Why Gene Editing is GM with Better PR
A simple briefing from GM Freeze

GM FREEZE
for a responsible, fair and sustainable food system

1. Introduction

GM Freeze is the UK umbrella campaign on the use of genetic engineering[1] in food and farming. We are clear that gene editing is GM with better PR (public relations) and these notes explain why in a way that we hope everyone will understand. Please note that many of the references we include as evidence are much more technical.

2. Genetics – the basics

2.1. Nucleotides are small molecules that act like a kind of biological information code. There are five different nucleotides, usually known by the letters A, C, G, T and U[2].

2.2. Nucleotides are combined into more complex molecules known as DNA[3] and RNA[4]. Each organism's[5] DNA is unique, and the information it contains is sometimes referred to as its genome. RNA comes in many forms and plays a vital role in "decoding" genetic information. In this briefing we use the term genetic material to include both DNA and RNA as the two often work together, hand in hand.

2.3. Sections of DNA that have been identified as doing a particular job are usually known as genes. Coding genes help the organism's cells build a particular protein while regulatory genes are involved in controlling how, when and where different coding genes become active. Some genes have an impact on lots of different traits (characteristics). At the same time, most traits are controlled or influenced by more than one gene. The genome is far more complex than people used to believe, and many factors can influence how and when different genes are active.

2.4. Mutations are changes to an organism's genome, often caused by a genetic injury or an error when cells multiply. Mutations happen frequently and play a big part in evolution, but new research shows that some parts of the genome are protected and suffer very few mutations. This is probably because they are so important to the way that the organism works.[6]

3. Genetic modification

The terms genetic modification (GM) and genetically modified organism (GMO) are defined in UK law.[7] They mean that the genome of an organism has been changed in ways that don't involve breeding. The legal definition of a GMO does not say anything about whether or not a new gene (or other genetic material) is added to the organism.

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4. How gene editing works

4.1. The term gene editing[8] is not defined in law, but it generally means using laboratory techniques to change an organism by modifying its existing genome rather than deliberately adding a new gene.

4.2. The first step is to force genetic material into a target organism cell[9] using the same techniques as with older GMOs.[10]

4.3. The genetic material that is added includes the editing tool and, usually, one or more "marker" genes that help the genetic engineer identify organisms that they have modified (for example genes for resistance to particular antibiotics). Sometimes extra genetic material is added to act as a guide or template (see 4.4 below). The genetic material used in the gene editing process usually comes from other species (including bacteria) but some of it is synthetic (made from scratch in the laboratory).

4.4. The gene editing tool seeks out a particular nucleotide sequence (a specific combination of A, C, G and T molecules). When it finds this sequence, it damages the target organism's DNA. The organism responds by trying to repair this damage. At this point a few different things can happen:

- The organism can make a perfect repair and there is no change to its genome.
- The organism can make an imperfect repair that changes its genome in ways that may – or may not – help the genetic engineer to achieve their aims.
- If the genetic engineer has included a template (see 4.3, above) this will force the organism to repair the damage in a way that makes a particular change to its genome.

4.5. Genetic engineers often plan to remove the genetic material they have added but they don't do this until late on in the process and it does not always work. Some of the gene-edited GMOs growing in UK field trials still contain the gene editing tool, in an active form.[11] Also, gene-edited "hornless" cattle were found to contain genetic material that was supposed to have been removed, including genes for antibiotic resistance.[12]

4.6. Gene editing is an invasive process that disrupts the way that an organism protects and repairs its genome. Gene editing can access – and change – all parts of an organism's genome, including the areas that are usually protected from mutations (see 2.4, above).

5. How gene editing can go wrong

5.1. Gene editing is often described as precise because it targets a particular nucleotide sequence (see 4.4, above). However, a very similar sequence can appear in many different parts of the genome, just like addresses can be so similar that our post gets delivered to the wrong house. Being precise is not the same thing as being accurate and gene editing can happen in the wrong place on the organism's genome. This kind of mistake is usually called an off-target error or effect.[13]

5.2. The genetic engineer may be successful in injuring the part of the genome that they intended but this may result in different genetic changes than were planned, either instead of or as well as the planned changes. This kind of mistake is usually called an on-target error.[14]

5.3. The gene editing process involves lots of complex stages that can put the target organism under stress. This can cause additional genetic injuries which are often called process-induced mutations.[15]

5.4. The genetic changes can go as planned, but still create unexpected outcomes in the organism because the genome operates in very complex ways that scientists do not fully understand (see 2.3, above)[16]

5.5. Even if everything in the laboratory goes entirely as planned, releasing a gene edited organism into the environment can disrupt the ecosystem. This kind of problem is usually called an unintended consequence and can happen with any change (not just gene editing) but the more we interfere with nature the more we risk setting off chain reactions that we cannot stop.

5.6. Many people are concerned that, like with other forms of GM, gene editing will be used in ways that prioritise the interests of big business rather than animal welfare, human health or the environment.

6. **Don't believe the hype**

6.1. The genetic engineering industry does not like being regulated. They want the safety of the plants and animals that they create to be taken on trust and the development of new techniques gave them an opportunity to "re-brand" what they are doing. Lots of new names have been used including gene editing, genome editing, new breeding techniques and precision breeding. None of these terms is currently defined in law.[17]

6.2. Gene editing processes – and the organisms that are created with them – can be patented. This means that the law considers them to be inventions and not the same as organisms that occur in nature or that are developed through breeding.[18]

6.3. We often hear that gene editing makes small genetic changes. This is not always true as gene editing can be used to delete or add large sections of genetic material, and to make changes in lots of different parts of an organism's genome at once. More importantly, when it comes to genetics, even tiny changes can have huge impacts.[19]

6.4. Those who want to remove safety checks and our GM labels don't want people to think of gene editing as a form of genetic modification but that is exactly what it is. There is much that can go wrong, and proper regulation is an essential safety net for our food, our farms and the environment.

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Notes and references

[1] Genetic engineering is not defined in UK law but is generally understood to mean changing genetic material directly (rather than through breeding). We use this term when we need to be sure that everyone understands we mean both older GM techniques and the newer ones that are given various different names (including gene editing).
[2] The five nucleotides are also known as bases and are adenine (A), cytosine (C), guanine (G) thymine (T) and uracil (U). DNA is made up of A, C, G and T in varying numbers and orders. RNA is made up of A, C, G and U, sometimes in very small sequences and sometimes in much longer ones.
[3] Deoxyribonucleic acid.
[4] Ribonucleic acid. There are lots of different types of RNA which you may see referred to with an extra initial letter, eg mRNA (messenger RNA).
[5] An organism is a living thing. It could be a plant, an animal or a microbe (tiny organisms such as bacteria).
[6] Kawall K. New possibilities on the horizon: Genome editing makes the whole genome accessible for changes. Front Plant Sci. 2019;10. doi:10.3389/fpls.2019.00525
[7] https://www.legislation.gov.uk/uksi/2002/2443/contents/made
[8] Also known as genome editing
[9] A cell is the basic unit of life as we know it. All organisms are made up of cells.
[10] For example, *Agrobacterium*-mediated transfer or microparticle bombardment.
[11] https://www.gmfreeze.org/wp-content/uploads/2021/06/Multi-agency-response-to-GM-wheat-trial-application-ref-21_R08_01-UPDATED.pdf
[12] https://www.gmwatch.org/en/news/archive/2019/19096-fda-finds-unexpected-antibiotic-resistance-genes-in-gene-edited-dehorned-cattle
[13]https://www.testbiotech.org/sites/default/files/Frequently_asked_questions_about_CRISPR_and_Co.pdf
[14] http://www.genewatch.org/uploads/f03c6d66a9b354535738483c1c3d49e4/genome-editing-techniques-fin.pdf
[15] https://www.econexus.info/publication/transformation-induced-mutations-transgenic-plants. This paper focuses on older GM techniques but the problems it discusses are caused by the mechanisms used to insert genetic material, the use of tissue culture and other laboratory processes that are also used in gene editing.
[16] https://www.testbiotech.org/sites/default/files/New_GE_unintended_effects_2.pdf
[17] The Genetic Technology Bill aims to create a new legal status for “precision bred organisms”. This will set a legal precedent.
[18] In 2020, the European Patent Office Enlarged Board of Appeal confirmed that plants and animals exclusively obtained by essentially biological processes cannot be patented https://www.epo.org/law-practice/case-law-appeals/pdf/g190003ex1.pdf.
[19] Consider, for example, that sickle cell disease, Tay-Sachs disease and colour blindness are all caused by a single point mutation, where only one nucleotide (the smallest unit of genetic material) is altered.