

In November of 2018, the scientific community was turned upside down by news of the actions of Chinese scientist He Jiankui. Going behind Chinese scientific regulations, he had edited the CCR5 gene of embryos of two newborn twin girls using CRISPR-Cas9 technology in order to prevent HIV infection. This technology which allowed for the precise cutting and editing of DNA was discovered just six years earlier, opening up various avenues for treatments for genetic diseases. Along with it came a Pandora's box of questions regarding where the balance between science and nature would lie. Although it followed many existing gene therapy and engineering methodologies, the CRISPR-Cas9 was revolutionary in its efficiency, precision, and programmability¹. The excitement of this new biological weapon can be seen with the awarding of the 2020 Nobel Prize in Chemistry to Emmanuelle Charpentier and Jennifer Doudna, pioneers in the work on CRISPR-Cas9.

Just as I chose to classify this technology as a “biological weapon”, this breakthrough genetic editing technique is a double edged sword. The potential for a medical paradise is not too far away if CRISPR-Cas9 can be harnessed to cure genetic diseases such as cystic fibrosis, sickle cell anemia, and cancers. On the other hand, I believe this weapon is of the sort Toby Ord cautions of in *The Precipice*— a technology for which “humanity currently lacks the maturity, coordination and foresight necessary to avoid making mistakes from which we could never recover”². In terms of human genome editing, there is an ever present gap between our power and wisdom.

Therefore the National Academy of Science, one of the leading institutions organizing the International Summit on Human Genome Editing, should host a third summit in which clear guidelines and regulation for scientific research in genome editing, somatic and germline, are set with global consensus. For this summit, there should be an emphasis on communicating with policymakers as well as engaging with the public on where the future of genome editing will take us. The two previous summits highlighted the need for oversight of somatic cell editing while stating that heritable genome editing of germline cells would be irresponsible at the time. Now, four years later, there is a need more than ever to make those decisions regarding regulatory oversight and relook at the current genetic editing landscape. Concrete standards and principles for the future of germline editing are needed to ensure no more

breaches occur before we are ready. Only by pushing the international scientific community and informing the public of the status quo can there be a multilateral push for international coordination on safeguarding humanity against the potential dangers to come.

Despite news leaking shortly before the second summit in 2018 of Dr. He's editing of implanted embryos, he was still able to participate and speak at the summit. Not surprisingly, many objections rose from the audience consisting of the world's leading researchers, ethicists, policymakers, and representatives from scientific and medical academies³. In an interview, Dr. Feng Zhang of the Broad Institute, another pioneer of CRISPR-Cas9 technology, commented on the news of the genetically edited twins. He noted that the technology may have unintended consequences including making unwanted edits or in the case of editing the CCR5 gene, increased likelihood of contracting West Nile Virus or dying of the flu⁴. After the summit, the organizing committee summarized – “Even if the modifications are verified, the procedure was irresponsible and failed to conform with international norms.” Additionally, there was “an inadequate medical indication, a poorly designed study protocol, a failure to meet ethical standards for protecting the welfare of research subjects, and a lack of transparency in the development, review, and conduct of the clinical procedures”³.

This kind of scientific breach can very well happen again if there is not multilateral communication regarding where humanity currently stands on the topic of human genome editing. Although no country explicitly permits heritable human genome editing, the current landscape for regulatory policy on human genome editing lies on a global spectrum⁵. While a large majority of countries have legislative guidelines and regulation regarding genome editing for gamete or early-stage human embryo modification, most do not have ones specifically addressing germline genome editing. Additionally, some countries explicitly permit this activity and a small minority have exceptions to heritable genome editing. The large spectrum of what is allowed provides much room for some form of research tourism, where scientists can travel to countries with more lenient regulations to perform their research studies.

In consideration of the worst-case scenario, this technology could be further developed under the table to create unimaginable consequences. At the very essence of humanity and our existence is the makeup of our genetic code, something that has evolved and mutated for over 6 millions years from our apelike ancestors to what it is today. We are playing with very dangerous weapons, having the ability to edit, cut, and paste our very own DNA. We face the hard questions of which genes would we edit, if we would allow these edited genes to pass on to future generations, and what would happen if we end up prematurely editing the “wrong” genes. We are playing a very dangerous game.

Additionally, there is the possibility of the creation of an unrecovered dystopia, as defined by Ord. If this power is abused by select groups to edit for the “best” traits, for example genes affecting IQ or health, there could be a homogenization of the human genome and potential for exacerbating existing inequalities and human rights abuses⁶.

Therefore there is an incentive for the National Academy of Sciences, a leading institution in the scientific community, to take charge in helping set guidelines for this new future as well as safeguarding it from potential dangers posed by genetic editing. While the National Academies of Sciences, Engineering, and Medicine has an existing framework for oversight of human genome editing with specific regulatory rules for the US⁷, there needs to be international coordination in order for existential risks to be sufficiently dealt with. By joining forces with other national science academies and publishing a new and updated joint declaration on human genome editing informing of clear guidelines and punishments for breach, there will be a set example for regulatory policy and greater transparency in this field. We are at a very critical point of biotechnology and scientific innovation, dealing with one of the most powerful biological weapons to date.

This is no easy task, as it is entanglement with ethics, science, policy, and medicine will stir up many differing opinions and perspectives. However, in order to safeguard the future of humanity, leading scientific organizations such as the National Academy of Sciences need to take charge in helping set guidelines for this new future. If done correctly, humanity will be able to unlock immense potential, eradicating many incurable diseases. If we one day approach the doors of unlocking heritable genome

editing, humans will evolve like never before, having access to the very code that defines each and every one of us.

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