CRISPR/Cas9- a game changer in biotechnology?

Linn Syding
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Institution for biology undergraduate studies, Uppsala University

Can CRISPR/Cas9 be used in order to cure bacterial infections and is it possible to use it as a tool for producing suitable organs for transplantations? Well, before we answer these questions it is appropriate to go through what CRISPR/Cas9 actually is.

CRISPR/Cas9 is a system borrowed from the immunology of bacteria which protects them from invasive viruses. It stands for ”Clustered Regularly Interspaced Palindromic Repeats” and is more or less what the name suggests, short palindromic repeats of nucleic acids (nucleic acids are what makes up the DNA in all organisms) that are interspaced by short sequences of genetic material from other organisms (spacers). The mechanism behind it is based on the following. A short fragment of the intruding viruses genetic material is saved and stored in the genome of the bacteria. This means that the next time a similar intruder appears, the bacteria is able to recognize it through the base pairing of the short fragment and the viral genome. The fragment of DNA together with a protein (Cas9) binds to the intuders DNA and through that the Cas9 protein cleaves it, which leads to its destruction. While this certainly may seem interesting on its own, a key question is; how can this be of use to us? Well in fact, this system has already been proven to work as an efficient tool within biotechnology and has also many different applications in a varied spectra of other areas.

By using this tool, it has been made easier to edit the genes in all organisms, human cells included. It is possible to delete the expression of genes and to incorporate new genetic material as well. Shortage of organs for transplantation is a global issue, there are more people in acute need for organs than there are organs available. Xenotransplantation, transplantation of organs from non-human animals to humans, has been considered as a possible solution to this. For this to be feasible it requires efficient genome editing in order for the body not to repel the new organ. That technical difficulty has been significantly reduced with CRISPR/Cas9 as it has, in lab experiments, been proven to work. Although this would provide significant progress in readying non-human animal organs to be used by humans, this raises the question of research ethics. If this technique would be applied in xenotransplantations, then that would mean that animals, such as pigs for example, would be brought up for the sole purpose to have their organs harvested. This brings up the rather philosophical dilemma of whether the consequences of saving a human life outweighs the ethical cost of the systematical breeding and killing of animals.

Another possible use of this technique is for curing bacterial infections. Bacteria that are multiresistant to antibiotics is an urgent problem in the world today. Due to the over-use of antibiotics most bacterial strains have mutated so that they are no longer sensitive to antibiotic treatment. And, as if that is not bad enough, they also have ways of passing this insensitivity protection from one to another. Since the discovery of antibiotics in 1928, they have been used vigorously and antibiotics have enabled our society to evolve and increase our life spans. However, with the increasing threat of antibiotic resistance it is currently up to us to start pursuing alternative options.

The CRISPR/Cas9 technique has been proven effective in re-sensitizing bacteria to antibiotics. By engineering the CRISPR so that the spacer has nucleic acids that correspond to the ones of the antibiotic resistance genes in the bacteria, it will bind and the Cas9 protein will cut it. When successfully cut, the former resistant bacteria regains sensitivity to and can now be treated with antibiotics. Antibiotics are however not discriminatory, during a treatment a lot of other bacteria including ”good bacteria” in the body gets killed off and repeated use of antibiotics can create adverse consequences such as inflammations and obesity. To remedy this scientists took the

CRISPR/Cas9 method as an antimicrobial one step further. Instead of targeting the antibiotic resistance gene they targeted vital genes in the bacterial chromosome. That way the antimicrobial can be very selective, making it possible to choose exactly which bacterial strain that is to be targeted. Although the technique has shown remarkable possibilities it still has to be tested clinically and exactly how and to what extent it will work, when injected into a patient, is yet to be discovered.

These two applications are just two out of many possible applications. The technique is still quite new and needs to be further tested before it can be used safely or effectively. So far it does however show promising signs of being able to revolutionize biotechnology as we know it today.

For more information:
Lander ES. 2016. The Heroes of CRISPR. Cell **164**:18-28
Syding L. 2016. CRISPR/Cas9- Ett revolutionerande system för biotekniken