From viral infections in bacteria to gene therapy in humans

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Ever since we started sequencing the genomes of bacteria, some mysterious sequences in their genomes have been troubling the minds of researchers. But just a few years ago, a group of scientists in Umeå put the final pieces to the puzzle of the mystery sequences and presented a theory of a bacterial immune system that has had a huge impact in the field of biotechnology. Thanks to their discoveries, editing and repair of defective genes in human genomes might soon become a reality.

Bacteria has immune systems too

The difference between humans and bacteria might seem huge, but in fact we share quite a lot of common features. Just like humans, bacteria can be infected by viruses and recently scientists have discovered bacterial immune systems that defeat these infections. The immune systems are called CRISPR/Cas - and to understand them, one must first get a grip on the infecting mechanisms of viruses. When a virus infects a bacterium it inserts its genetic material into the bacterial DNA and uses the cells own machinery to reproduce inside the cell. Eventually, the virus particles inside the cell are so many that they basically makes the cell explode, causing its death. To protect themselves, bacteria has developed the CRISPR/Cas immune system, which has become to be known as the ”gene scissors”. The system works by cutting up the viral DNA into small pieces and inserts them into the bacterial chromosome to be used as a memory of the infecting species. If the bacterium once again is infected by the same type of virus, the CRISPR/Cas-system will rapidly recognize and destroy the viral DNA.

Programming immune systems for gene therapy

The discovery of the CRISPR/Cas systems has brought gene technology to a whole new level. Scientists are now using the CRISPR systems as programmable tools that can cut, insert and delete sequences almost anywhere in the genome. However, even if they are few, there are some restrictions to where the CRISPR/Cas-system can be designed to cut. To overcome these restrictions scientists all over the world are identifying and characterizing new CRISPR/Cas systems from diverse organisms. The main aim of researching on CRISPR/Cas systems is thus to find bacterial mechanisms that we can modify into tools for precise gene therapy in humans. One of these systems that have shown promising properties is CRISPR/Cpf1. By further researching these systems we will hopefully soon be able to cure severe genetic diseases such as cystic fibrosis, hereditary breast cancer and Parkinson’s disease. By using CRISPR-based gene therapy we could permanently repair the genetic defects and spare patients from repeated treatments and lifelong medications.

Further reading

Jinek, M., Chylinski, K., Fonfara, I., Hauer, M., & Doudna, J. A. (2012). A programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity. Science (New York, N.Y.) 337:816-821.

Isolehto, I, (2017) CRISPR/Cpf1 – Vårt nästa stora verktyg för genmanipulationer? Uppsala Universitet.