FirstRand

A cut and paste tool for human DNA

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How CRISPR-Cas9 technology has taken genetic engineering mainstream

Genetic engineering is one of those fields of science that make people feel queasy. Something about it feels dangerous, perhaps even creepy.

And yet human beings have been engaged in genetic engineering for as long as agriculture has been around. In its simplest sense, genetic engineering is merely strengthening the traits you want, and minimising the traits you do not want, through selective pairing.

All the breeds of dogs, the ubiquitous Holstein-Friesian cows producing much of the world's milk, drought resistant crops and carrots that are orange (as opposed to the original purple) are all examples of genetically engineered products currently in wide circulation.

In a lab – the same principles apply. The benefits of labs are that we can manipulate ever smaller pieces of the genetic puzzle, in a controlled environment. So our work can be precise, tested and simulated before it is applied in the real world.

It took us thousands of years to domesticate dogs. With laboratory genetic engineering, we could have achieved it in about 365 days, provided we had the imagination to think of all the variants that chance produced.

The possibilities are endless – we can eradicate hereditary diseases, optimise the features and traits we want in our offspring, and slow down, stop or even reverse ageing. But precision genetic engineering has always been held back by three practical problems: it is expensive, it is complicated and it is time consuming.

These three practical problems have now been solved, thanks to a new technology known as CRISPR Cas-9, and humanity is at about to embark on a biological technology revolution that will change everything about what we believe is possible… or normal.

DNA (Deoxyribonucleic acid) are two strands of genetic letters, twisted around each other in a double helix shape. There are only four genetic letters (A, C, T and G) – and the different combination of these four letters determine a lot. Whether you have blue eyes or brown; whether cancer, obesity or high blood pressure runs in your family… everything about in and from the human (physical, intellectual or emotional) take marching orders from these four letters. In fact, over 3,000 genetic diseases are caused by a single 'incorrect' letter. There are also thousands of genes that affect the risk of disease. And retroviruses (which would include things like HIV, Cancer, and Hepatitis-B) actually insert themselves into human genes through RNA.

It was while researching the eternal battle between Viruses and Bacteria that scientists at Berkeley and elsewhere stumbled on a process that will now enable them to edit genes - cheaply, quickly and simply for the first time. So far, labs have noticed a 99% reduction in costs, using the technology. What used to take a year can now be accomplished in a matter of weeks. And editing can be done pretty much by anyone with a lab.

A virus injects hostile RNA into a bacteria. The host protects itself by detecting the viral RNA, and then produces two of its own strands, the first essentially copying a mirror sequence of the 'bad' RNA, and then combining it to form a protein called Cas-9.

CRISPR written out is quite a mouthful: Clustered Regularly-Interspaced Palindromic Repeats. But all that CRISPR actually refers to are short segments of DNA, consisting of 20-40 letters.

Cas-9, the protein, is essentially like a little car, that transports the new sequence to DNA. It cuts out a piece of the existing DNA, and replaces it with a CRISPR sequence.

Interestingly, it can cut any DNA. It can even be done inside living cells. What is also exciting is that every cell in a human body is a copy of the entire genome: 20,000 genes with 3 billion DNA-letters.

With CRISPR, DNA can now be edited. Not in the future, not soon – but right now. At the Salk Institute, the lifespan of mice has been increased by 25% - while boosting the vitality and quality of that lifespan. Human trials are currently being set up, and clinical trials are already underway for editing the t-cells of patients to fight cancer cells and lymphoma, to boost hemoglobin in patients with sickle cell disease and editing photoreceptor cells to treat inherited blindness.

CRISPR-Cas9 has been described as a copy and paste tool for genetics. Simply click, edit and replace – and anything is possible. Ethics and regulations will still impact the work done – but those safeguards should guide, rather than stifle research.

It is not often that humanity stands at the cusp of a new technology that can change everything we understand. But here we are – and ten, twenty years from now – the world will be a very different place from the one we inhabit today. Perhaps, in another 85 years or so, those reading this article now can reflect on just how much the world has changed – without the need for any reading glasses.