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A Map for Regulating Gene-Editing

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The Future of CRISPR

Gene editing has been all over the headlines lately, and for good reason. CRISPR/Cas9, the state-of-the-art gene modification technology, has allowed scientists to perform previously complicated experiments is a rapid and cheap manner (Baltimore et al. 1). As a result, the number of papers published yearly mentioning "CRISPR" has been doubling annually from 2012 and it still is a rate way beyond other recent comparable discoveries in the field (Mulvihill et al. 19).

For the uninitiated, CRISPR is a way of manipulating the DNA directly by programming it to search for a specific sequence of genes and replacing them with another; this allows for faster and more precise DNA editing than previous methods (Mulvihill et al. 18). For years, scientists in large, well-funded institutions have been investigating our DNA to pinpoint which genes are responsible for specific characteristics (Baltimore et al. 1). With old methods and testing on rats, they were able to identify which genes are responsible for most of our tangible and intangible characteristics (Ishii 8), and even genes that are guilty of expressing deadly diseases such as HIV, herpes, and leukemia among others (Caplan et al. 5). Acting on this information was previously limited and costly, but with CRISPR/Cas9{,} many labs are now able to tap into the DNA and modify these genes, with vastly improved results and reduced costs (Baltimore et al. 1).

Risks

Humanity now has a huge repository of information that can be used to prevent many diseases or even start enhancing our genetic makeup (Bosley et al. 8). That is not to say that it

will be easy going forward. All these treatments require risk evaluations and testing to be ready for mass distribution. Non medically vital modifications are also controversial and worrying: Imagine if a hostile actor were to genetically modify people to be smarter and stronger than the rest of us (Bosley et al. 9). Also very worrying is making an inheritable mistake that propagates to all humanity (Chan et al. 6). When our worst-case scenario is the extinction of humanity, we need to take a step back and start evaluating and approaching this technology slowly and cautiously (Gutmann et al).

Off Target Mutations

One of the obstacles holding CRISPR adoption back, for the time being, is off-target mutations. These mutations are unintended gene edits that are applied along with intended ones. These edits could be harmless, or they could significantly alter healthy genes, resulting in harmful effects on subjects. All modern gene editing technologies like CRISPR, TALEN, and ZFN suffer from these off-target side-effects, so this is not a particularly new phenomenon (Ishii 3-4). This is not to say that these side effects are a breaker as we are continuously improving our detection and prevention methods. However, we are going to need to make sure that these mutation rates are significantly lower before we approve treatments (Ishii 6).

Germline Editing

A hotly debated application of gene editing, a potential breakthrough, and a current set back is Germline editing. As previously stated, certain diseases can and are being treated by editing normal genes in the patient's body: these are called somatic genes. On the other hand, germline-editing modifications genes that get passed along to offspring (Chan et al. 3). The

potential of properly conducted germline editing is huge. It could cure inherited genetic disorders, or genetically enhance the subject's descendant (Mulvihill et al. 5).

Establishing Laws and Regulatory Frameworks

Many regulatory issues are about a balance between two or more, somewhat mutually exclusive objectives. Biotechnology is abundant with debates and discussions on many different issues. This paper is going to specifically address the balance between ensuring the safety of gene-editing experiments and medical usage while maintaining the progress of research in the field for the benefit of everyone (Charo 5).

Let us talk about how should we approach the problem of regulating such revolutionary and potentially dangerous technology. The main goals of this framework are the following:

1) Preventing any genome-engineering procedures that risk causing humanity extinction threats.

2) Protecting the earth's biosphere from any potential damage introduced by gene editing.

3) Preventing any subset of humanity from gaining a threatening genetic superiority/advantage over the rest.

4) Protecting patients from any unintended side effects, unless they were informed about the risks and approved taking them.

International Guidelines

Starting from the top, the UN should assemble a panel of scientists, philosophers, and bioethics experts to study the issue in a global and long-term scale. They should establish rules and red lines that nobody should pass. These lines should be crafted cautiously in order to only

limit research to technologies that threaten the future of global humanity while at the same time steering clear of the sovereignty of countries, scientific societies, and research labs to make their own decisions and establish their own rules — provided that these local regulations do not interfere with the scope of the global ones. To avoid future conflict as much as possible, These rules should be as specific as possible and mainly geared toward existential threats much like their nuclear weapons policy.

Prevention and Enforcement

Major violations against these rules should be looked at as unacceptable actions throughout the international community; there should be harsh deterring consequences. Such cutting-edge, high-risk research should be treated the way nuclear programs are treated: Safe nuclear power and research are allowed under strict supervision to ensure they do not go rogue.

Agreements Among Smaller Societies

Many states around the world have similar policies on various topics, while many others differ. We should embrace these differences and collations to our advantage. A famous example is how European countries have more conservative policies relative to the US — their default stance is that something new is dangerous until proven otherwise, contrary to the US which approves the public use of new technology unless it is proven dangerous. Establishing different frameworks across the globe will help us protect ourselves. The main benefit for such diversification is that a high-risk experiment approved in a certain locality will not be approved in another, making sure we do not risk everybody. At the same time, the world will not be

limited by the slow progress of those who avoid risk as other countries will be developing breakthroughs and treatments that are deemed safe are likely to be embraced in other places.

Self-regulation

In the quest to establish a stable future for gene-editing, conferences where professors, researchers, bioethics experts, and philosophers meet should be encouraged and held regularly. The goals of these conferences should be to: 1) Encourage and lobby the local governments to establish regulatory frameworks for gene-editing. 2) Provide recommendations to the legislative branches of the government. 3) Discuss any major, controversial breakthroughs around the world, and decide whether any protective actions should be taken, or if experiments with that technology are encouraged. 4) Discuss any other relevant news or issues.

An Example of Successful Self-Regulation

An often cited example of self-regulation in the scientific community was the historic 1975 Asilomar conference in Napa, California that addressed the safety of Recombinant DNA technology. It began when Paul Berg, a Nobel laureates in Chemistry, was experimenting with cutting and transforming DNA from different species into a modified one. Prior to conducting the last step of his experiment, Berg started receiving many letters from colleagues voicing their concerns about the potential safety biohazards of the experiment (Carmen 61). So, the experiment was temporarily halted for these concerns to be addressed. As a result, in 1975, 140 biologists and lawyers assembled in the Asilomar conference area to assess the risks associated with such experiments. They concluded with ways to risk assess experiments, safety guidelines

and recommendations (Berg et al. 1981-1984). Later on, Berg successfully performed his experiment starting a whole new field in biology: Gene Editing.

Conclusion

In conclusion, to avoid the risk of causing severe damage to humanity in the pursuit of medical advancements, we should make sure that we approach this new technology with both caution and an open mind. This paper proposed and discussed having three levels of committees — global, regional, and local — that are going to put out regulations, frameworks, and legislative recommendations. These corporate-influence free committees should consist mainly of experts in relevant fields such as, but not only, gene editing, bioethics, risk assessment. Having these different committees should ensure that we have global coordination on what is out-of-question and should not be explored while strengthening the cooperation between similarly minded regions and institutes to flourish ideas for safe, innovative medications and application.

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