Essay on the CRISPR/Cas-9 Technology

The CRISPR/Cas-9 technology has been a revolutionary discovery in the science of gene modification. The technology has given us a tool to change genetic material in living organisms, by using a mechanism that was originally a defence system in bacteria. In this essay, I explain how the technology works, as well as what I believe it should be used for. I also discuss an ethical problem with by using the technology.

The CRISPR/Cas-9 system consists of two main components: the CRISPR gene and the Cas-9 protein.

CRISPR is an acronym for *Clustered Regularly Interspaced Short Palindromic Repeats* and are short interspaced sequences of DNA, which are repeats of each other. In between these identical strands of DNA are other smaller strands of DNA. When CRISPR was first discovered in E-Coli, researchers found that the small sequences in between the repeats were virus DNA. This shows that when virus DNA attacks the cell, the bacteria has DNA of the virus stored or has the ability to store DNA. The complex also holds the DNA for the nuclease-protein Cas. This protein has the ability to separate a gene and cut it with molecular scissors. When the Cas protein searches for the DNA, which it has to cut, it opens up a genetic sequence by separating it and then checks after the DNA that matches its RNA. If it matches Cas starts to destroy the DNA by cutting it. If it does not match, Cas closes the DNA again and continues searching for its matching DNA.

Professor Jennifer Doudna and researcher Emmanuelle Charpentier developed the CRISPR/Cas-9 system in 2012. They deciphered the defence system in the bacteria Streptococcus pyogenes. From this system they have created the 'tracr-RNA-cr-RNA chimera' system. Simply, they exchange the virus cr-RNA (CRISPR-RNA) with RNA of their choice. The tracr-RNA (tracer-RNA) holds the cr-RNA in place in the Cas-9 protein.

The system consists of the Cas-9 protein as well as the cr-RNA-tracr-RNA, also referred to as the g-RNA (guide RNA). Furthermore, the system also consists of the host DNA that is inserted into the inactivated gene cut by Cas-9. A g-RNA that codes for this particular DNA is developed. The complex is inserted into a cell by using a plasmid with the genetic codes for the developed g-RNA and the Cas-9 protein. It is inserted into the Cas-9 protein. Cas-9 finds the DNA that matches its g-RNA and cuts it. From here, you have a DNA sequence with a gap in it. Sometimes the DNA will mutate to repair the break, but often it is possible to inactivate the sequence and then insert the

chosen host DNA into the break and repairing it. Therefore, it is possible to alter DNA sequences by using the CRISPR/Cas-9 method and any organism can be easily edited[1].

The accuracy of the CRISPR system means it can be used in different fields. In medicine the tool has been proven to be extremely useful. It has not been yet approved for usage on humans for clinical trials. However, according to Jennifer Doudna[2] it is very likely that we will see approved clinical trials and therapies on adult humans within the next ten years. According to Doudna, we can most likely use CRISPR to possibly cure the genetic defect that causes sickle cell anemia[3]. There are already possibilities in treating HIV with the technology[4] as well. CRISPR is universal on all cell types, which opens up countless possibilities. It is being tested for use in microbiology-related agriculture[5] as well. All of these uses of CRISPR are ways to better our world, which I deem to be a positive use of the technology.

Nonetheless, there are ethical considerations when it comes to CRISPR by using it predominantly without consent, for example in regard to editing the genome in embryos. These are modifications, which change the generations of humans, thus modifications on an organism that affects the evolution of it. An adult can give consent to having something modified by using the CRISPR method, but an embryo cannot give its consent and neither can its offspring that also receives these modifications. Hereby, it makes it non-consensual and therefore problematic. The majority of the Danish Council on Ethics agrees that it is irresponsible to use CRISPR on embryos[6] and I agree. This is an aspect of the technology that we should not exploit.

[1] See: **Reference 1, Websites**
[2] See: **Reference 1, Videos**
[3] See: **Reference 2, Websites**
[4] See: **Reference 3, Websites**
[5] See: **Reference 2, Websites**
[6] See: **Reference 4, Websites**

References

Websites

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3. http://journals.lww.com/aidsonline/Citation/2017/02200/New_research_on_using_CRISPR_Cas9_to_treat_HIV.1.aspx (Kristin N. Harper - February 20th, 2017)
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2. http://www.radiolab.org/story/update-crispr/ (Radiolab: Update CRISPR - February 24th, 2017)

Student picture: