3. Gene editing causes genetic changes that are different from those that happen in nature

MYTH

Changes brought about by gene editing are the same as could happen in nature or mutation breeding.

REALITY

Gene editing causes genetic changes that are different from those that happen in nature or mutation breeding and their consequences are poorly understood.

Lobbyists claim that gene editing techniques "generally create plant products that may also be obtained using earlier breeding methods"[1] such as mutation breeding, or that could result "from spontaneous processes in nature".[2]

Mutation breeding (also called random mutagenesis) is a decades-old technique in which seeds are exposed to chemicals or radiation to induce mutations in the hope that one or more may result in a useful trait. The lobbyists say that gene editing is more precise than mutation breeding, yet mutation bred plants are exempted from the requirements of the GMO regulations, so gene-edited plants should also be exempted.[3]

However, claims that gene editing can produce organisms that could arise in nature or through mutation breeding are entirely theoretical.

No one has proven that any given gene-edited organism is the same as a naturally occurring vor mutation bred organism, either at the level of the genome or in terms of its molecular composition (the proteins and natural chemicals that make up the structure and function of the organism).

Indeed, if someone were to produce a gene-edited organism that was the same as a naturally bred one, this would call into question any patent on the gene-edited organism, as patents require an "inventive step".

NO EVIDENCE THAT CHANGES FROM GENE EDITING ARE FEWER THAN FROM CONVENTIONAL OR MUTATION BREEDING

Dr Michael Antoniou, a molecular geneticist based at a leading London university, said that claims that the mutations induced by gene editing are the same as could happen in nature or mutation breeding are scientifically unfounded. Moreover, he said there is no evidence demonstrating that gene editing is more precise, in the sense of causing fewer mutations, than conventional breeding or mutation breeding.

He said "Gene editing can cause large deletions, insertions, and rearrangements in DNA, which can affect the function of multiple genes at off-target and on-target sites." I am not aware of any studies using reliable screening methods that compare the frequency of these types of large-scale DNA damage in conventionally bred, mutation bred, and gene-edited plants. What we do know is that there is clear experimental evidence showing that assumptions that gene editing only causes small insertions and deletions at off-target and on-target sites are false."[4]

> "Gene editing can cause large deletions, insertions, and rearrangements in DNA, which can affect the function of multiple genes at off-target and on-target sites"
> - Dr Michael Antoniou

MUTATIONS FROM GENE EDITING ARE DIFFERENT IN TYPE FROM THOSE FROM CONVENTIONAL OR MUTATION BREEDING

Evidence shows that mutations induced by gene editing are not the same as those induced by chemicals or radiation in mutation breeding. For example, a scientific review shows that gene editing can produce changes in areas of the genome that are otherwise protected from mutations.
In other words, gene editing makes the whole genome accessible for changes.[5]

Dr Michael Antoniou says that mutations induced by mutation breeding will more often than not occur in areas of the genome that are non-coding and non-regulatory and therefore are unlikely to affect gene function.

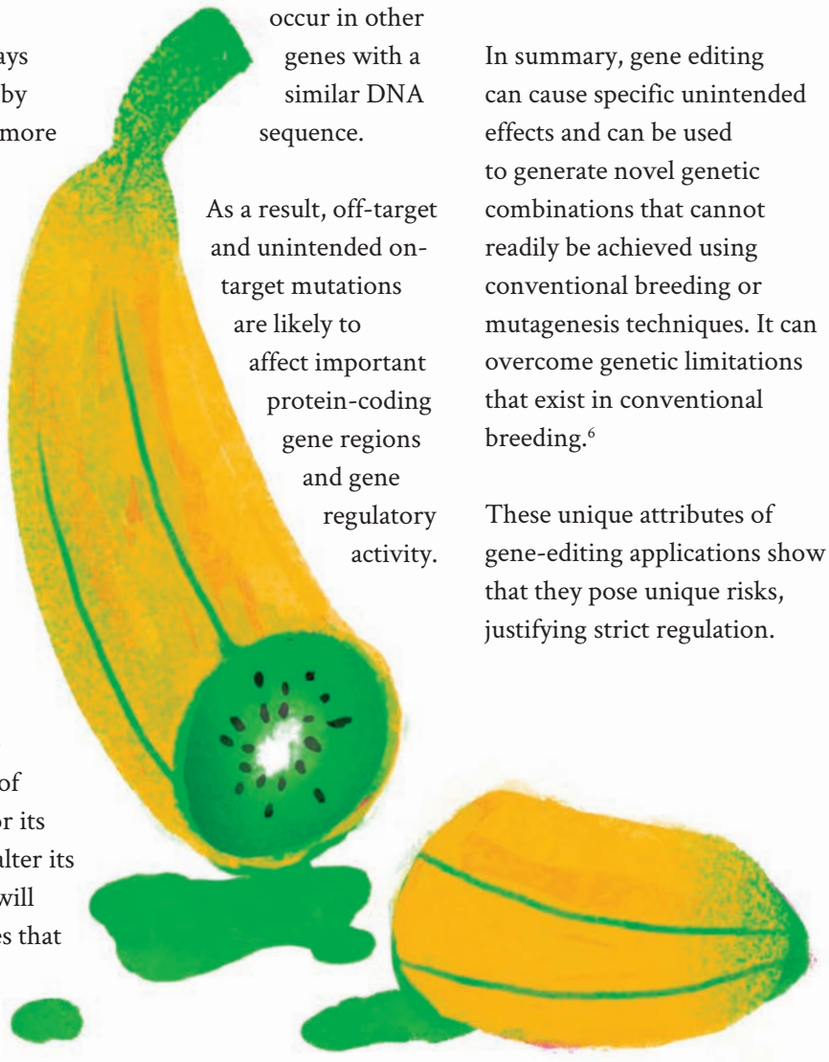
With gene editing, in contrast, mutations are more likely to happen at locations in the genome that directly affect the function of one or more genes. First, there is intentional targeting of a gene's coding region or its regulatory elements to alter its function. Gene editors will preferentially target sites that are relevant for protein production and gene regulation for alterations, since the objective is to change a trait. Second, much of the off-target mutation-causing activity of the gene-editing tool will occur at locations within the genome with a similar DNA sequence to the intended target site. This means that if the intended gene editing target site is a gene's coding region or its regulatory elements, off-target mutations will occur in other genes with a similar DNA sequence.

As a result, off-target and unintended on-target mutations are likely to affect important protein-coding gene regions and gene regulatory activity.

A separate scientific review shows that gene-editing techniques enable complex alterations of genomes that would be extremely difficult or impossible to achieve with conventional breeding or mutation breeding. In gene editing, so-called multiplexing approaches allow the targeting and alteration of multiple gene variants, which can be members of the same or different gene families.[6]

In summary, gene editing can cause specific unintended effects and can be used to generate novel genetic combinations that cannot readily be achieved using conventional breeding or mutagenesis techniques. It can overcome genetic limitations that exist in conventional breeding.[6]

These unique attributes of gene-editing applications show that they pose unique risks, justifying strict regulation.



REDESIGNING NATURE

CRISPR inventor Jennifer Doudna has made clear that the aim of CRISPR gene editing is not to replicate or enhance nature but to redesign and replace it. She wrote:

"Gone are the days when life was shaped exclusively by the plodding forces of evolution. We're standing on the cusp of a new era, one in which we will have primary authority over life's genetic makeup and all its vibrant and varied outputs. Indeed, we are already supplanting the deaf, dumb, and blind system that has shaped genetic material on our planet for eons and replacing it with a conscious, intentional system of human-directed evolution."[7]

The limitations imposed by natural processes may help, rather than impede, evolution

However, given that scientists do not fully understand the function of the vast complex networks of genes and their products that constitute a healthy functioning organism, they are not remotely close to being able to predict the outcome even of a single gene manipulation. Thus it is difficult to see how a new era in human-led predictable, directed evolution has dawned. From this perspective, when it comes to evolutionary processes, it is arguably genetic engineering that is a "deaf, dumb, and blind system", rather than nature.

The limitations imposed by natural processes may help, rather than impede, evolution.

NOT NATURE-IDENTICAL

The evidence shows that the genetic changes brought about by gene editing are different from those that would happen in nature or mutation breeding and their outcomes and the risks attached to them are poorly understood.

With this in mind, gene editing must remain under the EU's GMO regulations and the risk assessment should be broadened to take account of the special risks attached to the technology.

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