CRISPR: A Revolutionary Technology

by Haley Quinn

Recent medical research suggests that Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) offers solutions to many genetic diseases. In 2013, a paper discussing the potential application of CRISPR was published, causing awareness of the topic to increase. As awareness increased, controversial opinions began to appear. The Food and Drug Administration states that all medical procedures and tools must be deemed ethical before they are implemented. A wide debate surrounds the ethical aspects of CRISPR since it is unknown how CRISPR will affect humans in the long run, which is something that needs to be considered in great depth. Although some might say using CRISPR to change human DNA is unethical, it is beneficial to humans because it activates helpful genes and deactivates harmful genes, removes genetic sequences that have an error and replaces them with correct sequences, and prevents or cures problems such as cancer and sickle cell disease.

When a virus attacks the immune system, bacteria take a piece of the virus' DNA, and it is then incorporated into a genetic sequence in the bacteria called CRISPR. This process helps the immune system recognize and destroy the virus faster if it invades the body again. Cas-9, a protein that works with CRISPR, cuts the DNA of a virus recognized by CRISPR and destroys it. Researchers have discovered that they can manipulate CRISPR and Cas-9 to edit the human genome.

CRISPR activates genes that are helpful and deactivates genes that cause damage in the genome, which will improve the lives of many people. Many genetic diseases are the result of genes improperly functioning, whether it be from a gene working too much or too little. The

article “Scientists Modify CRISPR to Epigenetically Treat Diabetes, Kidney Disease, Muscular Dystrophy” states that researchers tested CRISPR in mice with problems such as diabetes and muscular dystrophy. For mice with diabetes, researchers programmed CRISPR to turn up genes that produced insulin, and for those with muscular dystrophy, they activated genes known to prevent symptoms. Those experiments, among a few others, proved successful and CRISPR was able to turn on genes that relieved the symptoms of these disorders (“Scientists Modify CRISPR”). These results can change the lives of future generations drastically, and if the results are able to be repeated in humans, diabetes and muscular dystrophy will be problems of the past. In addition, “Could the DNA-editing CRISPR Revolutionize Medicine” says that CRISPR can be used to turn genes completely off, and being able to do so will allow us to further understand how each gene affects functions in the body. Experiments involving CRISPR can be done outside the body that will help doctors safely treat or prevent genetic disorders by furthering the understanding of genetics. If a gene controls multiple functions, the experiments will be able to alert the researchers of it, which will then allow doctors to choose the best treatment regarding problems involving that gene.

Despite the benefits, some may argue that effects of turning genes on or off are unknown and could cause serious damage, but this is not the case. For example, the article “Careful Cuts with CRISPR Turn Genes On or Off,” by Mike May, mentions a protein called Nrf2 that helps protect the body from toxins. However, it can also cause tumors, and scientists are unsure what causes this protein to harm or help the human body (May). This proves that one gene can affect multiple factors in the human body. In the given example, turning off the gene that produces Nrf2 in a patient that has tumors would cause the patient’s body to have problems with detoxifying. However, the article “Modified CRISPR Can Now Turn Gene Expression On and

Off," by Jelor Galego, argues that this version of CRISPR "gives researchers control over the amount of gene suppression and allows them to reverse it if needed." Any problems created by using CRISPR to turn genes on or off can easily be reversed. If turning a gene off begins to cause negative symptoms, researchers can turn the gene back on and reverse said symptoms, which means no damage will be done to the patient.

Defective genetic sequences can be cut by CRISPR and replaced with a functional version. "CRISPR Is a Gene-Editing Tool That's Revolutionary, Though Not without Risk," by Mark Shwartz, states that for problems such as sickle cell anemia, two genes are required to cause the misshape of the red blood cells. To cure a patient of sickle cell disease, only one gene must be edited. To do this, CRISPR targets one of the genes and cuts it, and then a virus is engineered to put the healthy DNA sequence in its place (Shwartz). CRISPR enables doctors to cure most genetic defects as a lot of them involve one malfunctioning gene. "Here's What We Know About CRISPR Safety -- and Reports of 'Genome Vandalism'" says Jianhua Luo conducted experiments on animals that suffered from cancer and successfully targeted cancerous cells without damaging healthy ones. Animal trials have proven to be successful, meaning there is a high chance that this procedure would also be successful and safe on humans. Even though there are clear benefits, some critics argue that the potential danger of off-target cuts is too risky. In fact, the article "DISCOVERing Off-Target Effects for Safer Genome Editing," by Hope Henderson, states that off-target edits could cause healthy cells to malfunction or die. This is a serious potential risk as the loss of certain cells could have significant negative impacts on the health of a patient. However, the book *Cells Are the New Cure : The Cutting-Edge Medical Breakthroughs That Are Transforming Our Health,* by Robin L. Smith and Max Gomez, explains that cells can also be removed, edited outside of the body, and returned to the patient where they

carry out their proper functions (142). This solution would allow cells to be edited and fixed without off-target damage.

Another fear surrounding this application of CRISPR is the creation of babies that are superhuman or who show certain physical traits the parents prefer (i.e. blue eyes), which is scientifically impossible. “The Embryo Project Encyclopedia,” by Sarah Ly, states that designer babies could separate society into two divisions: those who can afford to edit their child with CRISPR and those who cannot. There are already class divisions in society, but introducing designer babies would create yet another factor in this division. People are scared that those who have desirable traits would have more luxury and more respect than those who are born without edited traits. Nevertheless, the potential for designer babies shouldn’t worry anyone. "Fear of Dystopian Change Should Not Blind Us to the Potential of Gene Editing," by Kenan Malik, argues that doctors and researchers are unable to control traits such as intelligence and physical attributes since “most complex traits—whether intelligence or appearance or musical ability—are . . . shaped by a multitude of genes.” Furthermore, Hank Greely, a bioethicist, says that creating superhuman babies is currently impossible since “we don’t know now any genes that give people superpowers” (qtd. in Shwartz). When it comes to making designer babies, worrying is unnecessary because there are no genes that create super humans, and to edit the appearance or talent of a child would require editing multiple genes, which is not realistic given the current understanding of CRISPR.

Researchers and doctors can use the many different methods of CRISPR (ex: edits outside the body, inside the body, and to the germline) to cure a wide variety of diseases and genetic malfunctions. The article titled “7 Diseases CRISPR Technology Could Cure,” by Clara Rodríguez Fernández, says CRISPR could offer a cheap and fast solution to “AIDS, cystic

fibrosis, muscular dystrophy, and Huntington's disease." Currently, there are no cures for these problems, and treatment is often quite expensive. In addition, "CRISPR Enters Its First Human Trials," by Tina Hesman Saey, says clinical trials to cure sickle cell anemia, cancer, beta thalassemia, and an inherited version of blindness have begun. This means researchers have done enough experiments and research to begin trials on humans. Cancer can spread and cause damage because T cells don't recognize cancerous cells as dangerous since cancerous cells are a lot like regular cells, but T cells can be removed and edited with CRISPR, which would enable them to detect and destroy cancerous cells (Smith and Gomez 147). Attempting to cure cancer by turning genes on and off through CRISPR would require it to be able to edit the DNA of many cells quickly since cancerous cells divide at a fast rate. Editing T cells to allow them to recognize cells that are cancerous and attack them, yields a higher chance of preventing cancer.

While CRISPR can be used to solve many diseases, some argue that using it to edit embryos is unethical and dangerous; however, there isn't a reason to edit the germline (cells that are passed to offspring). This outlook comes from the fact that "one off-target event could have serious consequences for newborns and their descendants" (Shwartz). CRISPR is still relatively new, and results from tests on humans have not yet occurred. Researchers have no idea what editing genes will cause, and editing the germline would cause any negative effects to be passed on to future generations. However, "There is No Reason for Germline Therapy" states germline editing is unnecessary "since there are equivalent and ethically less problematic alternatives," such as "in-vitro fertilization and pre-implantation diagnostics." Other alternatives exist for having a healthy baby. In addition, most conditions can be cured by just editing somatic cells (non-germline cells), so germline editing wouldn't really have a purpose.

CRISPR can be beneficial to humans because it allows humans to remove harmful genes and replace them with healthy versions, activate and deactivate genes as needed, and cure harmful or deadly genetic diseases. CRISPR has far more benefits than downfalls, and it will allow humans to have a healthier population. In fact, it can lower the number of deaths in infants and young children by providing treatment for many genetic problems that cause death during this age. CRISPR is revolutionary for the medical field, and it should be used to help advance humanity.

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