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Genome Editing in Agriculture: Methods, Applications, and Governance

A paper in the series on The Need for Agricultural Innovation to Sustainably Feed the World by 2050

Genome editing is the process of making precise, targeted sequence changes in the deoxyribonucleic acid (DNA) of living cells.

- Genome editing, as it is most frequently practiced, uses reagents that specifically recognize and precisely cleave DNA targets within the genomes of living cells.
- It is also possible to create targeted modifications using short pieces of DNA (oligonucleotides).
- Recently, an approach to genome editing that allows specific mutations of individual DNA bases without requiring a double strand break has been developed.

Genome editing has the potential to have a large, positive impact on plant agriculture.

- One reason is the efficiency of the technology.
- A second reason is that in contrast to random mutagenesis, it causes relatively few or no mutations at unintended sites in the genome.
- Finally, genome editing allows knowledge-based alterations to a plant genome.

There are numerous recent reviews on genome editing in livestock.

- Much effort has been devoted to improving production traits.
- A number of applications target improved livestock health.
- There is increasing effort to use genome editing technology to improve livestock as bioreactors.
- Finally, as in plants, genome editing has been pursued to develop strategies for biocontainment of animals, with a focus on transgenic fish.

The new technology has accelerated the development of improved crop varieties and livestock with commercial potential, making clarity in how they should be governed paramount.

- Issues that will affect governance of this powerful technology as it relates to plant and animal improvement include how genome editing compares to other methods of genetic manipulation, environmental and animal welfare impacts of specific applications, values of producers and consumers, and economic impacts, among others.
- No method of genetic modification, including conventional plant or animal breeding, is without the possibility of unintended effects.
- Genome editing is likely to be subject to the same underlying factors of information processing and risk perception by individuals that have been found across multiple other emerging technologies.
- Genome editing may help smaller companies and public sector organizations innovate in the development of improved crops and livestock, particularly in specialty crops or livestock species for which there are not large commodity markets.

The power of genome editing suggests that, if conducive social and regulatory conditions are in place, it can substantially increase the positive impacts of plant and animal breeding on human welfare and sustainability.

- A distinction between product- versus process-based regulatory systems is that the latter must be revisited with every innovation in process; product-based regulatory systems are therefore more likely to be stable.
- U.S. Secretary of Agriculture Sonny Perdue issued a definitive statement that the USDA “does not regulate or have plans to regulate plants that could otherwise have been developed through traditional breeding techniques as long as they are not plant pests or developed using plant pests.”
- An advocate general in the European Court of Justice issued an opinion that suggests that some genome-edited organisms need not be regulated in the same way as conventional GM organisms.
- Successful deployment of genome editing for crop and livestock improvement will benefit from science-informed, value-attentive regulation that promotes both innovation and transparency.

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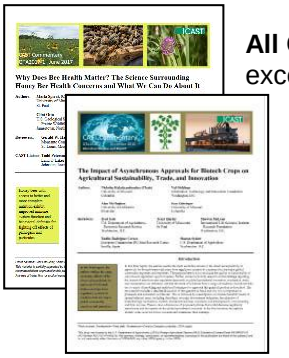

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