



## Flashing the Yellow Traffic Light: Choices Forced Upon Us by Gene Editing Technologies

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### ABSTRACT

The 2018 birth of two designer babies in China has sparked an immediate global controversy over the ethics of gene editing. For the longer range future, however, we must assess how CRISPR/Cas9, like so many other new bio-technologies, is forcing choice—moral choice—on a large scale. Gene editing for purposes of medical therapy, human enhancement, engineering of future children, and even creating a posthuman species, confront our society with the inescapable necessity of making moral choices. The task for churches in partnership with universities is not to decide in advance what is right or wrong. Rather, it is to prepare our people to make responsible choices.

### KEYWORDS

CRISPR; gene editing; ethics; bioethics; choice; Jennifer Doudna

Professor He Jiankui of the Southern University of Science and Technology in Shenzhen, China, announced that in 2018 he successfully altered the genomes of two human children and that a third designer baby was then in the pregnancy stage. The first two, twin girls, underwent gene editing one day after IVF conception. He knocked out the CCR5 gene. By knocking out the CCR5, the pathway would be blocked for HIV to enter the immune cells. In effect, because of this gene editing, these two girls will be protected from HIV. In sum, if this experiment holds up to criticism, Jiankui will have proof of concept that gene editing can be used successfully for therapy, for disease prevention in humans.

Not everyone greets this scientific triumph with applause. When presenting his research at the 2nd International Summit on Human Genome Editing in Hong Kong in November 2018, Alta Charo, a member of the U.S. National Academy of Sciences Committee on Human Genome Editing, declared that Jiankui's work was "misguided, premature, unnecessary and largely useless."<sup>1</sup>

The controversy did not end there. Jennifer Doudna, co-discoverer of the CRISPR-Cas9 technique for gene editing voiced outraged. "It is imperative that the scientists responsible for this work fully explain their break from the global consensus that application of CRISPR-Cas9 for human germline editing should not proceed at the present time," she touted. Doudna added three additional points.

- (1) The clinical report has not been published in the peer-reviewed scientific literature.
- (2) Because the data have not been peer reviewed, the fidelity of the gene editing process cannot be evaluated.
- (3) The work as described to date reinforces the urgent need to confine the use of gene editing in human embryos to cases where a clear unmet medical need exists, and



where no other medical approach is a viable option, as recommended by the National Academy of Sciences.<sup>2</sup>

In sum, this Chinese experiment in human gene editing is subject to both scientific and ethical criticism.

For the near future, scientists and bioethicists will slug it out over the rightness or wrongness of human genome editing. For the medium and long term futures, however, we in the human race must adapt to a big change. That big change is the arrival of choice in baby-making. From now on, we simply cannot pretend that letting nature take its course is devoid of moral import. We must choose to edit or not edit. And, if we edit, we must choose what to edit.<sup>3</sup> We are condemned to freedom, as philosopher Jean Paul Sartre has announced.

It is time for churches and university communities along with scientists to think ethically about CRISPR and other biotechnologies.<sup>4</sup> This thinking-through should not simply distinguish between good and evil, as Adam and Eve wanted to do. Rather, this thinking-through should be aimed at equipping our people to make responsible choices, choices guided by human well-being and the common good.<sup>5</sup>

While we have our foot on the brake, should we stop completely as if the traffic light is red? Accelerate forward as if the traffic light is green? Or, perhaps better, look both ways and proceed as if the traffic light is flashing yellow? I'll make a case for the yellow light.

### Therapeutic Gene Editing with CRISPR

Here is something you don't need to know. CRISPR stands for *Clustered Regularly Interspaced Short Palindromic Repeats*. What does this mean? In the past, our human genomes incorporated palindromic DNA repeats from bacteria and archaea which were their adaptive method for strengthening their immune systems. The summary point to get is this: palindromic repeats of DNA base pairs provide targets for the geneticist to shoot at.

Like an archer, the CRISPR researcher aims at these targets with Cas9 arrows. What's Cas9? It's an endonuclease capable of cleaving DNA. When combined with specific RNA in a system it can either insert or delete specific genetic sequences. If Cas9 is the arrow, the CRISPR archer can fire it to a specific target on a DNA strand, cut it, insert a prescribed sequence of nucleotides, and then re-connect the DNA strand. We call this "gene editing" for short.<sup>6</sup>

What is the upshot? CRISPR/Cas9 technology can be used for highly specific and convenient gene editing, either inserting sequences in target genes, deleting genes, or turning genes off. The overwhelming scientific consensus is that this technology will usher in an age of cheap and easy genetic manipulation. If we don't like the DNA nature has bequeathed us, we can employ CRISPR/Cas9 to edit it to our standards.

CRISPR editing could be effective in genetic therapy. In 2017, Shoukhrat Mitalipov, who directs the Center for Embryonic Cell and Gene Therapy at Oregon Health and Science University in Portland, changed the DNA of a large number of one-cell embryos with the CRISPR gene editing technique. His target was a gene responsible for an inherited disease, hypertrophic cardiomyopathy. Mitalopov proved the technique in principle, even though as yet clinical trials have been postponed awaiting further ethical deliberation. An embryo with such a genetic alteration could be born without a



predisposition to hypertrophic cardiomyopathy. If this gene editing technique would take place in somatic cells (already mature cells in an individual patient), we would have an effective therapy for thousands of monogenic inherited disorders. And if this gene editing would take place in gametes (sperm or egg), future generations would also be born free of this inherited threat just as Jiankui's twin girls and their progeny are free of the HIV threat.<sup>7</sup>

### Gene Editing with CRISPR for Enhancement

In addition to employing CRISPR for genetic therapy, it could also become a technique for genetic enhancement. "The term *enhancement* is usually used in bioethics to characterize interventions designed to improve human form or functioning beyond what is necessary to sustain or restore good health," according to former director of the Ethical, Legal, and Social Implications Research Program at the National Institutes of Health, Eric Juengst.<sup>8</sup> Might CRISPR gene editing go on sale like performance enhancing drugs to create children superior in intelligence, size, strength, and talent? Are gene therapy and gene enhancement moral equivalents? Or, do we evaluate them differently?

The U.S. National Academy of Sciences guides us through the thicket of enhancement deliberation.

To begin, it is necessary to define what is meant by "enhancement." Formulating this definition requires a careful examination of how various stakeholders conceptualize "normal." For example, using genome editing to lower the cholesterol level of someone with abnormally high cholesterol might be considered prevention of heart disease, but using it to lower cholesterol that is in the desirable range is less easily characterized, and would either intervention differ from the current use of statins? Likewise, using genome editing to improve musculature for patients with muscular dystrophy would be considered a restorative treatment, whereas doing so for individuals with no known pathology and average capabilities just to make them stronger but still within the "normal" range might be considered enhancement. And using the technology to increase someone's muscle strength to the extreme end of human capacity (or beyond) would almost certainly be considered enhancement.<sup>9</sup>

What is needed for moral decision-making regarding genetic enhancement is the partnership of knowledge with wisdom combined with personal integrity oriented toward the common good.

### Applauding the Science of CRISPR While Doubting the Ethics of CRISPR

There is good reason for our scientists to applaud CRISPR with vigor. According to Jennifer Doudna, one of the CRISPR pioneers, "the simplicity of CRISPR-Cas9 programming, together with a unique DNA cleaving mechanism, the capacity for multiplexed target recognition, and the existence of many natural type II CRISPR-Cas system variants, has enabled remarkable developments using this cost-effective and easy-to-use technology to precisely and efficiently target, edit, modify, regulate, and mark genomic loci of a wide array of cells and organisms."<sup>10</sup>

Scientists are applauding. Some bioethicists are not. George Annas at Boston University's School of Public Health flashes the red light to stop all traffic. "The core challenge is what the new technology means to the human species. Is it a technology that affects



our understanding of humanity and opens the door to a neo-eugenics agenda that could threaten the survival of the species?”<sup>11</sup>

Once gene editing is let loose on the market, would-be parents will feel morally obligated to edit the genomes of their children. For therapeutic reasons: why permit a risky genetic lottery when we could eliminate genetic predispositions to disease in advance? For enhancement reasons: why not take advantage of a technology which could provide a competitive advantage for our children?<sup>12</sup> As genome modification services go on sale, free market eugenics will be blown by the unpredictable winds of fashion, fad, and frenzy. Overall, the human genome will evolve. The human race will change. Will our inherited genomes go extinct? Annas would, if he could, erect a shiny red traffic light to stop free market eugenics before it begins.

Arthur Caplan at New York University's School of Medicine, in contrast, flashes the yellow caution light. “In addition to the discussion about human germ line editing, CRISPR raises or revives many other ethical issues, not all of which concern only humans, but also other species and the environment.”<sup>13</sup> If CRISPR/Cas9 threatens species survival, then this warrants a red stop light. Otherwise, a yellow caution light will suffice.<sup>14</sup>

### The Transhumanist Proposal for a Posthuman Species

Might someone actually wish to employ gene editing to alter the human species? Yes. A Promethean transhumanist will snap up such a technology. CRISPR/Cas9 could provide a tool in the tool box the transhumanist needs to build a super-intelligent species, a posthuman species which will leave today's *Homo sapiens* in the dusty archives of evolutionary history.

Transhumanism, also known as Humanity Plus or H+, “holds that current human nature is improvable through the use of applied science and other rational methods, which may make it possible to increase human health span, extend our intellectual and physical capacities, and give us increased control over our own mental states and moods.”<sup>15</sup> This, according to Oxford's Nick Bostrom, a recognized H+ savant.

Bostrom tries to mollify critics who fear the extinction of the current human species by affirming genetic continuity between humanity today and posthumanity tomorrow. “There would be a continuity of differently modified or enhanced individuals, which would overlap with the continuum of as-yet enhanced humans.”<sup>16</sup>

In sum, gene modification along with other biotechnologies could be employed today to surpass humanity and bring a superior posthumanity into existence, but some continuity between the old and new species would endure.

Despite Bostrom's attempt to calm critics, this transhumanist vision causes bioethicists to tremble in their Nikes. They fear that such playing God will lead to a recklessness that might put an end to our species before a superior one can emerge. Hava Tirosch-Samuelson unleashes a barrage of criticism. “The transhumanist project is misguided because of its mechanistic engineering-driven approach to being human, its obsession with perfection understood in terms of performance and accomplishments rather than moral integrity, and its disrespect for the unknown future. Transhumanism is a utopian vision that, like all utopias, has gone awry because it mistakenly believes that the ideal is realizable in the present instead of remaining just a beacon for the future.”<sup>17</sup>



Perhaps we should acknowledge that the transhumanist vision is grand, big, comprehensive, and dramatic. Long before we open the gate to a posthuman species, however, our society will likely follow a long rocky path requiring ginger baby steps. We are already on that path, as the news from China indicates. What should be our next baby step? Should we look ahead at a red light or a yellow light?

### Formulating CRISPR Ethics

CRISPR ethics, like all ethical deliberation, is future oriented. I define ethics as reflection on how to make a better future. I think of ethics proleptically. That is, we begin with a vision of a transformed future and then pave a road with transformative actions that will help get us there. When it comes to scientific and technological advance, proleptic or anticipatory ethics takes into account the many unknown factors or even pot holes that might require a detour or circumnavigation. Yet, the vision of a transformed future, like the star followed by the Magi, provides our moral beacon.

When it comes to gene editing combined with other biotechnologies and medical research, we must project a vision of a future characterized by optimum human health, planetary flourishing, and universal participation in the common good.<sup>18</sup> If we begin with such a vision, then we can measure the potential contributions of CRISPR gene editing accordingly.

The caveat is that we must admit that we are not in complete control of what happens. Despite our attempt to engineer our bodies and engineer our future, contingent events and side effects and unforeseen negative repercussions will ineluctably require repeated changes in course. Bioethical seer Hans Jonas alerts us to this caveat. "The gap between the ability to foretell and the power to act creates a novel moral problem."<sup>19</sup> This leads Jonas to a disposition of caution, the need to recover respect; he advises humility in the face of the subtle and complex whole of evolution we still do not, and cannot, know in its entirety.

I recommend that we proceed through a yellow traffic light, developing and applying CRISPR/Cas9 while invoking the Precautionary Principle (PP). There is no warrant either theologically or ethically for putting up a red light or stop sign to halt this particular technology. Theologically, I want to say this: human creativity belongs inherently to the *imago Dei*, because we are created by the God who does new things (Isaiah 65:17).<sup>20</sup> Human creativity even in self-transformation should be morally guided, not squashed.

Human creativity must be ethically thought of in terms of our relationship to self, God, and the world. The implication is this: if genome modification has the potential for improving human health, then the divine image of God at work in us will lead us to toward stewarding CRISPR's benefits. If we think of human society as the divine image on Earth, then our creative advance in human health along with ecological health through advancing medical technology would be a fitting expression of that divine image.

This leads to three middle axioms. First, gene editing of somatic cells for purposes of therapy should be a moral no brainer. Proceed.<sup>21</sup> Second, gene editing of somatic cells for purposes of enhancement raises ethical questions of definition, equal access, and fairness. Yet, nothing about essential human nature would be threatened by such enhancement. Proceed only after widespread public discussion and consent.<sup>22</sup> Third, gene



editing of the human germ line that could have consequences for generations to come, however, deserves a precautionary pause before deciding to go forward.<sup>23</sup>

"Where ethicists become most concerned is when germ cells are the target of CRISPR. Any changes in the germ cells can be potentially passed down to future generations, essentially introducing those changes into the human population."<sup>24</sup> We need caution here. So, I recommend we try this on for size: "Yes, but not yet."<sup>25</sup>

### Applying the Precautionary Principle to Gene Editing

I recommend that we pause when the yellow light is flashing, but we proceed with our drive toward gene editing. The yellow light should remind us of the Precautionary Principle or PP, originally formulated for ecological ethics but equally applicable to genetic stewardship. Here is how ethicists in the Evangelical Lutheran Church in America formulate the PP.

The importance of humility in the face of uncertain knowledge leads to a principle of wisdom: the precautionary principle. The ELCA understands this principle to mean "When human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, action shall be taken to avoid or diminish that harm." ... Precaution comes into play when existing tools for risk assessment are overwhelmed by a high level of uncertainty and proposed actions may dramatically affect the integrity and limits of the earth or the existence of future generations. In such cases, the burden to demonstrate safety rests upon those who promote the novel action.<sup>26</sup>

The proof need not have slam dunk finality, but the future forecast must incorporate the best knowledge and wisdom available at the time of choice. Exploring possible futures cannot go on indefinitely. At some point, researchers need to leap forward. The choice to move forward must be informed by the best knowledge and formed by persons who appeal to the common good.<sup>27</sup>

The PP ranks options according to risk due to unknown contingencies. Gene editing for therapeutic purposes or even enhancement purposes of an existing individual carries low risk. Gene editing of gametes that would affect the germ line for generations into the future, however, carries increased risk due to increased unknown contingencies. Some concerned scientists, led by Edward Lanphier, president of Sangamo and chairman of the Alliance for Regenerative Medicine in Washington DC, have sounded an alarm: "In our view, genome editing in human embryos using current technologies could have unpredictable effects on future generations. This makes it dangerous and ethically unacceptable. Such research could be exploited for non-therapeutic modifications. We are concerned that a public outcry about such an ethical breach could hinder a promising area of therapeutic development, namely making genetic changes that cannot be inherited."<sup>28</sup>

Note how these scientists have provided two reasons for precaution. First, unpredictable consequences risk negative impact. This in itself warrants appeal to the PP. Second, scientists want to avoid offending the public who might shut off the supply of their research money for non-germline research. The first seems to nest fittingly as a matter for ethical deliberation, while the second seems laughably self-serving.

Now let us ask: is my support for PP only a smoke screen? Does PP surreptitiously turn the traffic light red?<sup>29</sup> Dana Carroll and Alta Charo are suspicious here. "Critics [of CRISPR] will also point to the intrinsic uncertainty about downstream effects, and will



invoke some form of the precautionary principle, which demands a strong justification before permitting any risk-creating activity, with risk defined both in terms of known hazards and unknown possibilities. The latter, of course, is incapable of measurement, which is where the precautionary principle can be stretched into a generalized prohibition.”<sup>30</sup> It is not my intention to stretch the PP into a “generalized prohibition.” I recommend a yellow traffic light, not a red one.

Caroll and Charo spell out what the yellow caution light might entail for CRISPR decision-makers. “Ultimately, the issues are whether the beneficial uses of genome editing are adequately safe and acceptable, whether regulatory oversight appropriately balances realistic risk assessment with achievement of the anticipated benefits, and whether there are any other factors that point towards promoting or impeding its use.”<sup>31</sup>

Here is the hinge on which both the ethical and public image arguments swing: the distinction between genome editing in somatic cells and in germ cells. Everyone would approve morally of therapeutic gene editing in somatic cells such as the research on inherited heart disease mentioned above. But, germ line cells seem to be treated as if they have laboratory leprosy. A voluntary moratorium in the scientific community—now supported by geneticists such as Jennifer Doudna and David Baltimore—could be an effective way to discourage human germ line modification and raise public awareness of the difference between these two techniques. Such a moratorium would obey the PP while giving the public time to join the applause for our laboratory geneticists.<sup>32</sup>

## Conclusion

The traffic light for gene editing remains yellow and flashing. Proceed only with due caution.

CRISPR confronts our society with an inescapable demand to choose, with a forced option. We and our neighbors along with our world leaders cannot help but choose whether or not to alter the genomes of plants, mosquitoes, or human beings. To elect to snuff CRISPR and let nature take its course would require just as much ethical deliberation and commitment as spelling out a precautionary policy or, thirdly, allowing *laissez faire* capitalism to run over our genomes like a bull dozer. The near and medium range futures of gene editing will be the result of a moral choice, one choice or another. The task of the church and the university in the company of our best scientists, who are concerned about the moral integrity of our shared future, is to prepare the present and the next generations with the ability to make wholesome choices based upon a transformative vision guided by the common good.

## Notes

1. Cited by Rob Stein, “Facing Backlash, Chinese Scientist Defends Gene-Editing Research on Babies,” *Health News from NPR* (November 28, 2018), <https://www.npr.org/sections/health-shots/2018/11/28/671375070/facing-backlash-chinese-scientist-defends-gene-editing-research-on-babies>.
2. Public Affairs, U.C. Berkeley, “Update: CRISPR Co-inventor Responds to Claim of First Genetically Edited Babies,” (November 26, 2018), <https://news.berkeley.edu/2018/11/26/doudna-responds-to-claim-of-first-crispr-edited-babies/>.



3. This paper is revised from one originally delivered at a conference, "God and Human Suffering: Conversations on 21st Century Genetics and Our Shared Future" October 6–7, 2017. Sponsored by the University of Utah: Department of Pediatrics, Division of Medical Genetics, and UCEER Center for Excellence in ELSI (Ethical, Legal, Social implications); the Rocky Mountain Synod and its Utah Conference of the ELCA, Mount Tabor Lutheran Church of Salt Lake; and the Episcopal Diocese of Utah. See also: Ted Peters, "CRISPR, the Precautionary Principle, and Bioethics," *Theology and Science* 13:3 (July 2015), 1–4; doi:10.1080/14746700.2015.1056583. See also: Ted Peters, "Should CRISPR Scientists Play God?" *Religions* 8:61 (2017), doi:10.3390/rel8040061.
4. I have been pressing this point regarding the need to prepare for moral choice since publishing a treatment on genethics two decades ago, *For the Love of Children: Genetic Technology and the Future of the Family* (Louisville, KY: Westminster John Knox, 1996).
5. Pope Paul VI defined the common good as "the sum of those conditions of social life which allow social groups and their individual members relatively thorough and ready access to their own fulfillment." "Pastoral Constitution on the Church in the Modern World: *Gaudium Et Spes*, promulgated by His Holiness, Pope Paul VI on December 7, 1965," No. 26, The Holy See, [http://www.vatican.va/archive/hist\\_councils/ii\\_vatican\\_council/documents/vat-ii\\_const\\_19651207\\_gaudium-et-spes\\_en.html](http://www.vatican.va/archive/hist_councils/ii_vatican_council/documents/vat-ii_const_19651207_gaudium-et-spes_en.html) (accessed May 7, 2016). Today, the meaning of "common good" or "good of all" must include the community of all living creatures. The meaning also should extend beyond the present to include consideration for the future of the web of life. The sphere of moral consideration is no longer limited to human beings alone. Evangelical Lutheran Church in America, *Genetics, Faith, and Responsibility*, A Social Statement (2012), <http://www.elca.org/en/Faith/Faith-and-Society/Social-Statements/Genetics> (accessed October 20, 2017).
6. See: Arvin M. Gouw, "Introduction to the CRISPR Revolution," *Theologians Testing Transhumanism*, [https://theologyandtranshumanism.weebly.com/uploads/1/2/9/8/12986053/introduction\\_to\\_the\\_crispr\\_revolution.pdf](https://theologyandtranshumanism.weebly.com/uploads/1/2/9/8/12986053/introduction_to_the_crispr_revolution.pdf).
7. Steve Conner, "First Human Embryos Edited in U.S.," *MIT Technology Review* (July 26, 2017), <https://www.technologyreview.com/s/608350/first-human-embryos-edited-in-us/> (accessed September 29, 2017). Whether Mitalopov's results can be confirmed or not is disputed by scientific skeptics. Kelly Servick, "Skepticism Surfaces Over CRISPR Human Embryo Editing Claims," *Science* (August 31, 2017), <http://www.sciencemag.org/news/2017/08/skepticism-surfaces-over-crispr-human-embryo-editing-claims> (accessed September 29, 2017). Attempts to prove in principle that CRISPR is effective in altering the genomes of pre-implantation embryos has also been going on in Asia. See: Hong Ma et al., "Correction of a Pathogenic Gene Mutation in Human Embryos," *Nature* 548 (August 24, 2017), 413–419.
8. Eric T. Juengst, "What Does Enhancement Mean?" in *Enhancing Human Traits: Ethical and Social Implications*, ed. Erik Parens (Washington, DC: Georgetown University Press, 1998), 29. Most ethicists quickly give a thumbs up to therapy but a thumbs down to enhancement, because enhancement exacerbates inequality and injustice in the social fabric. Further, enhancement de-humanizes. "I do not think the main problem with enhancement and genetic engineering is that they undermine effort and erode human agency. The deeper danger is that they represent a kind of hyperagency—a Promethean aspiration to remake nature, including human nature, to serve our purposes and satisfy our desires.... And what the drive to mastery misses and may even destroy is an appreciation of the gifted character of human powers and achievements." Michael J. Sandel, "What's Wrong with Designer Children, Bionic Athletes, and Genetic Engineering?" *The Atlantic Monthly*, April 2004, 5.
9. NASEM (National Academy of Science, Engineering, and Medicine), *Human Genome Editing: Science, Ethics, and Governance* (Washington, DC: The National Academies Press, 2017), 9; or NASEM, "Gene Drives on the Horizon: Report in Brief" (2016), 7, <http://nas-sites.org/gene-drives/files/2015/08/Gene-Drives-Brief06.pdf> (accessed November 28, 2016).



10. Jennifer A. Doudna and Emmanuelle Carpentier, "Genome Editing: The New Frontier of Genome Editing with CRISPR-Cas9," *Science* 346:6213 (November 28, 2014), doi:10.1126/science.1258096.
11. George J. Annas, "The Mythology of CRISPR," *Science* 354:6309 (October 14, 2016), 189. Annas proposes an international treaty to ban such biotechnologies as gene editing that would lead to species-alteration along with cloning and such. George J. Annas, Lori B. Andrews, and Rosario M. Isasi, "Protecting the Endangered Human: Toward an International Treaty Prohibiting Cloning and Inheritable Alterations," *American Journal of Law and Medicine* 28:2,3 (2002), 151–178.
12. Tina Hesman Saey, "Parents May One Day be Morally Obligated to Edit their Baby's Genes," *Science and the Public* (November 28, 2017), <https://www.sciencenews.org/blog/science-public/ethics-gene-editing-babies-crispr>.
13. Arthur Caplan et al., "No Time to Waste—the Ethical Challenges Created by CRISPR," *Science and Society* (August 10, 2015), doi:10.15252/embr.201541337, Published online 08.10.2015.
14. The more immediate and realistic threat is *free market eugenics*. "There is also the prospect of 'consumer eugenics'—eugenics driven by parental choice rather than by state order, which would have similar results to traditional eugenics, such as a multitiered social system based on certain enhancements." Jonathan Moreno, quoted in "CRISPR Germline Engineering—the Community Speaks," *Nature Biotechnology* (May 1, 2015), 478–486, at 481, <http://0-web.a.ebscohost.com.grace.gtu.edu/ehost/pdfviewer/pdfviewer?vid=1&sid=a93200ca-d46f-48ac-b295-568112a9b39a%40sessionmgr4006> (accessed October 20, 2017).
15. Nick Bostrom, "In Defense of Posthuman Dignity," in *Transhumanism and Its Critics*, ed. Gregory R. Hansell and William Grassie (Philadelphia: Metanexus, 2011), 55–66, at 55.
16. *Ibid.*, 60.
17. Hava Tirosch-Samuels, "Engaging Transhumanism," *Ibid.*, 19–52, at 47. Theologian and bioethicist Ronald Cole-Turner is much more open to a marriage between secular transhumanism and Christian spirituality. "Human transformation is central to Christian thought." Ronald Cole-Turner, "Introduction: The Transhumanist Challenge," *Transhumanism and Transcendence*, ed. Ronald Cole-Turner (Washington, DC: Georgetown University Press, 2011), 1–18, at 5. On the one hand, self-identified atheist and transhumanist Russell Blackford complains about me for being too critical of H+: "Peters has adopted ... a disdainful attitude toward transhumanist thought." Russell Blackford, "Trite Truths about Technology: A Reply to Ted Peters," *Ibid.*, 176–188, at 187. On the other hand, transhumanism critic, theologian Celia Deane-Drummond warns that I am too cozy with the movement. "I am more wary of the slide from enhancement to transhumanism than are authors such as Ted Peters." Celia E. Deane-Drummond, *Christ in Evolution* (Minneapolis: Fortress Press, 2009), 259.
18. For proleptic ethics, see: Ted Peters, *God—The World's Future* (Minneapolis: Fortress Press, 3rd ed., 2015), Chapter 14.
19. Hans Jonas, *The Imperative of Responsibility: The Search for an Ethic in a Technological Age* (Chicago: U. of Chicago Press, 1984), 8.
20. Creativity and future orientation belong to a healthy theological anthropology. "The ELCA values genetic science as an expression of the human responsibility to learn and predict, imagine and invent for the sake of stewarding creation." *Genetics, Faith, and Responsibility*.
21. "The ethical norms and regulatory regimes developed for human clinical research, gene transfer research, and existing somatic cell therapy are appropriate for the management of new somatic genome-editing applications aimed at treating or preventing disease and disability." NASEM, "Gene Drives on the Horizon," 6.
22. "Genome editing for purposes other than treatment or prevention of disease and disability should not proceed at this time, and that it is essential for these public discussions to proceed any decisions about whether or how to pursue clinical trials of such applications." NASEM, "Gene Drives on the Horizon," 9.



23. "Heritable genome-editing research trials might be permitted, but only following much more research aimed at meeting existing risk/benefit standards for authorizing clinical trials and even then, only for compelling reasons and under strict oversight." NASEM, "Gene Drives on the Horizon," 7.
24. Steven Novella, "CRISPR and the Ethics of Gene Editing," *Science Based Medicine* (December 2, 2015), <https://www.sciencebasedmedicine.org/crispr-and-the-ethics-of-gene-editing/> (accessed November 28, 2016).
25. Another form of the PP is this: *think first!* "In view of the unresolved practical, ethical and societal issues, for the time being, it is more than advisable to refrain from any experiments involving human germline interventions. Instead: Think first." Elisabeth Hildt, "Human Germline Interventions—Think First," *Frontiers in Genetics* 7 (May 9, 2016), <https://doi.org/10.3389/fgene.2016.00081> (accessed October 20, 2017).
26. "Genetics, Faith, and Responsibility," 27. There are many versions, but I rely on the so-called Wingspread version of the PP as it was formulated at the 1992 United Nations Conference on Environment and Development: "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of the process or product, rather than the public, should bear the burden of proof." Wingspread Statement on the Precautionary Principle, 1998, <http://www.gdrc.org/u-gov/precaution-3.html> (accessed December 15, 2016).
27. Where I put *common good*, HUGO (Human Genome Organization) CELS (Committee of Ethics, Law, and Society) puts *solidarity*. "Solidarity is a complex term that defies just one meaning (e.g. 'we-ness', as group identify<sup>27</sup>), but which we use here to recognize the opportunities to share benefits as a public good; it helps conceptualize how disruptive technologies are also social phenomena that are subject to rapid and constant transformations. Achieving an orderly and equitable introduction of CRISPR into mainstream biomedicine requires a continued broad debate, including issues of benefit sharing *versus* private commercialization." John J. Mulvihill Benjamin Capps Yann Joly Tamra LysaghtHub A. E. Zwart Ruth Chadwick, "Ethical Issues of CRISPR Technology and Gene Editing Through the Lens of Solidarity," *British Medical Bulletin* 122:1 (June 2017), 17–29, at <https://doi.org/10.1093/bmb/ldx002>. "CRISPR–Cas9 also needs to be judged for the good of future generations." Ibid.
28. Edward Lamphier et al., "Don't Edit the Human Germ Line," *Nature* 521:117 (2015), <http://www.nature.com/news/don-t-edit-the-human-germline-1.17111>.
29. Otherwise conservative Valparaíso bioethicist Gilbert Meilaender entertains a cautionary approach to heritable germ line editing trials while recognizing that caution does not mean that they must be prohibited. "Which is to say, it sets before us a yellow light." Gilbert Meilaender, "Is Caution Enough? The Promise and Peril of Gene Editing," *Commonweal* 44:7 (April 4, 2017), 12–15, at 13. Caution just may lead to the decision to stop. "No doubt it is generally wise to let a yellow light make us cautious. But there may also be moments when we should remember that there always remains another possibility and that moral seriousness might sometimes be measured by our willingness to be as wise as kindergarteners and to know when to 'stop, stop, stop'." Ibid., 15.
30. Dana Carroll and Alta Charo, "The Societal Opportunity and Challenges of Genome Editing," *Genome Biology* (2015), 16:242, doi:10.1186/s13059-015-0812-0, [http://godandhumanagenetics-slc2017.org/sites/rms.clphost.com/files/carrollcharo\\_genomebiol\\_2015.pdf](http://godandhumanagenetics-slc2017.org/sites/rms.clphost.com/files/carrollcharo_genomebiol_2015.pdf) (accessed September 30, 2017).
31. Ibid.
32. Proposing a moratorium may be fruitless, at least in the minds of some prognosticators. "There is no interest in an internationally binding treaty or convention among all of the necessary Parties . . . . We have little choice but to trust CRISPR-Cas9 users and to know that the catastrophic, doomsday scenarios that occur in the imaginations of science fiction authors are so unlikely that they are nearly impossible." Adam Gross, "Dr. Frankenstein, or: How I Learned to Stop Worrying and Love CRISPR-Cas9," *Jurimetrics: The Journal of*



*Law, Science & Technology* 56:4 (Summer 2016), 413–447; AN 119465505 (accessed October 20, 2017).

### Disclosure Statement

No potential conflict of interest was reported by the author.

### Notes on Contributor

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