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Explanatory Note:

New Techniques in Agricultural Biotechnology

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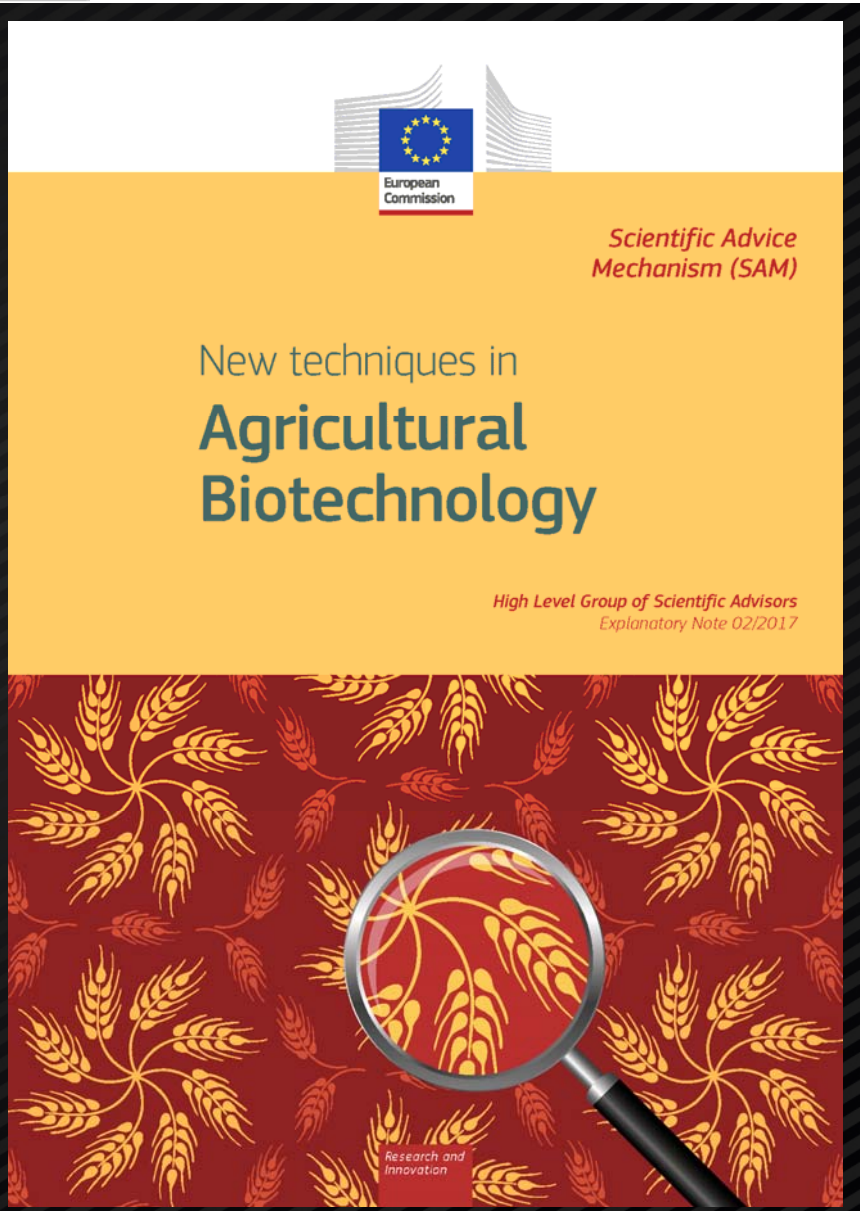
Independent scientific advice for policy making

Research and Innovation



Background:

- Since the beginning of agriculture around 10,000 years ago humans endeavoured to improve their crops and animals.
- We have selected plants, animals and microorganisms that give a greater yield, are more palatable, easier to process, etc.
- Features of plants, animals and microorganisms
  that make them useful for agriculture
  are a result of an organism's genetic makeup,
  which in turn is the product of natural, spontaneous mutations.

Background

- As technology has developed, the ways in which new varieties can be generated faster have become more sophisticated.
- At first, chemical or physical agents (such as x-rays) were used to make random changes to plant seeds (induced mutagenesis); this procedure still requires selection of organisms with desirable traits.
- More targeted changes became possible during the 1980s, involving the insertion of genetic material into organisms, some of which may be from other species (genetic modification, GM).

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Background:

- Recently, a variety of new breeding techniques (NBT) have been developed for agricultural biotechnology.
- Some of them do lead to the inclusion of genetic material from other species or to changes of genetic sequences, while others don’t.
- When changes to genetic sequences are made with a NBT, they are typically made in a more precise manner than those made with established techniques of GM.

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Gene editing and CRISPR/Cas:

Natural bacterial immunity system ,
which ”cleaves” DNA at programmed sequences

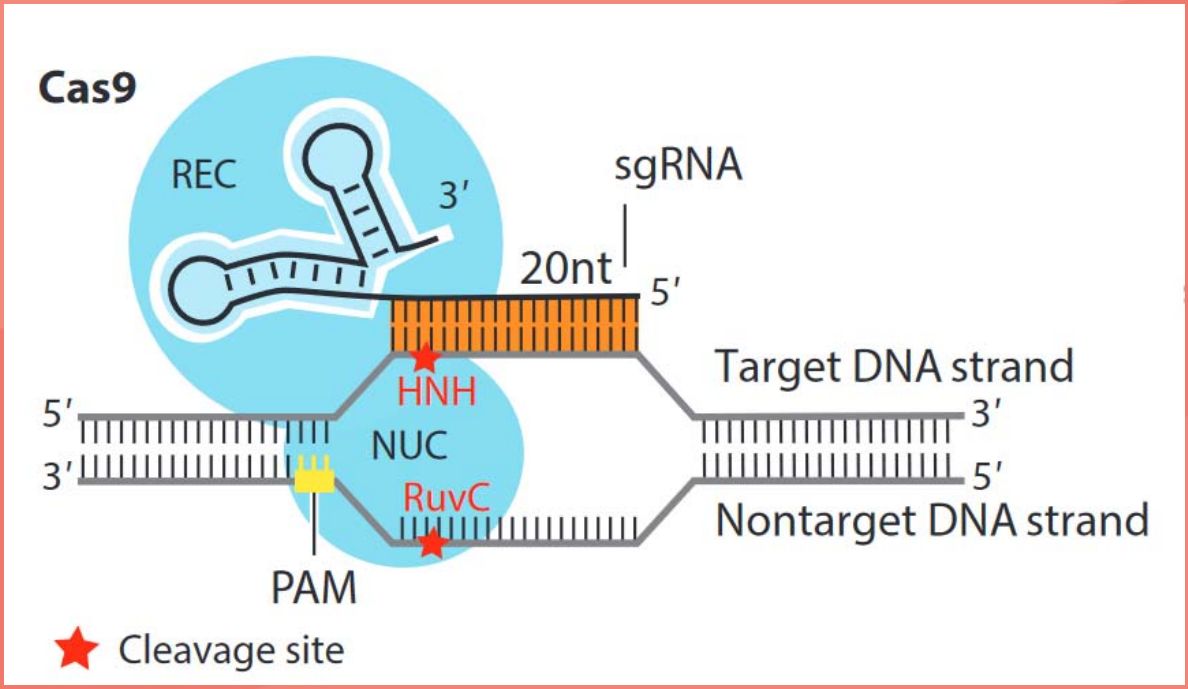

Figure adapted from
Annu. Rev. Biochem. 2016.85:227-264.
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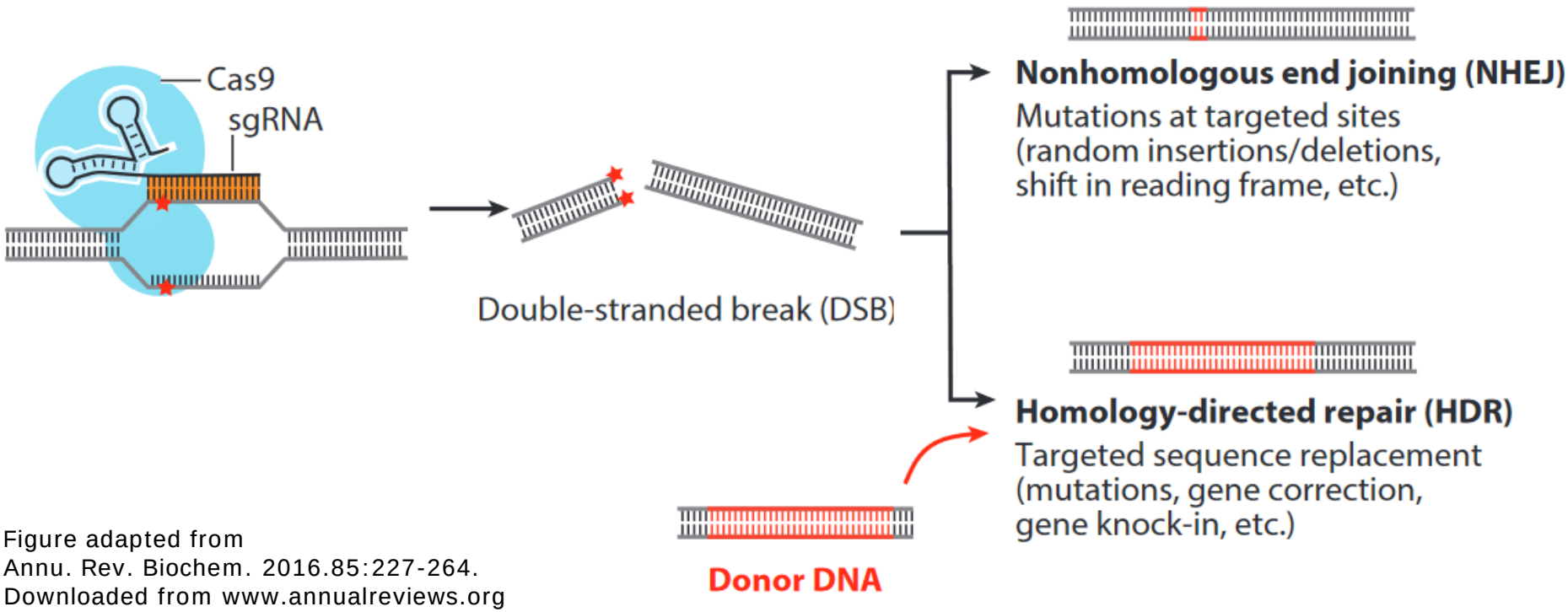
Gene editing and CRISPR/Cas:

Can be used in various organisms for:

- precise random mutagenesis
- precise template-guided mutagenesis



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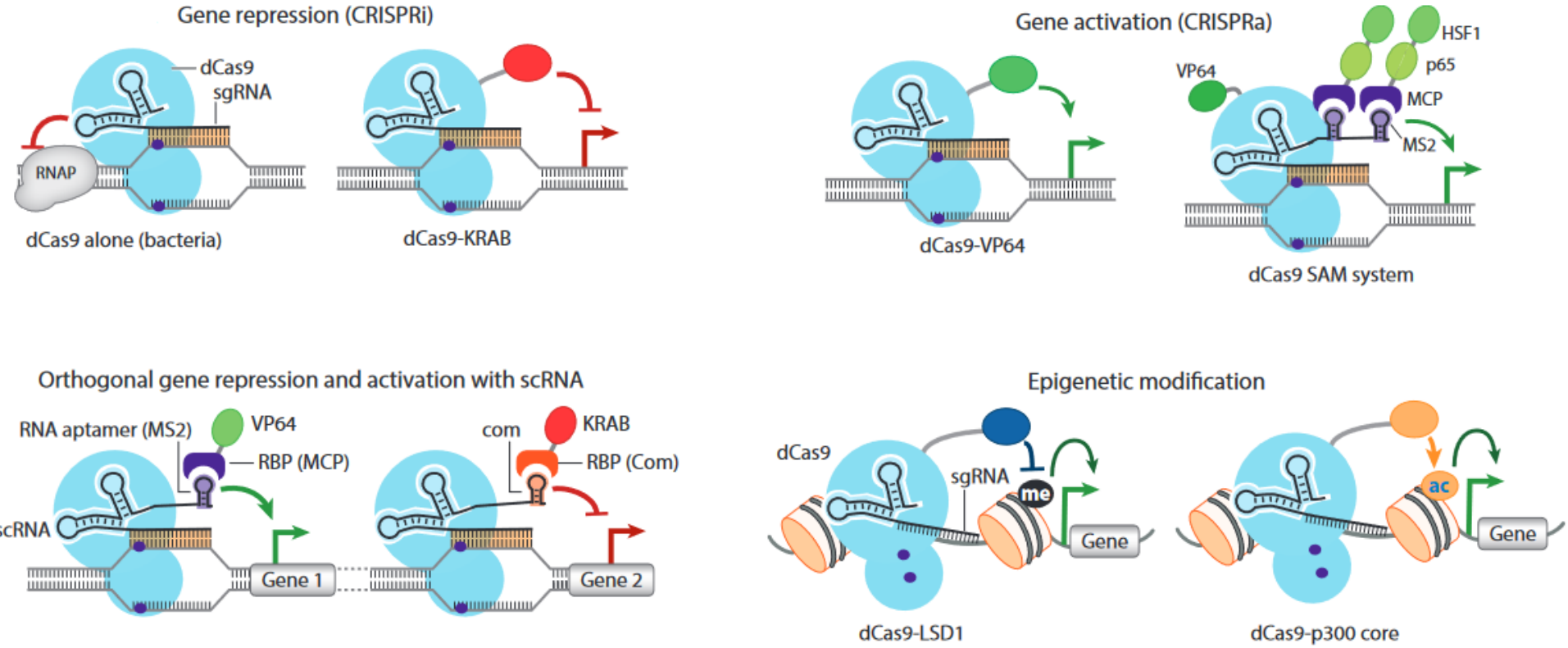
CRISPR/Cas beyond gene editing



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Frequently asked questions:

- How do the NBTs (and their products) compare to
  - each other?
  - the GM techniques?
  - classical (natural?) techniques
  (e.g. in terms of precision, cost, speed, safety)

- What is natural (observed in the nature) and what is not?

- Can organisms obtained with different techniques
  - be detected?
  - be distinguished from each other?

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We are all mutants!

- All living organisms are subject to genetic alterations occurring spontaneously and due to environmental stressors.
- These changes are the basis for evolution by natural selection.
- All breeding techniques (CBT, ETGM and NBT) make use of genetic diversity and change in order to allow the selection of desirable traits.

Techniques and their products

- Generally speaking:
  - organisms produced using CBT will not contain genetic material from organisms of other species,
  - those produced using ETGM usually will,
  - and those produced using NBT may or may not.

- The end products of NBT do not necessarily contain genetic material from other organisms.
  Such material may be present in intermediate stages.

- Some NBTs make no changes to genetic sequences at all.

Detection and attribution of changes

- NBT of genome editing can produce
  precise alterations of genetic sequences (local mutagenesis)
  that can be undistinguishable from changes occurring naturally.

- Without prior knowledge, changes are difficult to detect
  and the attribution of changes to a particular technique
  is generally impossible.

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Unintended effects:

- Classical techniques often produces many unintended effects
- Unintended effects are not necessarily visible or harmful, either to the organism in question, or to those who eat it
- Generally, genome editing techniques are more precise and result in fewer unintended effects than do CBT and ETGM
- It is not possible to define the safety of a technique solely based on its precision and/or the likelihood that it will produce unintended effects

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Safety:

- Assessments of the safety (environmental, health, etc.) of the organisms produced by the new techniques can only be made on a case-by-case basis taking into account, amongst others:

  - the specific mutation,
  - unintended effects,
  - the species into which the mutation is introduced,
  - the environment in which the end product is used,
  - the agricultural practice applied,
  - and its planned use and exposure.