Why gene editing matters

John Innes Centre
Unlocking Nature's Diversity

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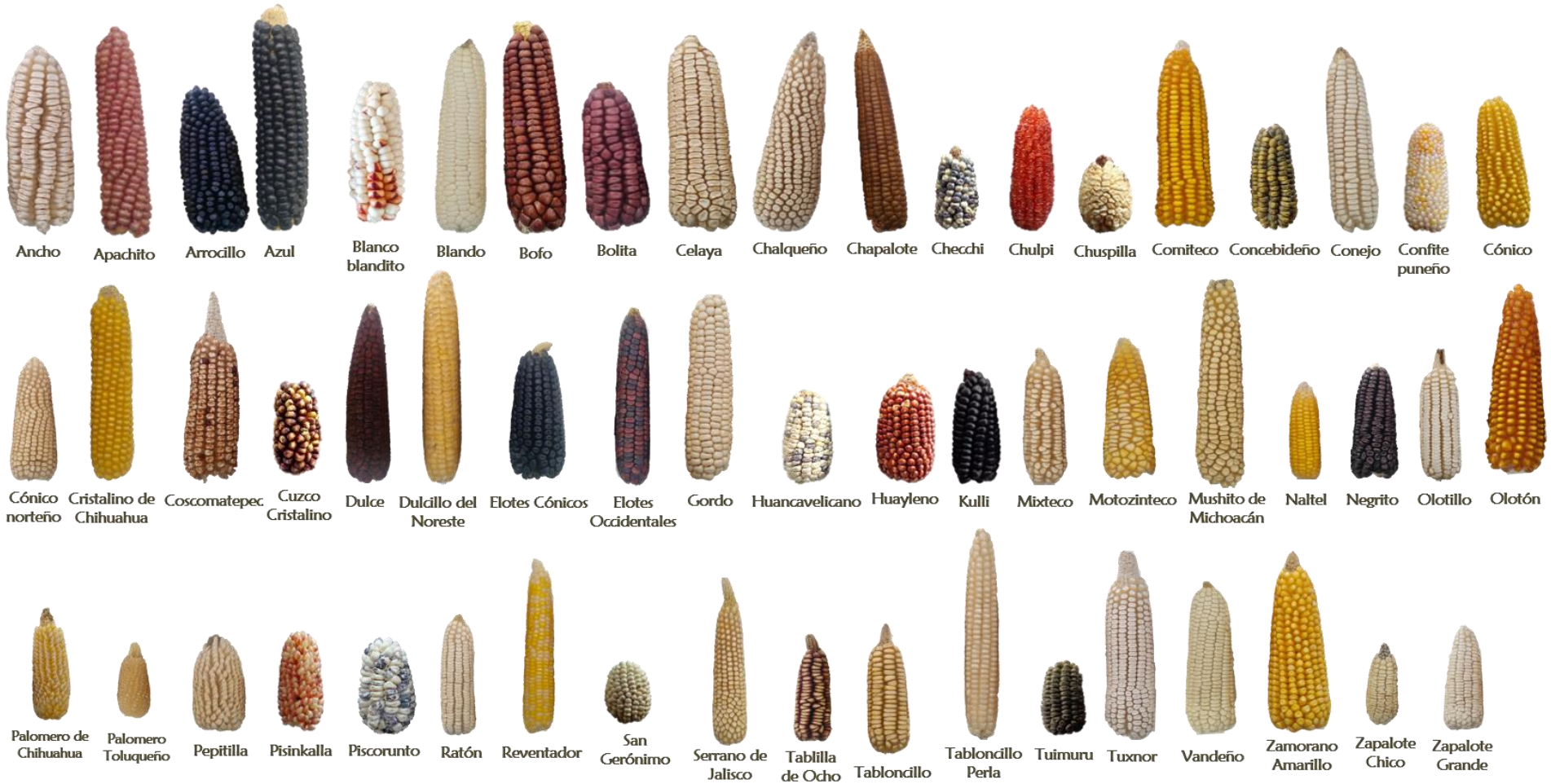
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Azul
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Blando
Bofo
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Concebideño
Conejo
Confite puneño
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Cristalino de Chihuahua
Coscomatepec
Cuzco Cristalino
Dulce
Dulcillo del Noreste
Elotes Cónicos
Elotes Occidentales
Gordo
Huancavelicano
Huayleno
Kulli
Mixteco
Motozinteco
Mushito de Michoacán
Naltel
Negrito
Olotillo
Olotón
Palomero de Chihuahua
Palomero Toluqueño
Pepitilla
Pisinkalla
Piscorunto
Ratón
Reventador
San Gerónimo
Serrano de Jalisco
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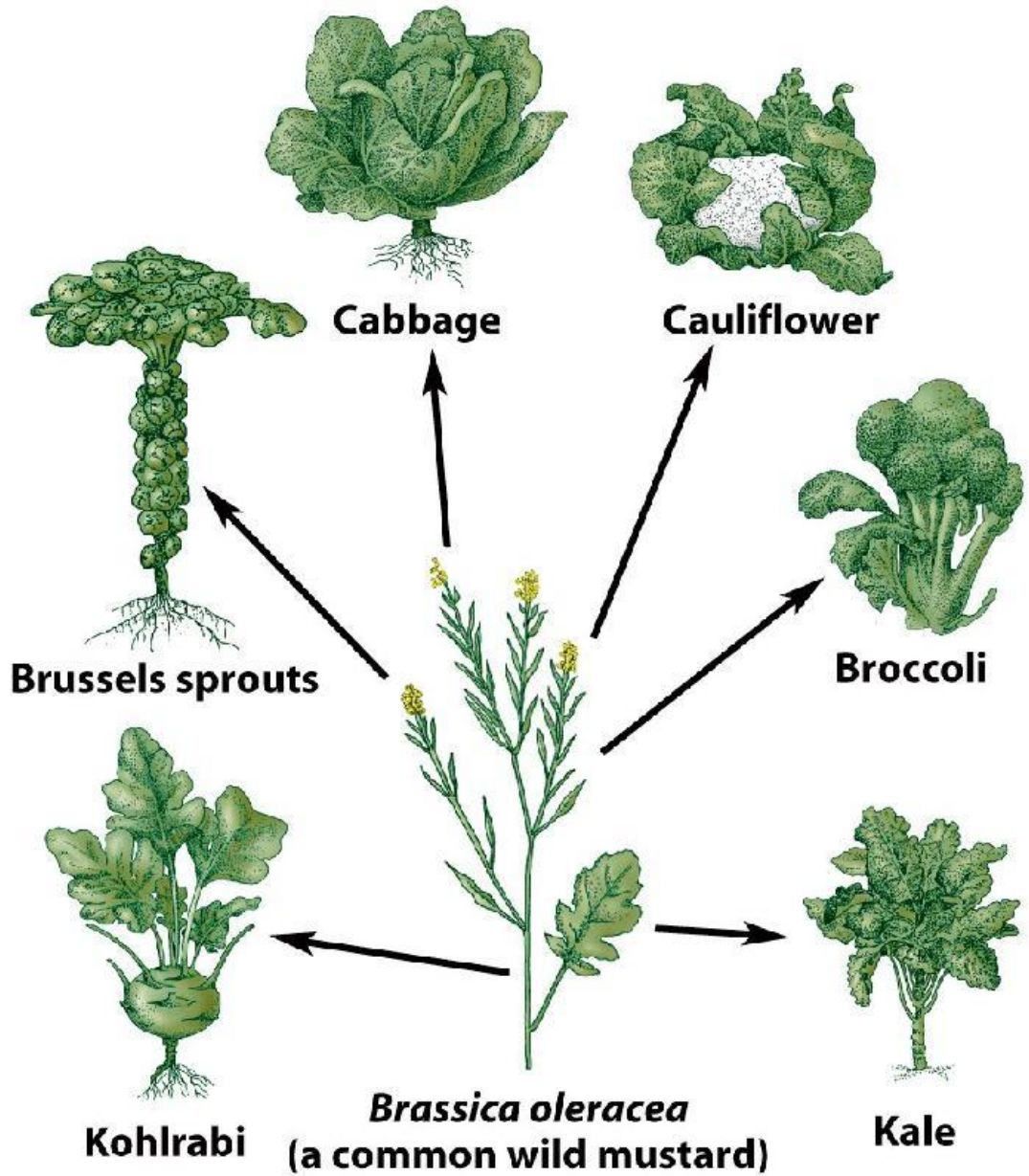
Zapalote Chico
Zapalote Grande


Cabbage
Cauliflower
Brussels sprouts
Broccoli
Kohlrabi
Brassica oleracea
(a common wild mustard)
Kale


2,500,000

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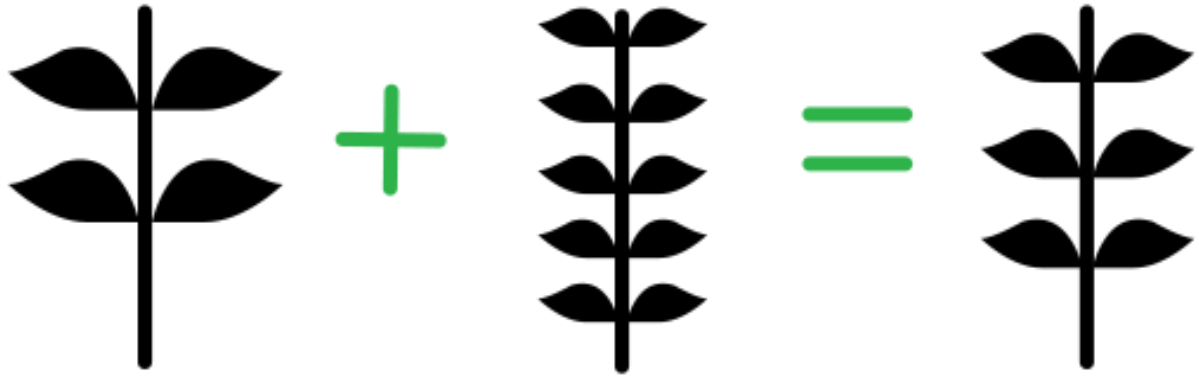
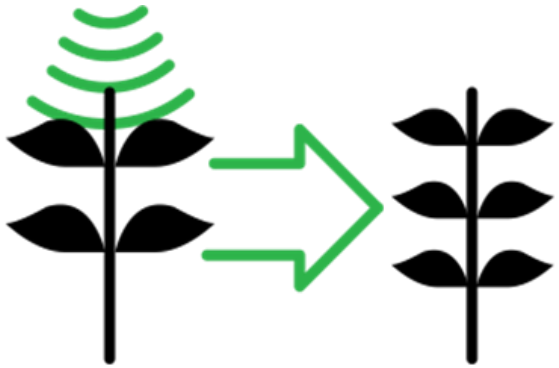


Traditional Breeding

Desired traits are identified in separate individuals of the same species, which are then bred to combine those traits in a new hybrid variety.

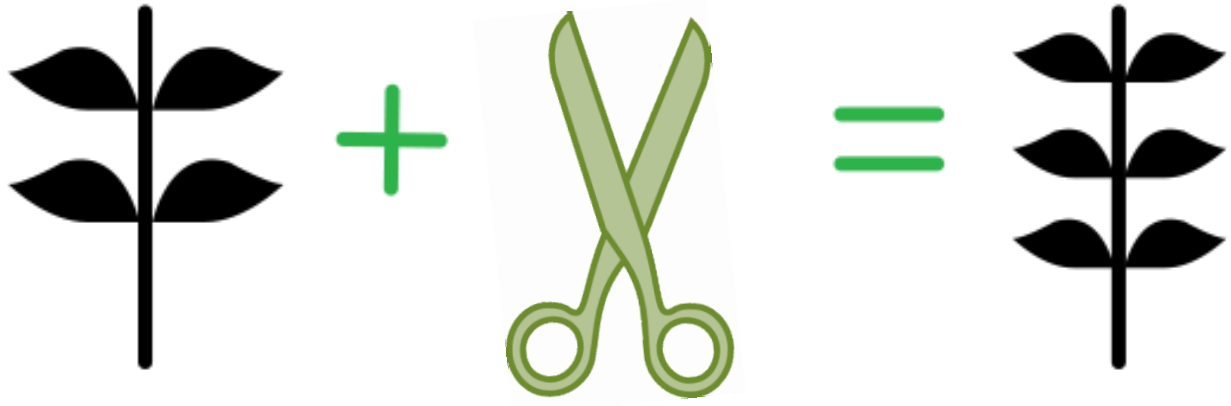


Mutation Breeding

Seeds are irradiated to promote **random** mutations in their DNA. If a mutation happens to produce a desirable trait, the plant is selected for further breeding.

Transgenic

Genes identified in one species can be **transferred** directly to an unrelated species, giving it an entirely new trait.



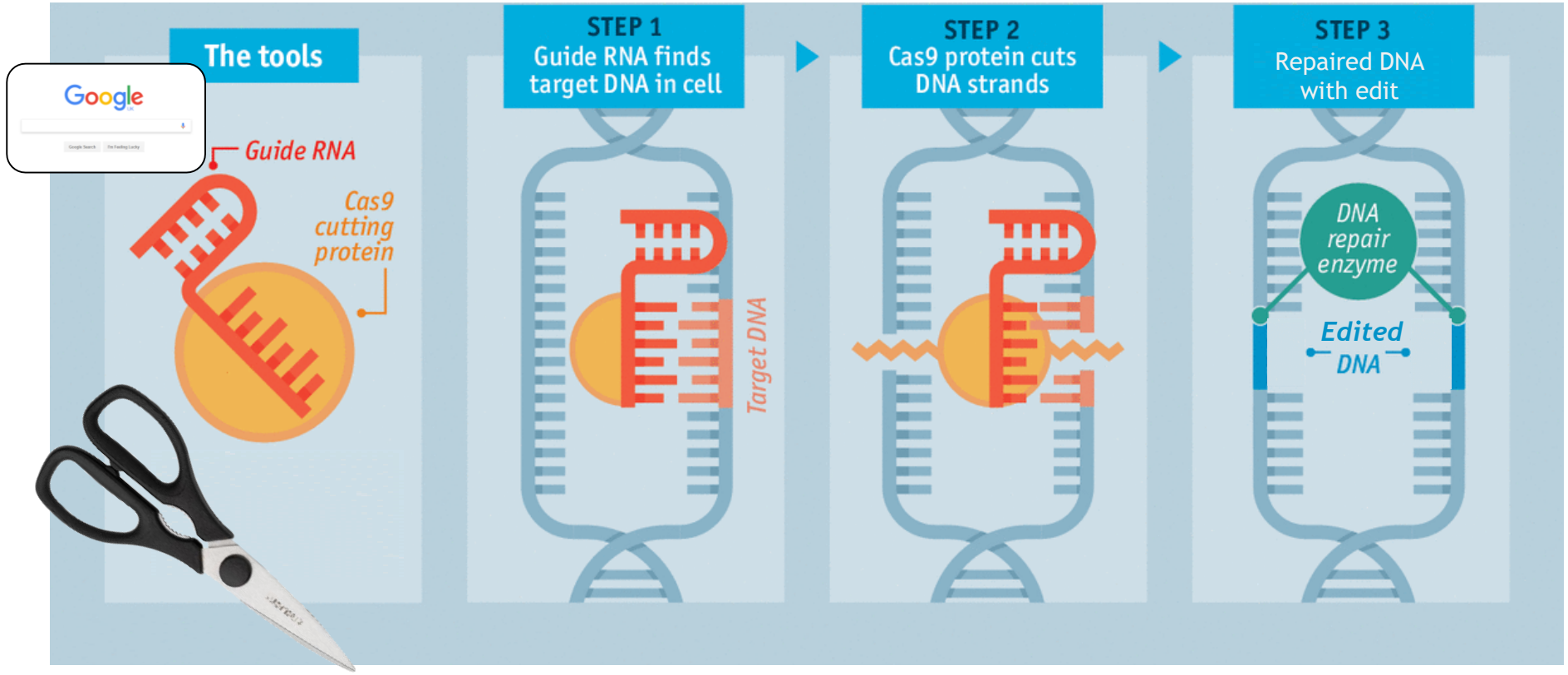
Gene Editing

Specific edits to DNA are made in a **targeted** manner to confer new trait. Genome editing can be used to:

- **remove/alter DNA** (*Mutation Breeding*)
- add new DNA (*Genetic Modification*)

Gene editing will redefine, accelerate, and enhance breeding

CRISPR-Cas9


The tools
Guide RNA
Cas9 cutting protein
STEP 1
Guide RNA finds target DNA in cell
Target DNA
STEP 2
Cas9 protein cuts DNA strands
STEP 3
Repaired DNA with edit
DNA repair enzyme
Edited DNA

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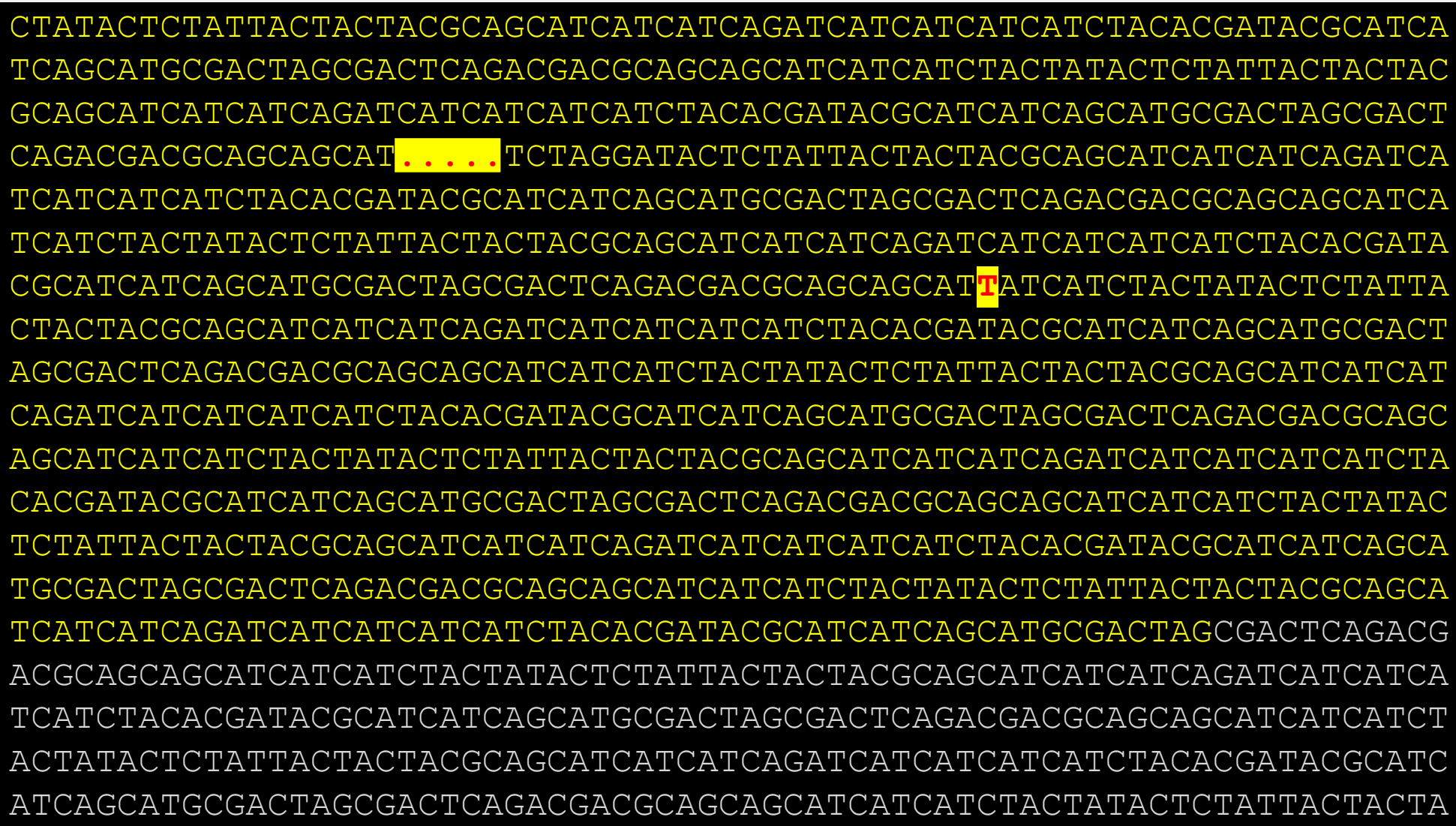
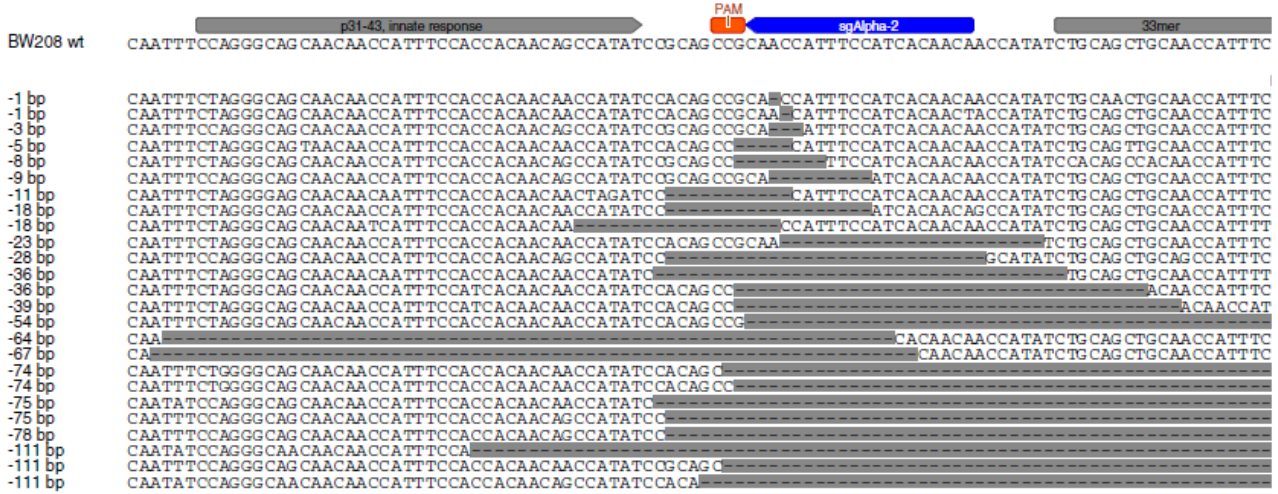
Mutations via gene editing are indistinguishable from naturally occurring mutations.



Low-gluten wheat engineered with CRISPR-Cas9



Sanchez-Leon et al 2017

Increase grain size/weight in wheat

Wang et al 2018

Main features of technologies

	mutations /changes	Type of mutations	Change could occur naturally	Foreign DNA	Transgenic step required?
Mutation Breeding	>500,000	Random	Yes	No	No
Transgenic	1 (or more)	Targeted	No	Yes	Yes
Gene Editing	1 (or more)	Targeted	Yes	No (possible)	Yes (not with new methods)

…some final thoughts…

- Mutations are essential for genetic variation within a species.
- Mutations via gene editing are indistinguishable from naturally occurring mutations, albeit targeted.
- Careful with the over-hype.
- Part of a broader toolkit for molecular breeders.

- Proportionate science-based regulation to promote innovation.
- Not just plant genetic diversity, but also human diversity!

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