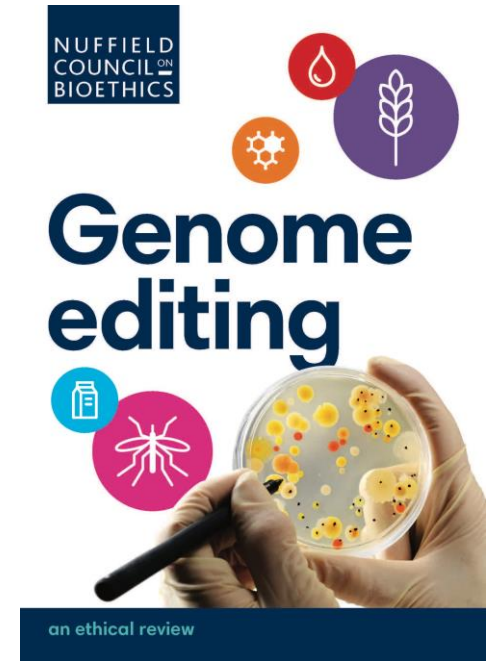


Genome Editing – Ethical Issues

Bioethics Advisory Committee's (BAC) 20th Anniversary
18th June 2021

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Disclosures

Research funding from the UK Medical Research Council

Fees for membership of HFEA Scientific & Clinical Advances
Advisory Committee

Fees for membership of UK Regulatory Horizons Council

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All opinions are mine and not necessarily those of any organization with which I am associated

CONSENSUS STUDY REPORT



Heritable
**HUMAN
GENOME**
Editing



Genome editing and farmed animals

Current Project

Current in-depth inquiry

About the working group

Terms of reference

Evidence gathering

Current research

Online public dialogue: genome editing in farmed animals

Related content ↓

Genome editing and farmed animals



Current Project
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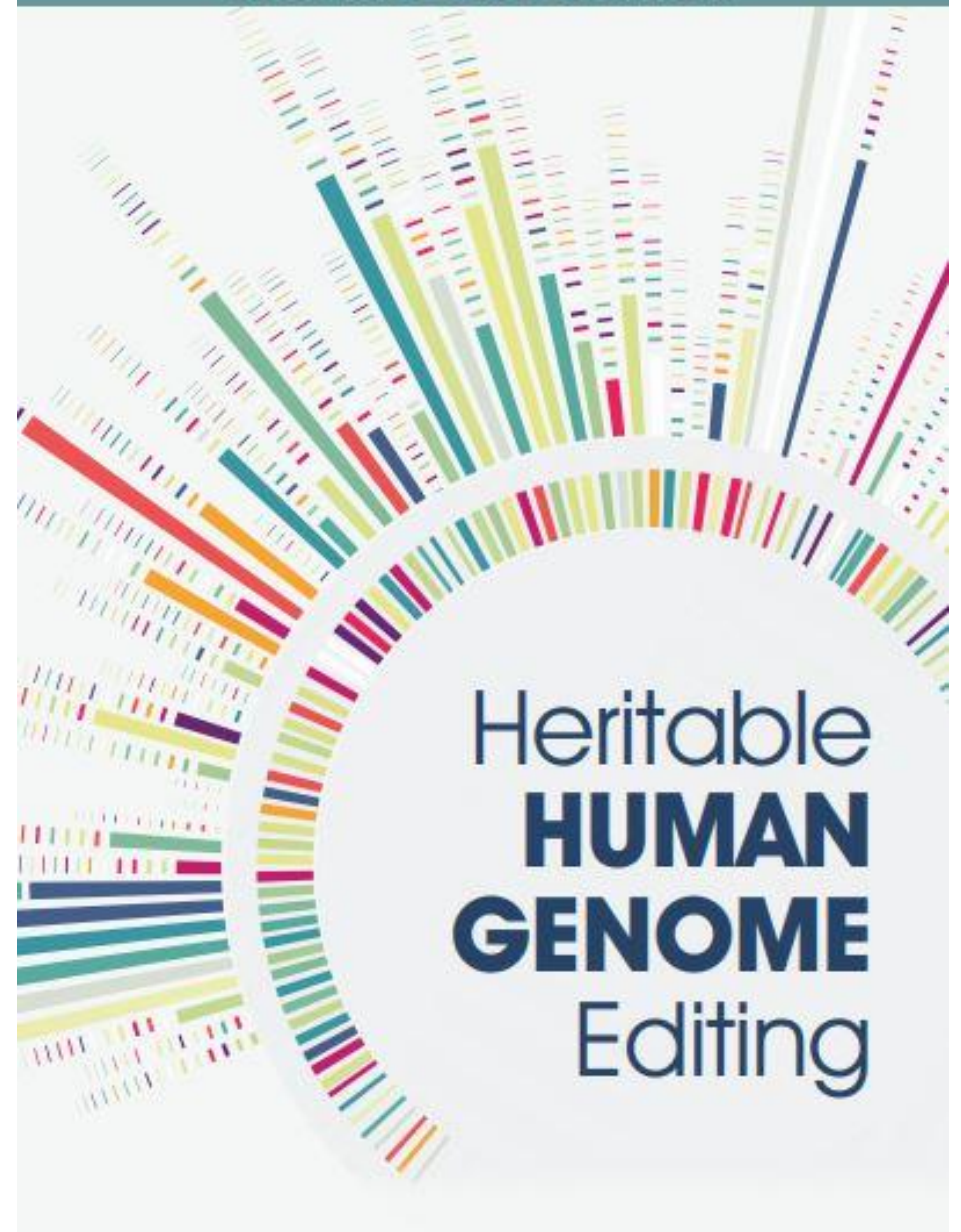
Evidence gathering

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Related content ↓

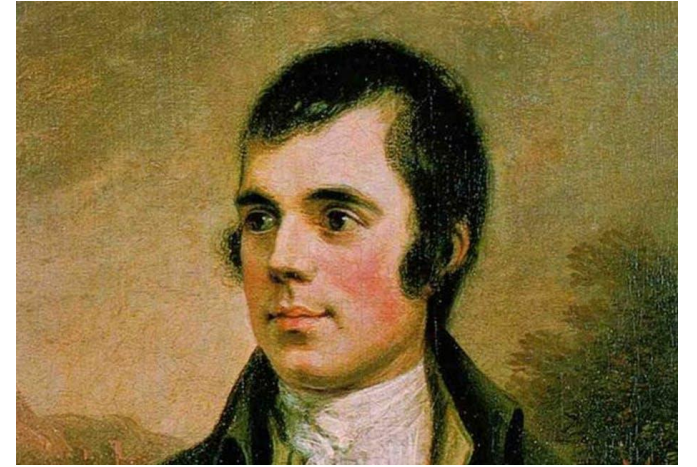
CONSENSUS STUDY REPORT



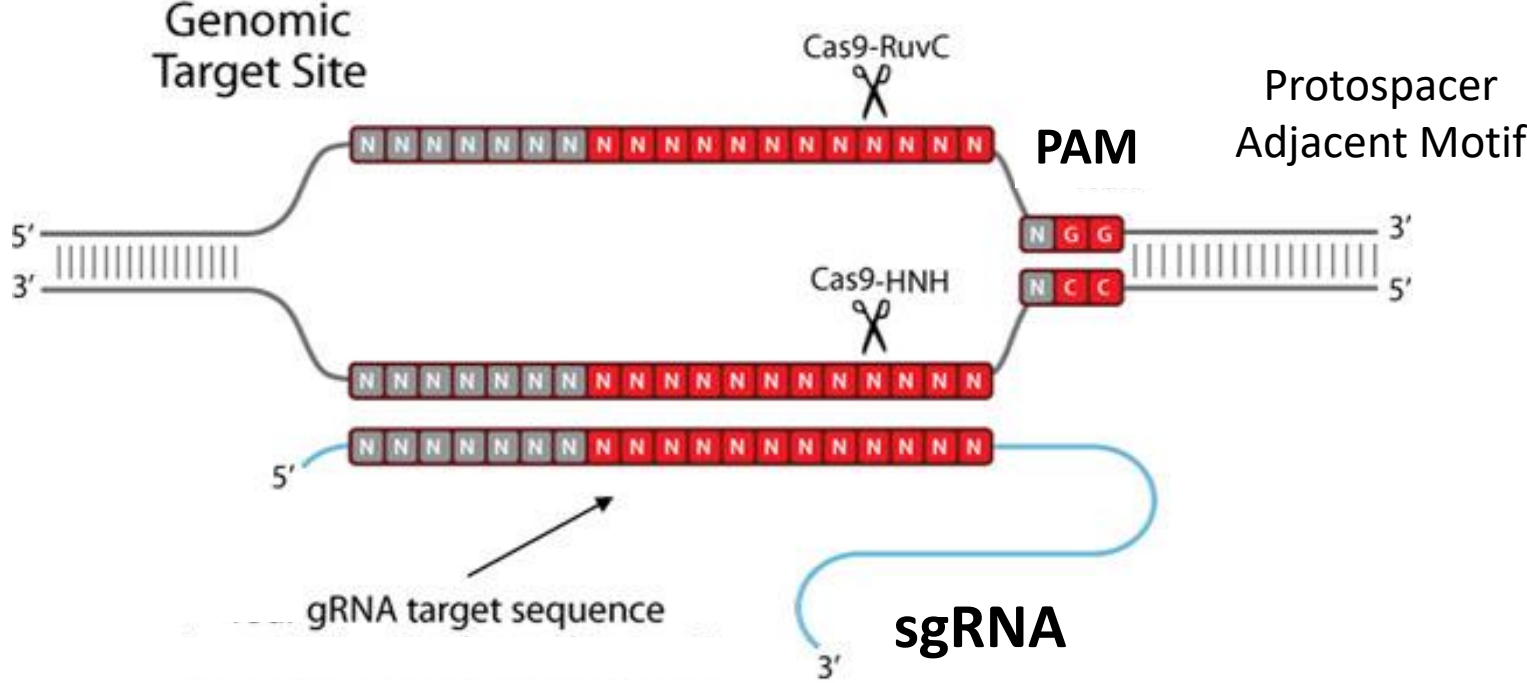
Heritable **HUMAN GENOME** Editing

I'm truly sorry Man's dominion
Has broken Nature's social union,
An' justifies that ill opinion
Which makes thee startle
At me, thy poor, earth-born companion
An' fellow-mortal!

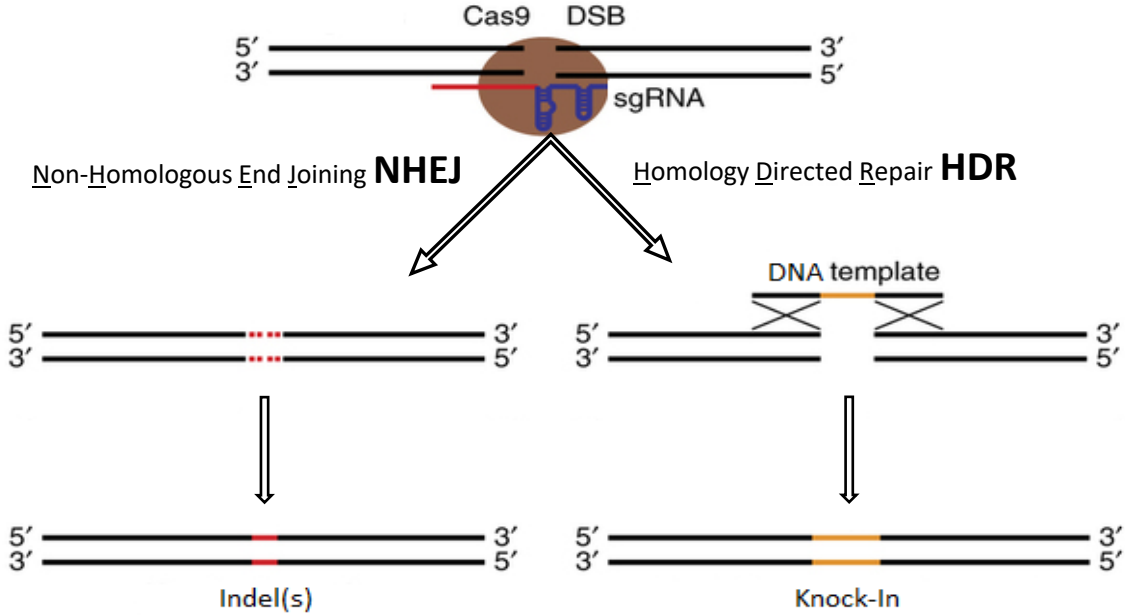
To a Mouse (Robert Burns, 1785)



CRISPR/Cas9 genome editing

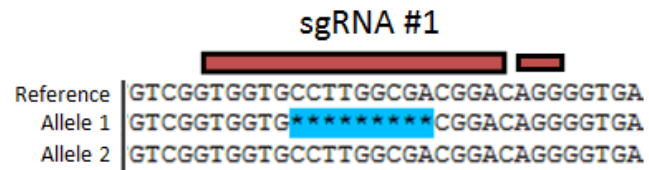


CRISPR/Cas9 genome editing applications

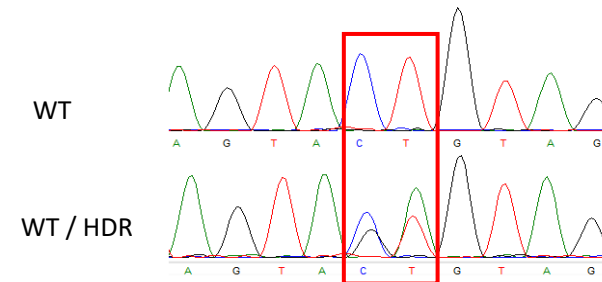


Genome editing toolkit in mice

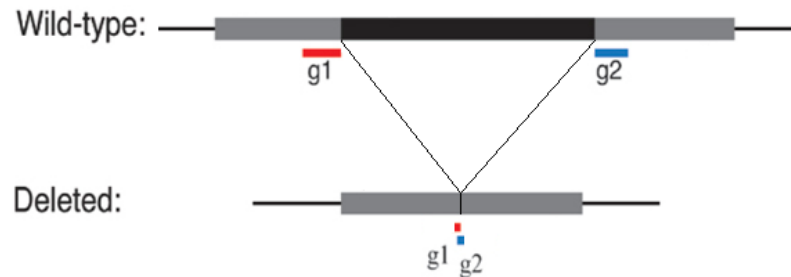
- Indel(s) / Knock-out(s) ✓



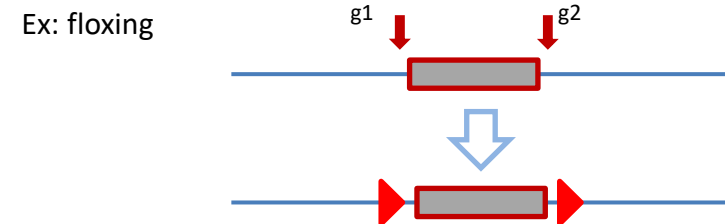
- Point mutation(s) ✓



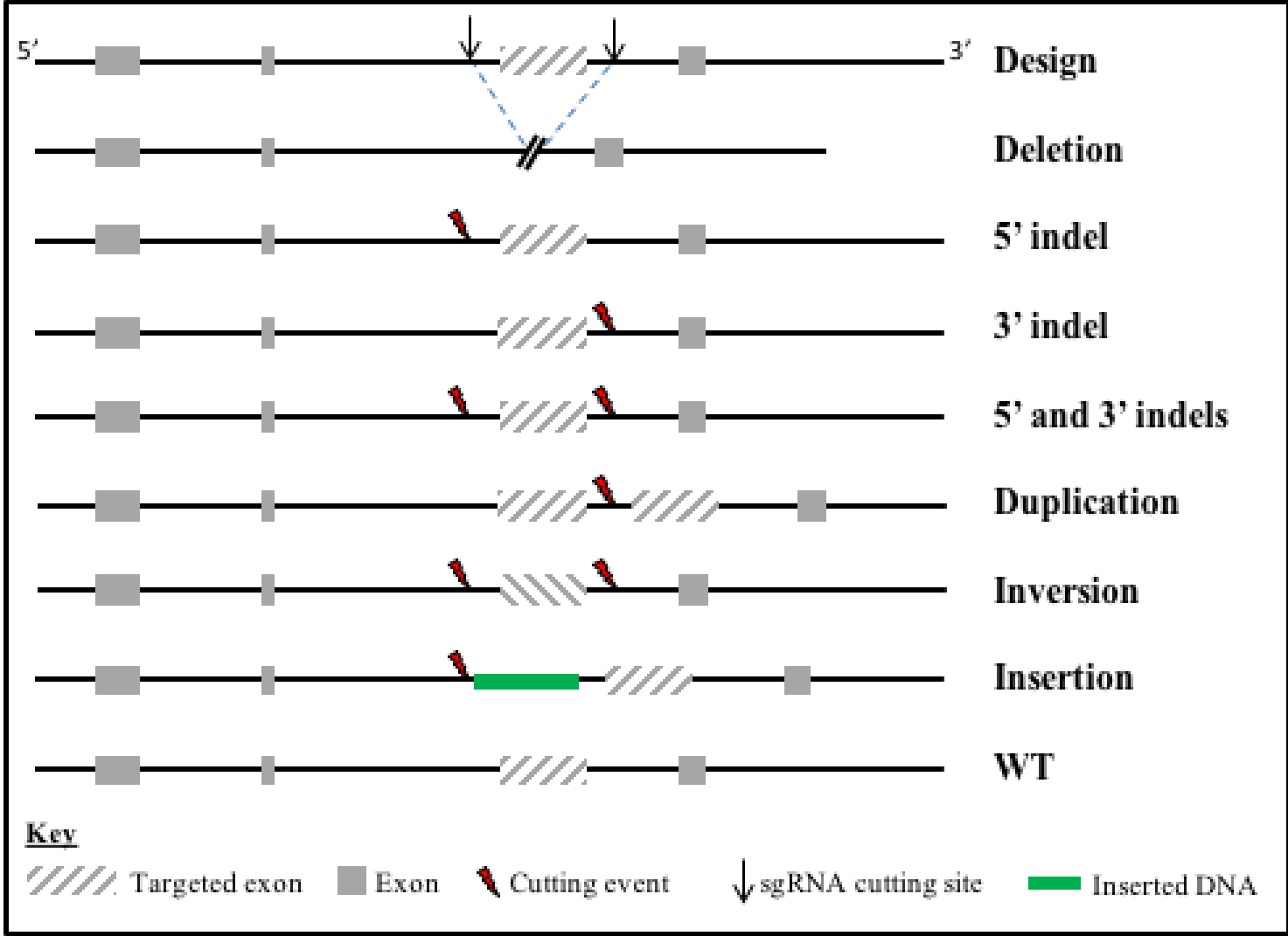
- Tailored deletion(s) ✓



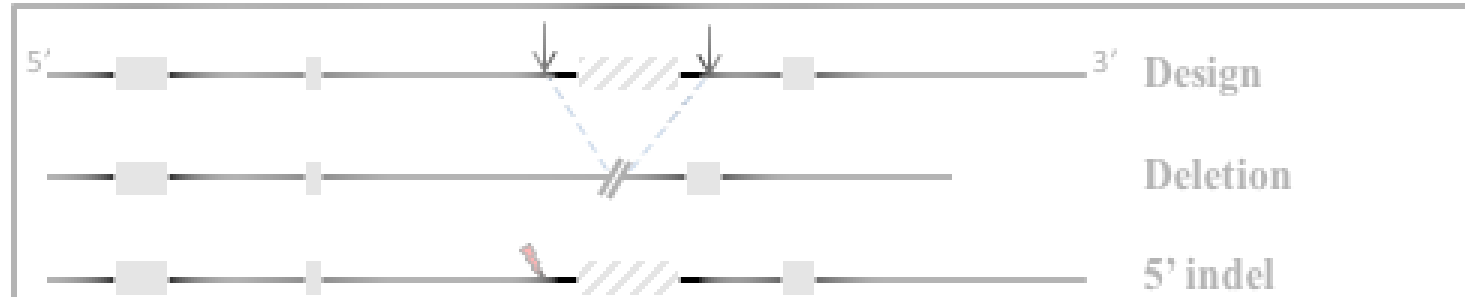
- Gene targeting/transgenesis ✓



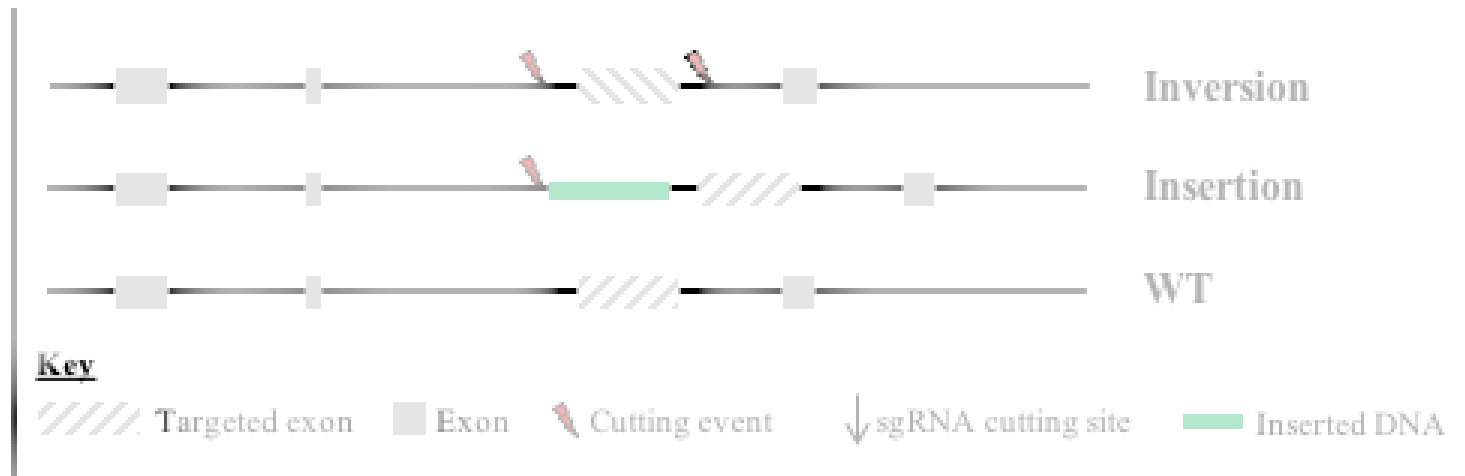
Validation of genome-edited mouse models



Validation of genome-edited mouse models

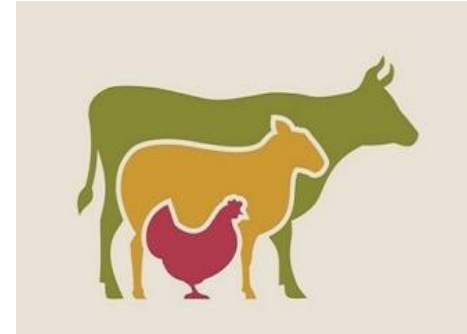


Genome editing technology is a constantly evolving suite of tools



Farmed animals project

- Two-year inquiry began in 2019
- Interdisciplinary working group – law, philosophy, genetics, biotechnology, political theory, animal welfare, food and society, sociology, and economics
- Publication of report (2021): will make recommendations for regulation, policy and practice



NUFFIELD
COUNCIL^{ON}
BIOETHICS

Applications of genome editing in farmed animals

- **POLLED** cattle



Polled Hereford

Dehorning, disbudding: reduce the probability of injury to humans and to other animals

Dehorning, disbudding: painful, stressful

POLLED variants – naturally occurring hornless cows

Genome editing can recapitulate such mutations in *elite* breeds

Genome editing ≠ GM

Applications of genome editing in farmed animals

- **Resistance to Porcine Reproductive and Respiratory Syndrome (PRRS)**

One of the most important and burdensome diseases of pigs in the world

Caused by a highly mutable RNA virus

PRRS: reproductive failure in sows and a complex respiratory syndrome in pigs of all ages

Published studies have found that *CD163* gene-edited pigs exhibit resistance to PRRSV infection

Such genome editing interventions appear to be welfare-oriented

But there are some complex issues to consider...

- **Might genome editing entrench morally objectionable intensive farming practices?**
- Might some imagined uses fundamentally alter animal nature (capabilities) and thereby offend against animal dignity?
- Public interest, public attitudes, regulation

- Might genome editing entrench morally objectionable intensive farming practices?
- **Might some imagined uses fundamentally alter animal nature (capabilities) and thereby offend against animal dignity?**
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Dignitary harms in animals

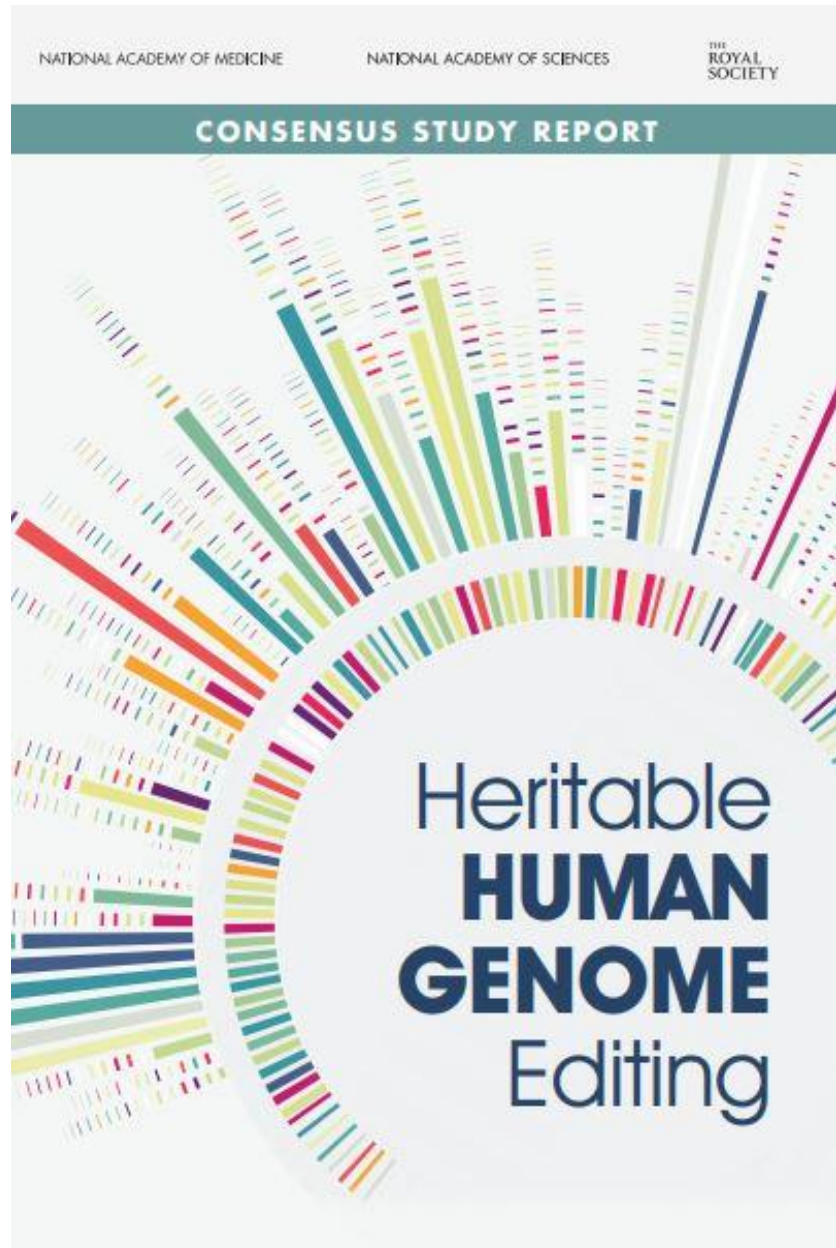
We can object to someone spitting on a dog, painting offensive graffiti on its coat, laughing and pointing if it hurts itself

Imagine using genome editing to radically sculpt animal capabilities for farming...cows and calves that do not object to separation....

The 'meaning' of being a cow or a chicken

- Might genome editing entrench morally objectionable intensive farming practices?
- Might some imagined uses fundamentally alter animal nature (capabilities) and thereby offend against animal dignity?
- **Public interest, public attitudes, regulation**

Some of the language used in this discussion of farmed animals should be familiar to those of you interested primarily in human reproductive (germline) interventions



Heritable Human Genome Editing

International Commission on the Clinical
Use of Human Germline Genome Editing

#HHGECommission

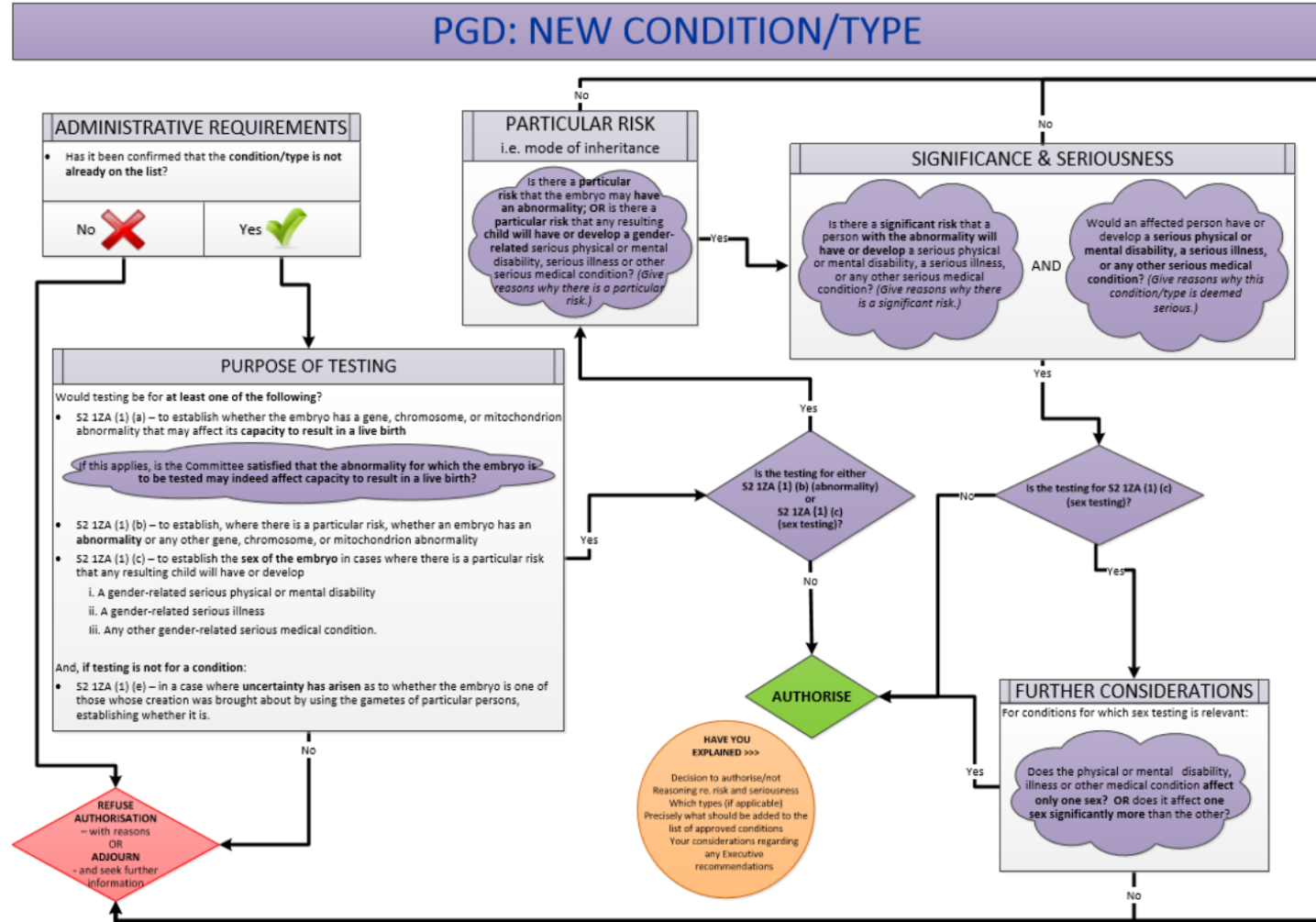
Objections to HHGE: Beyond Safety & Efficacy

- The human germline as inviolable
- The 'mere' desire for genetically-related children
- The 'meaning' of being human

Objections to HHGE: Beyond Safety & Efficacy

- The human germline as inviolable
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HFEA committee decision tree: application for PGD (new condition)



Preimplantation Genetic Diagnosis

Inter-generational/transgenerational justice

Consent

Objections to HHGE: Beyond Safety & Efficacy

- The human germline as inviolable
- The 'mere' desire for genetically-related children
- The 'meaning' of being human

Reproductive desires

- Are not necessarily 'mere' desires
- The 'need' to reproduce – look and listen (no theory required)
- Whether, when, how to reproduce: human rights?
- Liminal space between needs and desires?

Objections to HHGE: Beyond Safety & Efficacy

- The human germline as inviolable
- The 'mere' desire for genetically-related children
- **The 'meaning' of being human**

Stop generalizing! It's all about
circumstances....

Acknowledgments

- Colleagues on MRT [expert panels](#) (Peter Braude, Frances Flinter, Robin Lovell-Badge, Tony Perry, Caroline Ogilvie, et al.)
- Colleagues at [HFEA](#) (Peter Thompson, Sally Cheshire, Dave Archard, Bishop Lee Rayfield, Juliet Tizzard et al.)
- Colleagues on NAS/NAM/RS [International Commission](#) (Kay Davies, Rick Lifton, Doug Turnbull, Eric Lander, Dana Carroll, Jeff Khan, Haoyi Wang et al.)
- Colleagues on [Nuffield Council on Bioethics genome editing in farmed animals working group](#) (Pete Mills, Rebecca Baines, Liz Cripps, Helen Ferrier, Rob Fraser, Anne Murcott, Peter Stevenson, Bruce Whitelaw, et al.)
- Colleagues on [Nuffield Council on Bioethics genome editing working group](#) (Karen Yeung, Richard Ashcroft, Tony Perry, Christine Watson, David Lawrence, John Dupre et al.)
- Colleagues at [MRC Harwell Institute](#) (Sara Wells, Lydia Teboul, Steve Brown et al.)