GENE EDITING MADE EASIER

– CRISPR's Astonishing Power to Rewrite Human DNA

"*A momentous scientific achievement.*" "*A milestone in research.*" "*An amazing – and slightly terrifying – breakthrough.*" "*A turning point in human evolution.*" "*Staggering.*"

Sometimes scientific breakthroughs are over-hyped. But a recent advance in genetic engineering might actually deserve all the buzz it is getting. It's a gene-editing technique called CRISPR.

Genes and DNA

Genes are strips, or segments, of DNA (Deoxyribonucleic acid). The human body contains some 22,000 genes.

DNA is in every cell of a living organism, including plants, animals, and humans. It acts like an 'instruction manual' for an organism by determining all of its characteristics, like height and hair colour.

Genetic Engineering

Scientists engineer, or manipulate, DNA in genes to produce improved or unusual organisms.

In the past, they did this using two main techniques: **selective breeding** and **radiation breeding**. Then, five years ago, they discovered CRISPR. It's cheaper, faster, and easier than these two methods.

Discovering CRISPR

How did scientists make this discovery? While studying the DNA of ancient bacteria, DNA is organized into a double helix structure, like a twisted ladder. Along each of the two strands are rungs. The rungs are repeating units called nucleotides. Each nucleotide contains one of four organic **bases**. The specific order of these bases within a DNA molecule is what determines the genetic code for that organism.

The scientists noticed an odd thing in the bacteria they were observing. It had some mysterious repeating DNA sequences, called palindromes, that were the same front to back and back to front. They dubbed the palindromes CRISPR. The name is an acronym for "Clustered Regularly Interspaced Short Palindromic Repeats."

Definitions

base: a basic compound containing carbon, a chemical element found in all living organisms

radiation breeding: bombarding seeds or eggs with x-rays to cause spontaneous mutations, hoping that some of them exhibit new and beneficial characteristics. Red grapefruit were produced using this method.

selective breeding: selecting and breeding pairs of plants or animals with desired traits

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It turned out that CRISPR DNA played an important role in the bacteria's immune system.

Just like us, bacterial cells get viruses. CRISPR defended the bacteria from the invading virus by destroying the virus's DNA. How? By using a special molecule to target a specific area of the viral DNA, and then using an enzyme called Cas9 to cut through it like a pair of scissors so it could no longer **replicate**.

Biochemist Jennifer Doudna was one of the researchers who discovered CRISPR. Her team realized that they could use this same 'cut-and-paste' technique to modify any DNA sequence, not just DNA from a virus.

"It was one of those OMG moments," Ms. Doudna recounts. "[I] felt a sense of awe. This technology [could] be very powerful and [could]... in the end really change our world."

Big benefits

Excited scientists say CRISPR has a lot of potential for treating diseases. For example, it might be used to disable genes that cause Huntington's or sickle cell anemia. Trials are also underway to use CRISPR technology to target certain cancers, a rare form of blindness, and HIV. The technique could even alter mosquitoes' ability to spread malaria. The disease kills about half a million people every year.

There are other uses, too. CRISPR might make crops more drought-resistant, for example. Or it could help them fend off fungi like powdery mildew.

Proceed with caution

Most of this current research involves editing genes found in **somatic** cells. Genetic changes to these cells are not passed on to future generations.

However, scientists are also experimenting with edits to genes of human **embryos**. This process is called germline editing, and it's more controversial. Why? Because unlike genetic changes to somatic cells, changes to embryonic cells would be passed on to offspring. That's good if the change gets rid of a disease. But it's bad if the edit unintentionally creates a new disease that is then passed on to future generations – something scientists warn could happen.

Consider the future

So far, embryos used in CRISPR research haven't been allowed to develop into babies. In Canada, the U.S., and some other nations, that's illegal. But what about countries that don't have laws against allowing gene-edited embryos to be born?

Critics also warn that if we do start engineering humans, it will be hard to know when to stop. Getting rid of diseases is one thing. But creating 'designer babies' with super strength or intelligence, or mutant species, are another.

Important conversations

For now, these scenarios are distant possibilities. We don't have to worry about them yet. But scientists say that we do need to think about them.

"We need time to understand [germline editing] better," Dr. Doudna says. "We need time to discuss [this] as a society." ★

DEFINITIONS

EMBRYO: an animal or human before it is born, when it is beginning to develop and grow

REPLICATE: to reproduce or make an exact copy of

SOMATIC: of or relating to the body

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ON THE LINES

Answer the following in complete sentences:

1. What does **DNA** stand for? _____

2. Explain where DNA is found.

_____

3. Describe the purpose of DNA.

_____

_____

4. What is a **gene**?

_____

5. Explain what **genetic engineering** is.

_____

_____

6. What does **CRISPR** stand for?

_____

7. Explain how CRISPR was discovered.

_____

_____

8. How does CRISPR destroy an invading virus?

_____

_____

9. What did scientists realize after observing CRISPR's 'cut-and-paste' technique?

_____

10. Explain why this is such an important discovery.

_____

_____

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BEYOND THE LINES

1. Over the years, many science fiction films and novels have used the genetic modification of humans as a central feature of their stories. In almost all cases, they show us a dystopia – an imagined place or state in which many aspects of society are unpleasant.

a) Now it's your turn. Imagine and describe our world in the year 2100 – one in which CRISPR edits have produced mostly "bad" or "wrong" results.

b) Do the same from a utopian perspective. (The opposite of a dystopia.)

c) Draw a line (a spectrum) between these two worlds and put a circle where you predict we will be in 2100. Explain your choice.

2. Through selective and radiation breeding, humans have been "editing" the genes of animals and plants for centuries. Research some examples, then explain them to your classmates.

JUST TALK ABOUT IT

1. In February, 2017, the U.S. National Academy of Sciences and National Academy of Medicine released a report containing guidelines for altering the human genome. Read more about these guidelines online – but before you do, draft your own. Under what circumstances should scientists be allowed to use CRISPR for germline editing? Under what circumstances should scientists not be allowed to use CRISPR for germline editing? Explain.

2. ***What if…*** there were no restrictions on how CRISPR may be used? Explain.

ONLINE

Note: The links below are listed at **www.lesplan.com/en/links** for easy access.

1. Watch a brilliant cartoon explainer from In a Nutshell called "Genetic Engineering Will Change Everything Forever – CRISPR" at **https://www.youtube.com/watch?v=jAhjPd4uNFY**

2. Follow the 430,000 people who have already watched this TED Talk by CRISPR pioneer Jennifer Doudna at **https://www.youtube.com/watch?v=TdBAHexVYzc**

3. Read the Nature article, "CRISPR Fixes Disease Gene in Viable Human Embryos" at **http://www.nature.com/news/crispr-fixes-disease-gene-in-viable-human-embryos-1.22382**

4. Learn about the legal patent battle between the University of California and MIT. Just who exactly "owns" this technology, anyway? **https://www.youtube.com/watch?v=IboHEQumDGc**

5. Watch Cas9 as taught by A Capella Science at **https://www.youtube.com/watch?v=k99bMtg4zRk** ★