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Information Bulletin

# Gene Editing

## What is gene editing?

Gene editing involves removing, and sometimes replacing, individual genes or part of genes using "molecular scissors." Gene editing can achieve much greater precision than earlier forms of genetic engineering and promises to drive innovation in healthcare, agriculture, aquaculture and environmental sciences.

## How is gene editing done?

Gene editing can be used on living organisms including bacteria, plants, animals and humans. Nucleases, the "molecular scissors," can be directed to target specific genes and create breaks in the genome. Once a break is made in the genome at the desired position and the targeted piece of DNA has been removed, the cell's DNA repair mechanisms will repair the break in the genome. If a different (e.g., properly functioning) copy of the targeted gene is introduced into the cell, the DNA repair mechanism can insert that copy into the genome.

## Why use gene editing?

Gene editing has a number of human and non-human applications.

Plant genes can be edited to improve resistance to pests, disease, drought or herbicides. For example, by deleting the genes that repress defences against mildew, researchers have developed a strain of mildew resistant wheat.

In animals, gene editing has been used to produce hornless dairy cows. Hornless cows are desirable because horns can be dangerous to other cows and to humans and producing hornless cows averts the need for a potentially traumatic dehorning procedure. Hornless cows are naturally occurring and can be bred into herds through traditional crossbreeding techniques. But crossbreeding is imprecise and it can take years or decades to breed for both "hornlessness" and "high milk production." With gene editing, hornlessness can be bred into high producing cows within one generation.

Gene editing also has the potential to be used for restoring biodiversity. Gene alleles that have become rare or non-existent in a population can be reintroduced through gene editing.

In humans, gene editing can potentially be used to repair or eliminate gene mutations that cause diseases. Gene editing has achieved some progress toward treating diseases such as hemophilia, HIV and cystic fibrosis—though the therapies are still in testing and development.

## Limitations of gene editing

The technology for gene editing is advancing rapidly, but translating these advances into practical applications faces a number of challenges. Safety is a primary concern as gene editing always carries the risk of producing unanticipated outcomes, such as inadvertently creating biological agents that are more virulent, pathogenic, toxic or communicable.

In biomedicine, gene editing depends on precise knowledge of how genes function to produce a particular medical condition. The power of gene editing is limited by the complexity of the genetic basis of most common diseases, for which simple genetic causes have not been found. Another challenge in biomedicine is how to deliver gene editing systems to the appropriate target cells and in sufficient quantities to achieve a therapeutic effect.

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## Ethical Issues

With respect to plant cell gene editing, regulation and labelling are the main issues. Gene edited crops differ from Genetically Modified Organisms because gene editing does not involve the introduction of genetic material from different organisms. As a result, gene edited crops currently fall outside of the purview of GMO regulations, and food from gene edited crops can be labelled as non-GMO.

In human gene editing, a clear distinction is drawn between somatic (non-reproductive) and germ (reproductive) cells. Changes to somatic cell DNA are not inherited by offspring and somatic cell gene editing is generally considered to be an important and legitimate area of research. Changes to germ cell DNA are passed on to subsequent generations—with unpredictable effects. Most researchers are opposed to germ cell gene editing and it is illegal in many countries, including Canada.

## More Information and Resources

http://www.nature.com/news/human-genome-editing-summit-to-sample-global-attitudes-1.18879

http://www.theglobeandmail.com/opinion/gene-editing-where-medical-dreams-and-ethical-nightmares-collide/article27637335/

https://www.newscientist.com/article/dn28454-gene-editing-saves-life-of-girl-dying-from-leukaemia-in-world-first/

http://www.cbc.ca/news/health/crispr-dna-gene-editing-1.3339346

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