausen, Germany, October 2017
  - Co-organised by InterAcademy Partnership (IAP), EASAC, US National Academies of Science, Engineering and Medicine (NASEM) and German National Academy of Sciences Leopoldina. Funding support from Volkswagen Foundation and Gordon and Betty Moore Foundation
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## Purpose of the Herrenhausen workshop

- To bring together more than 100 experts in genome editing, security studies and public policy to establish an international dialogue
- To consider implications of genome editing:
  - Potential benefits
  - Potential security concerns associated with intended misuse
  - What might be done to prevent or mitigate potential harm

Previous work by various Academies was reviewed in briefing paper circulated prior to Herrenhausen workshop: <http://nas-sites.org/dels/files/2017/05/Biosecure-GeneEditingBiosecurity-Report-170925.pdf>



## What is genome editing and what might be the benefits?

- Molecular alterations can now be introduced more efficiently, precisely and simply.
- Builds on other recent advances in biosciences, e.g. the decreasing cost of DNA sequencing and synthesis
- Potential applications in tackling human disease:
  - Somatic cell editing, e.g. blood cells (cancer), muscle cells (muscular dystrophy)
  - Heritable (germ line cell) editing – still controversial
  - Also controversial – potential to enhance human biology

The technology raises ethical and social concerns including biosafety and biosecurity





## What are the security concerns about genome editing?

- Various concerns were highlighted in 2016 by US Director of National Intelligence; also PCAST work on biodefense
  - Others, including media, postulate various types of misuse, e.g. altered pathogens, gene drives to damage ecology or human populations, new types of biological and neurological weapons, enhanced military capabilities. But what is feasible stays open to debate?
  - It can be difficult to separate out biosecurity and biosafety concerns
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## Clarifying security concerns: points from Herrenhausen workshop

- Need for clarity on what are concerns, for whom and in what timeframe.
  - National security issues cover a wide range – from biological weapons, to also security of resources and data.
  - Pace of science and technology change might challenge traditional security and regulatory frameworks.
  - Herrenhausen had parallel breakout sessions with wide representation of disciplines, sectors, countries on applications for human cell, agriculture, gene drive and microbial genome editing
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## Potential concerns for applications

**Specific concerns about the genome editing technology are:**

- 1. Altering human, crop and animal pathogens**
- 2. Misapplication of gene drives**
- 3. New types of biological and neurological weapons**
- 4. Human enhancement e.g. "super soldiers"**

Questions for all the fields of application are: Is the technology **game changing** or an **extension** of existing technology?



## Potential concerns for applications

- Human cells – Germ-line editing is not near to application (10+ years?); problems for delivery systems (aerosol/viral) of for example lung cancer inducing editing; enhancement
- Agriculture – Food security by attacking crops; Difficulty in traceability challenges regulation and enforcement
- Gene drive – Further into future, and research requirements are complex but see recent mouse story; difficult to police as there are no select agents or DNA sequences; media hype might attract nefarious users
- Microbes – Categories of concern similar to previous microbial research; digitalised information flows increasingly important in widening access



## How might potential security concerns be prevented or mitigated? Range of approaches available

- Legal, regulatory and policy approaches – e.g. BWC; OIE Biological Threat Reduction; CBD Synthetic Biology Initiative; WHO Reference Laboratories
- Norms of responsible behaviour/codes of conduct – e.g. IAP work on responsible science; Leopoldina work on rules for scientific freedom and responsibility
- Scientific and technical strategies – e.g. Swiss Academies work on biosecurity; Safeguarding gene drive initiatives covering molecular, geographical and ecological options, researching anti-CRISPR proteins and small molecules, reverse editing and detection methodologies



## Mitigating security concerns for applications of genome editing: points from Herrenhausen breakout sessions

- Human cells – Important to achieve balance between preventing misuse while not preventing research. Importance of education, research funder governance and research support for counter-measures
- Agriculture - Also emphasises education and consistency in quality standards  
Opportunities to share good practice in governance between countries



## Mitigating security concerns for applications of genome editing: points from Herrenhausen breakout sessions (continued)

- Gene drive – Opportunities for increasing expertise for institutional biosafety committees and others; International frameworks may help to resolve competing interests between countries (cross-border issues)
- Microbes – Comprehensive regulatory frameworks already in place; Opportunities to inform responsible research and to test capacity in crisis exercises; Concern if research perceived as risky were outsourced to other countries



## Mitigating security concerns – general points from Herrenhausen discussion

- Are we indulging in genome editing exceptionalism? What is new?
- Importance of international regulations on research standards, e.g. like those for clinical trials
- Concern that additional governance would hamper responsible research without deterring intentional misuse
- Difficulty in separating mitigation for security and safety
- Importance of credible scenarios as part of education and planning for risk management
- Not concluding “no risk” but rather “no extra risk” or “proportional risk”. Recognise that uncertainty causes public concern



## Importance of public communication and engagement efforts

### general points from Herrenhausen discussion

- Scientific community needs on-going, open and inclusive dialogues with security community, policy makers and publics
- Public trust is increased if scientists are perceived as acting with integrity and for the public good
- Various opportunities for co-designing engagement mechanisms and using social media
- Standards of evidence and expert opinion are critically important – differing perception of threats and there are few data points for assessment



## Continuing engagement efforts - emerging points from Herrenhausen discussion

- Herrenhausen workshop was agreed to be a good first step but more needed – media concerns about genome editing are already widespread, e.g. for Do-It-Yourself (DIY) biology
- Scientists must engage with public, clarifying what is or is not likely, building trust through responsibility and integrity
- It is important to continue articulating the benefits alongside concerns – taking account of (changing) public values and perceptions
- Progressing security discussion from the traditional “weaponisation of disease” to “can biosciences manipulate what it means to be well?”



## In summary - from the Herrenhausen workshop

- Genome editing is an important tool for innovation
  - As with other tools, it could be misused, inadvertently or deliberately. There must be balanced discussion about benefits and risks
  - It is desirable to develop a sustainable network of scientific and security communities and others to share perspectives, facilitate information exchange, identify priorities for further study and act as basis for extending engagement more widely
  - Academies of science worldwide acknowledge their responsibility to continue these debates involving all stake-holders in society.
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## Thank You

QUESTIONS?

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