The CRISPR/Cas ‘gene scissors’ birthday

Ten years ago a crucial scientific paper paved the way for New Genetic Engineering

9 August 2022 / On 17 August, ten years ago, a crucial scientific paper officially published, for the first time described how CRISPR/Cas9 can be used to induce targeted genetic changes in the genome. It is a process which uses an RNA molecule as a ‘tracer’ to guide the gene scissors to a specific site in the genome where they are activated. The enzyme Cas9 vital to this process was originally found in bacteria and belongs to the category of nucleases which have the potential to cut the double strands of DNA. After publication of the paper, CRISPR/Cas became the most frequently used ‘New Genetic Engineering’ tool (also known as genome editing). Two of the authors, Jennifer Doudna and Emmanuelle Charpentier, were awarded the Nobel Prize in Chemistry in 2020.

The gene-scissors are mostly used to ‘knock-out’ natural gene functions. The process may include adding foreign genes or altering existing gene functions. CRISPR/Cas ‘gene scissors’ do, in fact, have a high technical potential and are more precise and flexible compared to previous methods of genetic engineering. The DNA cuts induced by CRISPR/Cas typically cannot be repaired by the cells to restore gene function. In addition, gene scissors can overcome also other mechanisms used by the cells to protect vital gene functions. This is all fundamentally different to conventional breeding methods which, amongst others, make use of random mutations. ‘Gene scissors’ can thus generate new genotypes which would certainly be unlikely to result from natural evolutionary processes. The technology makes it possible to induce extensive changes to the biological characteristics of organisms, even without the insertion of additional genes.

CRISPR/Cas ‘gene scissors’ have a wide range of application, e.g. in medicine or plant and animal breeding. The technology has made the genetic engineering of wildlife and interference into evolutionary processes possible. Many CRISPR/Cas applications have been heavily criticised. One reported example was of babies born in China whose genome had been altered with ‘gene scissors’. These interventions into the human germ line are highly problematic from an ethical perspective and may also have serious health implications. It is known that applications of CRISPR/Cas are frequently associated with unintended genetic changes. However, some medical applications seem to have been successful.

Releases of CRISPR/Cas organisms into the environment are particularly controversial. Even though these organisms may not have had additional genes inserted, when the resulting plants and animals are compared to those which have evolved naturally or are conventionally bred, there are often significant differences due to intended or unintended effects. The long-term environmental impacts are frequently hard to assess and are dependent on many factors.

The technology is also controversial because of patents awarded to industry: the European Patent Office has, for example, approved questionable ethical claims which do not clearly excluded interventions into the human germline. In addition, as far as plant and animal breeding is concerned, there has been an increase in new dependencies and blockades because many companies not only claim the technical processes, but also biological resources such as genes, seeds and plants.

At the same time there is acrimonious dispute about who even first invented the gene-scissors. Early patent applications submitted by Doudna and Charpentier seem to lack the technical details necessary for successful ‘gene scissor’ applications. In the US, a basic patent issued to Doudna and Charpentier was recently revoked. Oppositions have also been filed against the European Patent, although a final decision is still pending.

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