The CRISPR Apple on the Tree of Knowledge

with Arvin M. Gouw, "The CRISPR Apple on the Tree of Knowledge Conference Highlights: CRISPR in Science, Ethics, and Religion"; Arvin M. Gouw, "Introducing the Brave New CRISPR World"; Roger R. Adams, "Moral Decisions about Human Germline Modification"; Constance M. Bertka, "Navigating the Future in a Sea of CRISPR Uncertainty"; and Linda Groff, "CRISPR, CRISPR on My Mind."

NAVIGATING THE FUTURE IN A SEA OF CRISPR UNCERTAINTY

by Constance M. Bertka

Abstract. Humanity's toolkit for altering the world we live in now includes CRISPR. Through an evolutionary process, bacteria acquired a way to protect themselves from an invading virus, making their immediate future more secure. In human hands, this powerful genome-editing tool offers the potential to impact, at a breathtaking rate, not only our own evolutionary future, but the future of other life on this planet. Ethical concerns about altering genomes are not new, but the birth of two CRISPR gene-edited babies last year created a renewed urgency around navigating the future and the lack of an agreed-upon map to guide us is distressing. The goal of this article is not to provide that map but to suggest two essential questions, drawn from the context of events surrounding CRISPR to date, that should guide its drafting—"Who do we trust?" and "When is it time to act?"—and to consider what Unitarian Universalism might contribute to answering those questions.

Keywords: bioengineering; biomedicine; CRISPR; gene editing; germline

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For slightly over a year now, it has been public knowledge that somewhere in China two baby girls were born to parents who believed they had found a medical community willing to help them start a family, despite the father's HIV infection. While in some countries using IVF technology, that includes sperm cleansing to decrease the risk of infecting the embryos with HIV, is a viable option for such couples, in China, this option is

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unlikely. HIV is highly stigmatized in China and an HIV-infected father will not be able to benefit from costly IVF technology (Qiao and Feng 2014; McLaughlin 2018; Vernago and Cho 2018).

But what if this risk could be entirely removed by combining IVF with a new gene-editing technique, CRISPR, that would allow scientists to edit the gene that produces the protein necessary for HIV to infect white blood cells? Might this be a technology that would allow parenthood to be a socially acceptable goal for HIV-infected fathers, and wouldn't the scientist and/or team that made this technology a reality be assured a country's gratitude and accompanying professional and financial rewards? And, beyond any thought of rewards, wouldn't this just be the right thing to do? Chinese scientist He Jiankui must have thought so; he used CRISPR to edit the embryos that led to the birth of the two baby girls, and he did so in 2018 despite numerous proclamations from the scientific community, as early as 2015 (National Academies of Sciences 2015), that using CRISPR to edit the human germline, impacting not only the individual but also their offspring, should not yet proceed.

The first CRISPR gene-edited babies are over a year old now and while China, like other countries and scientific associations, has condemned He's work and assured the world that the babies' health will be closely monitored, there is still much uncertainty around the details of the events that led to their birth. This uncertainty includes a question of just how much intellectual and personal involvement He received from at least one American scientist, Michael Deem, a professor at Rice University and He's PhD advisor. In August 2019, Henry Greely, who directs the Center for Law and the Biosciences at Stanford University, published an article that carefully outlines what is publicly known about the events leading up to the birth of these babies and the reactions within and outside of China (Greeley 2019). More recently, in November 2019, *Time* reported that we still know nothing about the fate of He Jiankui or the health of the babies and that none of He's work has been published (Marchione 2019).[1] The *Time* article also noted that the Chinese investigation, begun after the announcement of the birth of the twins, confirmed a second pregnancy using a gene-edited embryo, and that Chinese officials confiscated He's lab records and any remaining gene-edited embryos. Then, in early December 2019, the *MIT Technology Review* released excerpts from the unpublished manuscript He submitted to *Nature* and *JAMA*; both journals had declined to publish the work. The *MIT Technology Review* shared the entire manuscript with a legal scholar, IVF doctor, an embryologist, and a gene-editing expert asking for their opinions on the work (Regalado 2019). A summary of these experts' reactions is provided: "Their views were damning. Among them: key claims that He and his team made are not supported by the data; the babies' parents may have been under pressure to agree to join the experiment; the supposed medical benefits are

dubious at best; and the researchers moved forward with creating living human beings before they fully understood the effects of the edits they had made" (Regalado 2019). He's work was not only an ethical failure but also a scientific one. The embryos' cells were not uniformly edited, only some acquired the HIV-resistant gene edit and other cells might have undetected "off-target," edits which could produce health issues for the babies in the future.

This particular experiment to alter the germline of humans should never have taken place, on that there is broad agreement. But will it ever be acceptable to alter the human germline using CRISPR technology and who gets to make that decision? And, while the question of human germline editing dominates public media attention, CRISPR germline editing of nonhuman animals and plants is already common (Greely 2017). Humanity now has a powerful tool to alter the evolutionary future of our own and other species in a very short time frame.

As we learn more about the new bioengineering possibilities offered by CRISPR, one word especially captures the state of affairs, "uncertainty." How can we prepare ourselves to move responsibly toward the hopeful possibilities that this technology offers while being honest about the challenge of predicting long-range implications of altering evolutionary paths? CRISPR is not the first gene-editing tool available to scientists and ethical concerns about altering genomes are not new. However, CRISPR is the first gene-editing tool available to scientists that makes gene editing simpler, less expensive, and more broadly applicable. Suddenly there is an urgency around navigating the uncertainty of altering genomes and the lack of a map to guide us is distressing. The goal of this article is not to provide that map but to suggest two essential questions, drawn from the context of events surrounding CRISPR to date, that should guide its drafting—"Who do we trust?" and "When is it time to act?"—and to consider what Unitarian Universalism, my faith of choice, might contribute to answering those questions.

While Unitarian Universalism has no dogma, we do have moral guides in the form of seven principles that our congregations promote (Unitarian Universalist Association 2019). These principles likely resonate with many other faith traditions (religious and secular) and all might be used to inform decisions about germline editing. Three in particular focus my thoughts on this topic: justice, equity, and compassion in human relations; a free and responsible search for truth and meaning; and respect for the interdependent web of all existence of which we are a part.

Who Do We Trust?

The Unitarian Universalist principle, "A free and responsible search for truth and meaning," suggests to me the first guiding question: "Who do

we trust?" Unitarian Universalism affirms as sources of wisdom both world religions and science. Given the stakes at hand with CRISPR technology, we would do well to welcome the wisdom of both. But the playing field is hardly level, and in regard to CRISPR technology, financial as well as nationalistic incentives may be getting in the way of a wise decision process.

Because CRISPR is a powerful research tool that continues to show promise for medical advancements, large quantities of dollars are at stake for the scientists, institutions, and companies claiming patent or licensing rights for this tool. Financial disputes have been part of the CRISPR story from early on (Cohen 2017; Mischel 2019). Soon after the first landmark paper by Emmanuelle Charpentier, Jennifer Doudna, and others was published in 2012 (Jinek et al. 2012), showing how CRISPR could be used as a gene-editing tool, Charpentier set out to create a company. Initially, she tried to include other CRISPR researchers, who just six months after the original landmark paper, had published their own paper showing the application of CRISPR in human cells. Prior to any of Charpentier's efforts at company building, Jennifer Doudna, in 2011, had started a company to market the use of CRISPR as a research tool (Cohen 2017).

In her book with colleague Samuel Sternberg titled *A Crack in Creation* that describes both the discovery of CRISPR, and her own concerns about the ethics of its use, Jennifer Doudna says this about those early days:

> It was a heady time. I was elated that the work published with Emmanuelle the preceding summer had inspired others to pursue a line of experimentation similar to our own. Only later would the contents and publication dates of these papers be dissected to support arguments on a dispute over CRISPR patent rights, a disheartening twist to what had begun as collegial interactions and genuine shared excitement about the implications of the research. (2017, 96)

Charpentier's attempt at unifying the researchers under a new company ultimately collapsed under the weight of predictable human foibles—egos and greed, and not just of individual researchers but also of their institutions. At the end of this saga, multiple companies were formed and billions of dollars invested in them. And, a good chunk of those dollars went toward lawyers' bills as they fought each other over patents (Cohen 2017).

There are now multiple companies, with a broad range of applications, both human and nonhuman, and scientists with interests in more than one company (Mischel 2019). Emmanuelle Charpentier and Jennifer Doudna, the two women who published that first landmark paper, work with and helped to found separate companies. But at the same time they fought together with UC Berkeley for patent rights against the Broad Institute and the Harvard scientists who published the first paper showing application of CRISPR in human cells (Cohen 2016). Now both the UC Berkley group and the Broad group have patents, the bottom line being that using

CRISPR could mean obtaining licenses from multiple parties (Mischel 2019). Here is the takeaway from a reporter for Synbiobeta, a network of those interested in synthetic biology: "There was a brief period in which it seemed that the core of early CRISPR scientists would be able to partner and share intellectual property. But disagreements over academic credit, company locations, loyalty, ego, financial gain and even Nobel Prize aspirations splintered the CRISPR pioneers" (Mischel 2019).

The temptations of fame and fortune are not unique to the field of science, but they do tarnish its portrayal as an earnest search for knowledge about the natural world and ultimately a trustworthy source of that knowledge. A similar fear is voiced by a colleague of Jennifer Doudna's, Michal Eisen, in a 2017 February blogpost about the patent saga titled "Patents are destroying the soul of academic science." This sentence sums it up nicely, "The flurry of CRISPR activity beginning in 2012 has become as much a patent gold rush as a journey of discovery" (Eisen 2017).

What particularly resonated with me is his accusation that, in the battle for patents, the scientific process was being misrepresented. He notes that public statements by Doudna including "experiencing frustrations in applying CRISPR to eukaryotic cells" and "it was not known whether such a bacterial system would function in eukaryotic cells," statements that are reflective of the scientific process in general, and ones a careful scientist speaking honestly about CRISPR would, and should use, these statements were being distorted to amplify the accomplishments of one group over another in order to win a patent. While he clearly sides with his own institution over another in this case, he also admits to expect no better of his own institution if they saw an opportunity to distort the truth for profitable gain. The broader question he poses is whether or not academic science has been transformed "from an engine of discovery into a source of institutional and personal riches" (Eisen 2017).

Regardless of how the patents and intellectual credits have been, and will continue to be sorted out, we are left with the reality that science has discovered a powerful tool to edit the DNA of organisms, but in the process the scientists involved lost trust in one another. In the epilogue to her book, Doudna reflects on competition, collaboration, and aspirations:

> These twin poles of science-competition and collaboration-have defined my career and shaped me as a person. Over the past half decade in particular, I have experienced the gamut of human relationships, from deep friendships to disturbing betrayals. These encounters taught me about myself and showed me that humans must choose whether they will control or be controlled by their own aspirations. (2017, 243)

The unfolding story of He Jianku's work on human germline editing is a lesson on scientific aspiration run amuck. If aspirations are threatening a responsible use of CRISPR, then how do we protect against aspirations out

of control? Religious insights can be a source of ethical guidance and we would hope that an open exchange with religious traditions will be helpful. We know, however, that this exchange brings its own challenges, including which or whose religious insights get priority. For example, while multiple traditions will be in favor of using CRISPR to ease human suffering, they will disagree on how to proceed if developing applications for CRISPR involves testing with human embryos, even if those embryos are not intended to be implanted in a women's uterus (*ex vivo* experimentation). Traditions will differ on whether properly regulated *ex vivo* experimentation is a step toward easing human suffering. Germline modification in human reproduction (*in vivo* experimentation) is specifically banned in many countries (for a review, see Greely 2019), but *ex vivo* experimentation is not, despite varying religious attitudes toward this experimentation.

We know that in the case of He Jianku's work *ex vivo* experimentation with CRISPR'd human embryos, and *in vivo* experimentation with CRISPR'd nonhuman animal embryos, were part of the research path that led to the births of the now one-year-old baby girls (Rana 2019). We also know that prior to this event, as early as 2015, Jennifer Doudna and others, concerned about the responsible use of this new technology and its potential application to human embryos, organized the First International Summit on Human Genome Editing. This summit concluded that: "It would be irresponsible to proceed with any clinical use of human germline editing unless and until (i) the relevant safety and efficacy issues have been resolved, based on appropriate understanding and balancing of risks, potential benefits, and alternatives, and (ii) there is broad societal consensus about the appropriateness of the proposed application" (National Academies of Science 2015). The summit was cohosted by the U.S. National Academy of Sciences and the National Academy of Medicine's Human Gene-Editing Initiative, the Chinese Academy of Sciences and the U.K.'s Royal Society, but their statement did not stop He from performing his experiment. And, it did not help other scientists, including those outside of China who either knew or suspected what He was up to, stop his actions (Greely 2019). However, after the fact, statements condemning the experiment poured in from around the world.

The presidents of the U.S. National Academy of Medicine, National Academy of Science, and the Chinese Academy of Science published an editorial in *Science* noting the scientific communities condemnation of He's actions and calling for a commission to determine under what conditions human germline genome editing might be allowed (Dzau, McNutt, and Bai 2018). Near the same time the World Health Organization announced plans to create a global multidisciplinary expert panel, which came to fruition in February 2019, "The Advisory Committee on Developing Global Standards for Governance and Oversight of Human Genome Editing" (GenomeWeb 2019). In March 2019, scientists and ethicists from

seven nations, including several CRISPR pioneers, published an editorial in *Nature* calling for a moratorium on gene-editing experiments designed to alter heritable traits in human babies and for an international governing body to oversee the technology (Lander et al. 2019). The Academy presidents continued to call for a framework to guide clinical research (Dzau, McNutt, and Ramakrishnan 2019). Creating this framework is now the task of the "International Commission on the Clinical Use of Human Germline Genome Editing." One concrete effort was launched in August 2019 by WHO, a registry for all studies of clinical applications of human gene editing (World Health Organization 2019). It appears that the scientific community worldwide is working to address the need for regulation of CRISPR technology. Notably, all of the efforts described above cite the need for a broad societal consensus concerning the use of CRISPR. Even prior to He's announcement, efforts were beginning to be focused on promoting a broader public discussion, for example, the proposed Global Observatory for Gene Editing (Jasanoff and Hurlbut 2018), and the Association for Responsible Research in Genome Editing (Montoliu et al. 2018).

The call for a broad societal consensus is one answer to the question "Who do we trust?" and an answer that resonates with the Unitarian Universalist principle of a "free and responsible search for truth and meaning." Such a search is not limited to a single source of wisdom—we cannot trust a science driven by, in Doudna's words, "the twin poles of competition and collaboration" to get this right on its own. The aspirations of the few who have the ability and opportunity to compete and collaborate should not be the ones in deciding if, how, and when the human germline is edited, even when those aspirations are far nobler than fame and fortune. The traditional spokespeople for the scientific community, academy presidents, and in this case many of the individual scientists who pioneered CRISPR technology have noted their agreement on this point. Nonetheless, there is also suspicion that the scientific community's call for a broad societal consensus is in part an effort to regain public trust so that CRISPR research can move forward, while in reality the scientific community needs to do more to both "enforce deterrence" of human germline editing and to "express humility" (Greely 2019, 179). While these suspicions and concerns may have merit, a commitment to the Unitarian Universalist principle of "justice, equity and compassion in human relations" suggests we do not lose sight of the fact that continued research by the scientific community is a necessary path forward to using CRISPR to ease human suffering. That said, the call for equity in human relations does demand that we work to broaden the range of voices both in the public CRISPR discussion, and within the scientific community. The importance of equity in the scientific community is noted in a *Guardian* article by Natalie Kofler (2019) and it is one that resonates with me.

Kofler is a molecular biologist, lecturer in bioethics at Yale University and founder of "Editing Nature," an initiative to empower impacted communities to have a voice in deciding how CRISPR might be used to intentionally alter wild species in the environment (Editing Nature 2019). Noting the predominance of men over women, and over people from historically marginalized backgrounds, in the scientific community, Kofler questions if a scientific community whose makeup does not "realistically represent society," should be trusted to steer the development of CRISPR technology. She also suggests that a scientific system fueled by competition is ill equipped to help CRISPR "equitably serve society" (Kofler 2019). Equity within the scientific community is a vexing problem that extends well beyond the genome-editing field. Likewise, promoting a broad public discussion about CRISPR technology will be a challenging undertaking. But if trust is not going to be limited to a community of expertise wanting in diversity, then we must try and address these challenges. Further complicating the matter is the fact that the technology is advancing quickly in a climate of intense international competition. What Doudna (2017, 243) described at the personal level "These twin poles of science - competition and collaboration" are operating at the international level as well.

When Is It Time to Act?

Can an international governing body reach an agreement about when it might be permissible to alter the human germline? The World Health Organization and the international commission organized by the National Academies are trying. Judging from what we know about the gene editing of somatic cells, or germline cells of nonhuman animals, timing will not be something that is easy to reach an agreement on.

Genetic editing using CRISPR technology is proceeding at different rates in different countries. The story here is what has happened in China compared to the United States and Europe (Cohen and Desai 2019). In April of 2019, scientists at the University of Pennsylvania, after being given the green light for a clinical trial ultimately involving 18 patients, began their first CRISPR treatments with two of those patients (Stein 2019). The treatments were medical interventions used to address the diseases of the individual patients and not an alteration of their germline cells. Immune system cells were removed from the patients, genetically edited in the lab to target and destroy cancer cells, and then infused back into the patients' bodies. Meanwhile, in Europe and Canada, numerous clinical trials are also launching that use CRISPR to treat genetic blood disorders and perhaps soon cancerous tumors. According to one gene-editing scientist, Fyodor Urnov from the Altius Institute for Biomedical Sciences, "2019 is the year when the training wheels come off and the world gets to see what CRISPR can really do for the world in the most positive sense" (Stein 2019).

But in this bike race, the Chinese have already been zipping around on a two-wheeler for some time. The first clinical applications took place there as early as 2015 and have involved dozens of people (Normile 2017). While the University of Pennsylvania experiment had to pass two federal review boards and the review of two hospital committees, in China, review by a single hospital committee was all that was needed to move forward (Stein 2018). China has made this type of research a priority and since 2012, China's annual investment in science overall has dramatically risen (Normile 2018). When it comes to CRISPR, China has been all about firsts: the first use of CRISPR-edited cells to treat cancer, the first CRISPR editing of a human embryo, and the first CRISPR editing of monkeys all occurred in Chinese labs (Fitzpatrick Dimond 2016). The challenge any international governing body will face setting guidelines to oversee this technology is the very real difference in societal values from one country to another.

In the interest of full disclosure, before I comment on contrasting values using China and the United States as examples, I will tell you that my interest in China is more than academic. I am married to one of the very first Chinese students sent to the United States by the Chinese government in the 1980s to attend graduate school in the sciences. We have been married for 28 years and have two daughters. Since 1992, I have traveled to China almost yearly with my daughters to spend a few weeks visiting the in-laws and/or traveling in the country. Last summer, one of my daughters spent two months in Beijing participating in an intensive language program. The other spent three weeks shuttling between uncles, aunts, and cousins in China who all tried to outdo each other in showing her an enjoyable time. I have always felt, from the very first time I visited China, warmly welcomed. When I hear or read news reports about China, my personal experiences certainly impact my impressions. But that doesn't mean I view China with rose-colored glasses; I don't.

My father-in-law joined the Communist Party because he believed they were working to help the people, later during the Cultural Revolution, he was publicly ridiculed and sent for re-education, his oldest son was sent to the country side to work. That same son is now a Communist Party member himself. All of my Chinese relatives know what happened in Tiananmen square 30 years ago and they are aware of what is happening with the Uyghur community in northwestern China today and of the growing concerns of Chinese living in Hong Kong and Taiwan. They have also experienced firsthand an increase in the quality of life for themselves and many rural Chinese over the last 30 years. I will suggest that stability is what matters to most Chinese people on the mainland. If their government continues to provide that stability, especially in an environment of economic growth and increasing prosperity, they will continue to be proud of China's accomplishments. We need to understand that nationalism is

alive and well in China, just as it is in the United States. And, one of the ways that nationalism is currently being expressed in China is an increased investment in science and technology.

The United States is no longer by default the first or only place Chinese graduate students or early career Chinese scientists consider pursuing their work (Cohen and Desai 2019). The Chinese government and people value science, no worries about teaching evolution or climate change in China. They also place a higher value on social relations, and what is good for society at large, often at the expense of the individual. It is not hard to see how those values combine to result in their bioengineering field advancing and continuing to advance at a rate that can be unsettling for Westerners. When it comes to gene editing of the human germline, it will undoubtedly be a challenge to reach an international agreement on when is the correct time to proceed (Rosemann et al. 2019). But this challenge is made even more arduous if gene editing is viewed as an international competition, a race to be first that endangers international scientific collaboration and exchange.

There is agreement among international research communities that CRISPR is a powerful lab tool. CRISPR is changing the landscape of research in biomedicine. It is being used to create laboratory animals and cell lines with specific genetic characteristics that help researchers better study human diseases. What once took years of research can now be accomplished in months. No longer do researchers need to wait years to breed generations of mice with different genes knocked out, they can do so in months with no breeding. But the use of animal models to study human disease is not without controversy, at least not in the United States.

While in the United States, using nonhuman primates as laboratory animals is facing a growing backlash from a public concerned about animal rights, this is not an issue in China. *The Atlantic* did a story on monkey research in China that highlighted the concerns of U.S. scientists around this discrepancy:

> American scientists worry that the United States is falling behind China on primate research. "I have two big concerns," says Michael Platt, a brain scientist at the University of Pennsylvania who studies primates. "The United States is not investing heavily in these [primate] models. Therefore we won't have the access that scientists have in China." The second, he says, is that "we might lose the talent base and expertise for actually doing primate neuroscience" (Zhang 2018).

It's all about the competition.

If the research a scientist is pursuing relies on using monkeys, then working with a collaborator in China will give them an edge in access to a large supply of nonhuman primates. While the Chinese public is

increasingly concerned about the welfare of dogs they keep as pets, this concern does not extend to animal models used to potentially advance human medicine. The Chinese public does not question the use of the animals in research and their government provides support for monkey breeding facilities. This is not to say there are no ethical concerns about the treatment of laboratory animals in China. In fact, according to the author of *The Atlantic* article, many of the Chinese scientists performing the research were trained in the United States and brought back to China a Western appreciation of the ethical care that should be afforded to these animals (Zhang 2018).

While for now, there seems to be international agreement to hold off on editing the human germline, as for plant, animal, and nonhuman primate germlines, the research community is moving forward as they are able, within the constraints applied by their respective governments. Action is already happening; whether you will applaud it or not, especially if it involves research with nonhuman primates, might depend on whether you or someone you love is suffering, for example, from autism or Alzheimer's, just two of the diseases that researchers are using CRISPR and nonhuman primates to study.

It is not hard to imagine that He was inspired by China's financial support of genetics research and proud of the advancement of science in China (Rana 2019). He specifically told us that he was proud of his own work leading to the live birth of two gene-edited babies (Fox 2018). However, as Greely warns, we should not interpret this pride to mean a lack of ethics by the Chinese:

> [W]hen it comes to research ethics, as far as I can tell the Chinese government and research establishment has roughly the same set of rules as the rest of the developed world, including (for the most part) the United States. China is not concerned about research with human embryos as the United States and some other Western countries are; neither are they as sentimentally concerned about genetic modifications to animals that do not clearly implicate the modified animals' welfare. But for human subject research, informed consent, and for both human and non-human research, some advance weighing of the risks to the research subjects against the possible benefits exist in China as well. (Greeley 2019, 180)

The largest difference Greely sees between Chinese biomedical research and the United States is that China does not have a "depth of regulations and regulatory bodies" (2019, 180) and that absence allowed He to proceed with his research unimpeded. Now, however, the response to that research by the Chinese government has been swift including removing He from his lab, directing educational institutions to inspect research involving gene-editing technology, new legislation regulating gene editing, and a national ethics committee to oversee regulation. China, like the rest of the world, is participating in efforts to responsibly regulate this new technology. It

remains to be seen whether the international community will together come to an agreement on the correct time, if any, to move forward with human germline editing. As for the germlines of animals, including nonhuman primates, experimentation is well under way.

From a Unitarian Universalist perspective, I suggest the principle, "respect for the interdependent web of all existence of which we are a part," speaks to the question "When is it time to act?" On the surface, it reminds us that the laboratory use of nonhuman animals for the benefit of humans requires concern for the welfare and treatment of those animals, but at a deeper level, it also reminds us that as individuals, we are inevitably connected to a larger whole. It speaks directly to the fact that the human germline is blind to international borders. Decisions about the use of CRISPR technology on the human germline made in China will ultimately impact the human germline in the United States and vice versa. When it comes to the application of CRISPR technology "respect for the interdependent web of all existence of which we are a part," suggests we would do well to question the wisdom of allowing scientific research to be unduly impacted by nationalism.

Final Thoughts

For all the uncertainty surrounding how CRISPR technology will impact the future of life on this planet, and around answers to the two questions that I suggest are vital to helping us navigate that future, CRISPR is not the first time humans have used culture and technology to insert themselves into an ongoing evolutionary process. What is unique about this time is a matter of rate and degree. Potentially, CRISPR paves the way for us to have a substantial impact on the timescale and the depth of manipulation. For these reasons, among others, He's actions should alert society to the urgency of the need to proceed cautiously with this technology.

We will never all answer the questions "Who do we trust?" and "When is it time to act?" the same way, but if we can agree to work to discover our answers in as broad and inclusive a community as we can muster, while valuing an appreciation of our connections at least as much as we do our national interests, then perhaps we will also discover a hopeful way to navigate this planet's uncertain future. That would be an approach Unitarian Universalism could applaud. What a gift the scientific community would have given us with CRISPR, not only a potential to ease human suffering from a medical perspective, but also encouragement to continue with urgency the complicated work of figuring out how to recognize and respect this beautiful interdependent web of all existence of which we are a part. By encouraging us to ask together the most essential questions, CRIPSR has the potential to help heal bodies and souls.

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Note

1. Update: At the end of December 2019, the world learned that a court in Shenzhen China sentenced He to three years in prison for forging ethical review documents and misleading the doctors who implanted the embryos (Normile 2019).

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