The CRISPR Journal
Volume 2, Number 5, 2019

DOI: 10.1089/crispr.2019.0046

The CRISPR Journal

PERSPECTIVE

The Use and Misuse of *Brave New World* in the CRISPR Debate

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Abstract

When writing about CRISPR and similar technologies, many bioethicists use science-fiction references to help readers picture the ramifications of germline gene editing. By a large margin, the most frequently referenced novel in this debate is Aldous Huxley's 1932 dystopia *Brave New World*. Despite its iconic status and effectiveness at communicating specific ethical issues, *Brave New World* provides relatively poor examples of interventions such as gene therapy or enhancement. In addition, the eugenic tropes that Huxley promotes in much of his work make *Brave New World* an uncomfortable choice for authors who oppose the use of CRISPR for illiberal purposes. Ethicists should consider bringing a wider variety of fiction references into the discourse on genome editing, especially stories that can complement *Brave New World* with insights about the ethical issues left undeveloped in Huxley's novel.

Introduction

In November 2018, on the eve of the Second International Summit on Human Genome Editing, Antonio Regalado, a journalist with the *MIT Technology Review*, revealed that Chinese biophysicist He Jiankui had become the first scientist to use CRISPR clinically in human embryos. Knowing that He was scheduled to appear at the summit and that extraordinary levels of interest had been sparked by worldwide media coverage of the genetically modified babies, organizer David Baltimore chose to open the event by stating:

> Three years ago, I had the honor of opening the First International Summit on Human Genome Editing in Washington DC, and I mentioned there Aldous Huxley's 1932 novel *Brave New World*. The novel imagines a future society where embryos are selected and conditioned to become individuals who will live in predetermined social classes. Although Huxley could not have conceived of genome engineering, I mentioned that as we consider new technologies that offer the ability to manipulate traits of the human population, we should take to heart the warning implicit in that book.[1]

Ironically, He Jiankui *et al*. had just published a commentary in this journal—subsequently retracted—that argued against comparisons between gene editing and ''the prophesy of Aldous Huxley's *Brave New World*'' (Fig. 1).[2] Clearly, he thought that allusions such as Baltimore's might pose a threat to the public reception of his experiments.

The important role played by science fiction in these debates should not be surprising. Since the origin of bioethics in the 1960s, many authors have used fiction to illustrate potential ethical issues with technologies that did not yet exist in the real world.[3] Although there are many novels about genetic manipulation for bioethicists and other stakeholders to cite, *Brave New World* continues to be the most frequently referenced work of fiction in the genome-editing discourse.[1,4–54]

In fact, it is almost surprising when a book or magazine article on genome editing does not cite *Brave New World*. The novel is mentioned by proponents and by opponents of gene editing,[55] by secular authors and by theologians,[6,23,26,31] by authors who think its vision of the dystopian future is likely and by those who think it is absurd. Many authors have even chosen to incorporate the words ''brave new world'' into the titles of their own publications.[9,11,15,16,23,25,30,31,37,42,45,50,52] This trend shows no sign of abating. Allusions to Huxley's novel have appeared in more than 500 academic articles about CRISPR.[56]

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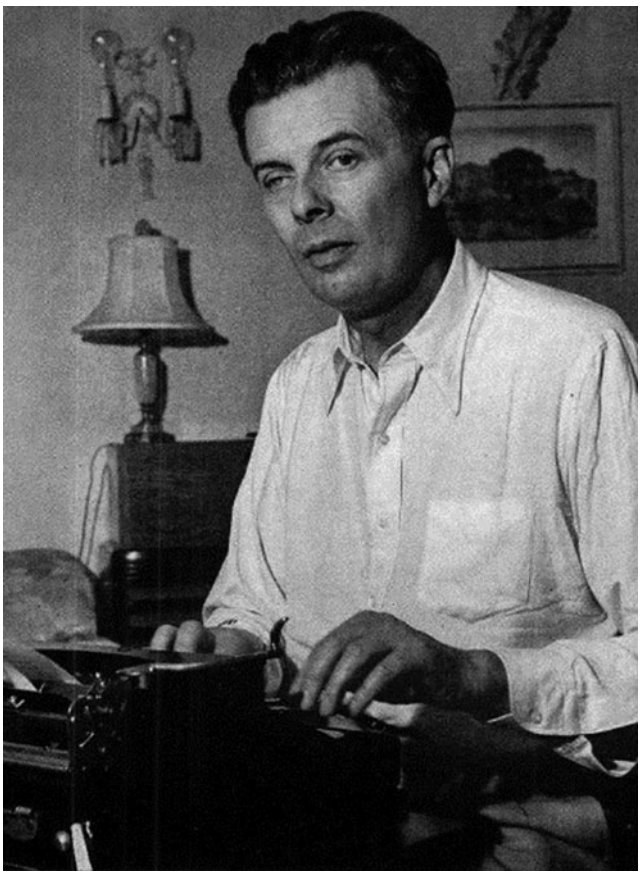

FIG. 1. Aldous Huxley. (Credit: *Life Magazine*, 1947).

There are a few obvious reasons for *Brave New World*'s supremacy. It is highly popular, being one of the 50 most-read books on Goodreads.[57] It is widely regarded as a literary classic, meaning that authors can allude to it while maintaining an academic tone.[58] It also has a very versatile title. Because the phrase ''brave new world'' is taken from *The Tempest*, it allows literary-minded authors to bring Shakespeare into their work.[30,53,54] In the original play, the heroine Miranda spots a group of bedraggled sailors and naïvely exclaims: ''How beauteous mankind is! O brave new world, /That has such people in't!''[59] This means the phrase can be used to suggest the ironic subversion of stakeholders' intentions. Finally, *Brave New World*'s title is both evocative in its own right and easily used in wordplay. As Google's Ngram Viewer shows, the phrase ''brave new [noun]'' has become increasingly popular as an idiom over the past 40 years.[60]

Another reason references to *Brave New World* are so common is that they have become self-perpetuating. Some authors may cite the novel simply because it has become a standard warning against new reproductive technologies. As John Lynch has suggested, *Brave New World* offers a ''rhetorical commonplace'' for stakeholders.[55] Others, such as He Jiankui himself, continue mentioning the novel simply in order to point out how common these references are.[2,27,33,43,61–64] In their book *A Crack in Creation*, CRISPR co-discoverer Jennifer Doudna and her former student, Samuel Sternberg, mused that germline genome editing (GGE) rarely appears in the media without *Brave New World* being ''directly or indirectly referenced.''[65]

Many authors who have discussed the use of *Brave New World* agree that these references are overused,[3] calling them ''facile''[33] or ''singularly unimaginative.''[63] In his 2003 book *Better Than Well*, Carl Elliott wrote:

> News stories about psychotropic drugs, stem cells, reproductive technologies, or genetic engineering inevitably appear with headlines reading Brave New Medicine, Brave New Babies, Brave New Minds, or Brave New People. It is as if we have no other metaphors for these technologies, no competing visions of possible futures. Whatever the new technology of the moment happens to be, we hear the same cautionary tale.[43]

Despite these objections to how frequently *Brave New World* is mentioned, few authors have examined how Huxley's book is actually being represented in the genome-editing literature. The current state of affairs raises some pertinent questions about the rhetoric of bioethics. Do the ethical concerns associated with *Brave New World* match up with the preoccupations of contemporary ethicists, or do they serve as a distraction? Do popular interpretations of the novel reflect its actual contents, or has *Brave New World* simply become a mirror for whatever each author chooses to read into it? Ultimately, would other works of fiction do a better job of inspiring bioethics?

How Is *Brave New World* Used?

Bioethics publications that invoke *Brave New World* tend to refer to a few specific aspects of its futuristic setting rather than its actual storyline. The only scene that appears repeatedly in the discourse is the one from the very beginning of the novel, in which some students go on a tour of the ''Central London Hatchery.'' This segment provides the reader with a huge amount of exposition describing the various technologies used in Huxley's dystopia.[55]

In the novel, *in vitro* reproduction is used at an industrial scale to produce people with five different levels of ability, ranging from ''future sewage workers'' to ''future World controllers.'' The process begins with eggs being ''inspected for abnormalities'' and dipped in a bath of sperm.[66] As Huxley specified in his later essay ''Brave New World Revisited,'' future Alphas result from

''biologically superior ova'' being matched with ''biologically superior sperm'' and given ''the best possible prenatal treatment,'' while future Epsilons are conceived from ''biologically inferior'' gametes and stunted prenatally by oxygen deprivation and toxin exposure.[67] Most famously, scientists use the ''Bokanovsky process'' to encourage embryos from the lower castes to divide into as many as 96 identical twins.[66]

As a result, citizens from higher castes stand above the others both mentally and physically. Alpha Pluses are considered good-looking, and there is a ''standard Alpha height'' that lower castes are hypnotically induced to associate with superiority. This does not always work: the character Bernard Marx, who stands eight centimeters shorter than the other members of his caste, feels shame that Deltas can look him directly in the face.[66]

Fetuses are also treated differently based on which jobs they are meant to perform. Future inhabitants of the tropics are preconditioned to enjoy heat, future ''rocket-plane engineers'' are rotated to improve their sense of balance and make them enjoy being upside down, and others are exposed to ''lead, caustic soda, tar, chlorine'' in order to build up resilience for their predetermined jobs in chemical plants. Most of the female embryos are dosed with male hormones to make them into sterile ''freemartins,'' while the rest are left viable in order to ensure that ''a good choice'' of ovaries are available to produce the next generation.[66]

Once born, the people of *Brave New World* receive various treatments to postpone old age, including transfusions of young blood. As Bernard summarizes it, ''Youth almost unimpaired until sixty, and then, crack! The end.'' Finally, some scientists from Huxley's World State have tried to improve the system's efficiency even further by developing Epsilons who grow to adulthood in six years, although their experiments remain incomplete at the time the novel is set.[66]

These technologies are not very scientifically accurate for our time or even for Huxley's, but commentators rarely dwell on the specific details of reproduction in *Brave New World*. Rather, they describe broad classes of ethical issues raised by the societal arrangement that these technologies are used to enforce, many of which are only indirectly connected to genome editing. In approximate order of frequency, authors writing about GGE tend to raise the themes of totalitarian control of life,[5,10,12,13,27,34–36,42,43,49] mind control,[17,18,20,21,24,26,28,33,34,37,40] the elimination of traditional families in favor of test-tube babies,[14,21,33,34,37,38,46,49,62,68] the division of society into distinct castes,[8,11,21,26,27,29,34,38,41,43] the pursuit of shallow unearned pleasures,[37,38,41,43,48,51] and the creation of people willing to perform menial jobs.[13,28,34,43]

In contrast, some of the most prominent ethical issues with GGE are rarely discussed. For instance, it is hard to draw a connection between Huxley's scenario and the idea of therapeutic genome editing. The use of ''biologically superior'' gametes for Alphas is mentioned in Huxley's later essays rather than in the novel itself, and even then, it is left unclear what that entails. Nor does the novel address the possibility of these processes causing unanticipated side effects.

The far-future setting of *Brave New World* also sidesteps many of the most famous critiques raised by opponents of genome editing, such as the impact of the technology on self-identity[69,70] (as all citizens are brainwashed into being happy about who they are), or the loss of parental humility[71] (as nobody still has parents in the conventional sense). *Brave New World* strongly evokes some ethical concerns, but it simultaneously minimizes others.

How Is *Brave New World* Misused?

One of the strangest aspects of *Brave New World*'s use in bioethics is that many authors use the novel as shorthand for ethical issues that never appear in the novel at all, and even some issues that contradict those portrayed in the novel.

First, *Brave New World* is often misrepresented as being about the direct genetic engineering of humans.[10,37] It is true that some of the technologies in *Brave New World* mirror those discussed in the gene-editing literature (such as making all Alphas the same height). Yet, as David Baltimore put it, ''Huxley could not have conceived of genome engineering.''[1] *Brave New World* was published more than 10 years before Avery determined that DNA was the carrier of genetic information and more than 20 years before Watson and Crick described its structure. Thus, there does not seem to be any genetic testing in *Brave New World*, and most of the methods described involve hormones and chemicals rather than heritable interventions. Although Huxley wrote that ''eugenics and dysgenics were practiced systematically,''[67] this seems to refer only to selective breeding and not to any kind of direct manipulation on the genetic level. (The Bokanovsky process does represent a form of cloning, but this is not ethically equivalent to GGE, and references to *Brave New World* may lead some readers to confuse the two technologies.)

Second, many authors assume that *Brave New World* is a parable about genetic enhancement.[35,43,47] In their report *Beyond Therapy*, the President's Council on Bioethics suggested that the novel was about ''producing improved … perfect or post-human'' people.[41] While it's true that the upper castes in *Brave New World* are smarter than the others, this is more because of the deliberate

impairment of the lower castes than because the upper castes are ''perfect.'' Rather than reducing the number of individuals born with genetic disorders or handicaps, Huxley's dystopia involves dramatically increasing their number. Concerns about large-scale disenhancement appear only occasionally in the gene-editing literature,[7,13,28,40] making *Brave New World* a poor match for these concerns. Furthermore, unfair competition for education or career opportunities is not an issue in Huxley's world because there is no real competition: everyone is created to fill a particular niche in society.

Third, consider the mass manufacturing process described in *Brave New World*'s opening chapter. Several bioethicists have argued that *Brave New World*'s premise of standard-issue babies is unlikely. Instead, they anticipate, parents will purchase genetic modifications for their children based on their own preferences.[30,42] But others seem to think that *Brave New World* itself is about individually customized ''designer babies.''[37,47,72] Theologian Ted Peters, for instance, used it as an example of genetic engineering based on ''cultural fads and parental whims.''[32] There is some overlap between *Brave New World* and the laissez-faire scenario: both raise ethical concerns about objectification and excessive consumerism. However, in *Brave New World*, the consumer mentality serves primarily as a distraction in the name of social stability, rather than a motivation in the creation of particular individuals. Children are not designed differently based on their parents' wealth, culture, or religion because parents do not even exist.

In some of these cases, it is possible that authors are misremembering the society described in *Brave New World*, or that they have not read the book in the first place. Others may be using the phrase ''brave new world'' less in reference to Huxley's novel and more to evoke the general idea of a futuristic dystopia. In many cases, this seems to involve reading contemporary bioethical concerns into *Brave New World* even when they are not supported by the text itself.

Aldous Huxley and Eugenics

Brave New World and Huxley himself are often held up as icons within bioethics. Howard and Rifkin's book *Who Should Play God* begins with a dedication ''To Aldous Huxley /he foresaw,''[14] while Leon Kass's essay ''Preventing a Brave New World'' states that ''Aldous Huxley saw it coming.''[37] This is especially common among ethicists who believe that GGE represents a slippery slope to worse and worse misuses of power. As Kass put it, ''creating and manipulating life in the laboratory is the gateway to a *Brave New World*, not only in fiction but also in fact.''[37]

This line of argument gravely misrepresents Aldous Huxley's personal views on new reproductive technologies. As Joseph Fletcher pointed out, Huxley was much more worried about totalitarianism than about the new technologies described in *Brave New World*.[21] In ''Brave New World Revisited,'' Huxley wrote: ''It is a pretty safe bet that, twenty years from now, all the world's overpopulated and underdeveloped countries will be under some form of totalitarian rule – probably by the Communist party.''[67] However, he didn't think that ''genetic standardization'' would be involved in this new world order. Biotechnology is mentioned only in passing in the essay, and it is not among the technologies (such as sleep-learning) that he recommended banning.[67] Quite the opposite: Huxley thought that *Brave New World* might come about if we *didn't* start selecting better children.

Like his brother Julian, who was one of the best known eugenicists of the era, Aldous Huxley was a member of the Eugenic Education Society.[68] According to Jonathan Greenberg, these views are manifested in ''*Brave New World*'s attention to the intelligence and the head shapes of its lower castes,'' which suggest that ''the mentally impaired, represented as a swarm of ugliness and stupidity, are John's true antagonists.''[73] Indeed, Huxley published an essay two years later titled ''What Is Happening to Our Population?'' in which he argued that England would become a nation of ''half-wits'' unless it adopted mandatory sterilization policies.[74] Even after two decades, when eugenics had largely faded from popularity, Huxley worried that a reduction in average intelligence might lead to totalitarianism. ''For how long can such a society maintain its traditions of individual liberty and democratic government?'' he wrote. Rather than abandoning new reproductive technologies, Huxley advocated taking a course ''between the extremes of laissez-faire at one end of the scale and of total control at the other.''[67]

Huxley was particularly enthusiastic about Nobel laureate H.J. Muller's well-known plan to improve the human gene pool by banking high-quality sperm.[75] He envisioned a society organized along those lines in his 1962 utopian novel *Island*, in which the sperm of men with high IQs are provided from a central bank to grateful married couples, and children play board games such as ''Evolutionary Snakes and Ladders'' or ''Mendelian Happy Families.'' In many ways, *Island* serves as an inverted version of *Brave New World*, demonstrating how a non-totalitarian society might use eugenics to great benefit. *Island* even suggests that people who were overly susceptible to persuasion could be trained to avoid hypnotism by would-be dictators.[76]

Huxley's lifelong interest in modifying humans at a biological level makes him a poor (and inaccurate) icon for common-sense controls on GGE. Although many ethicists may be unfamiliar with his other writings, these strongly suggest that *Brave New World* was never meant to be a warning about technologies such as CRISPR. Authors looking to use science fiction in their work might want to cite authors who provide a better foundation for their ethical arguments.

Conclusion

Although *Brave New World*'s omnipresence in the gene-editing debate seems to be motivated by a reasonable desire to draw on the insights of science fiction, the use of this particular novel is problematic for several reasons. Huxley's dystopia has only vague parallels to gene editing for therapeutic purposes or for enhancement. It offers few concrete referents for many of the most common perspectives on GGE. Authors who use *Brave New World* to dramatize concerns such as the creation of designer babies run the risk of twisting the scenario beyond all recognition, as well as misrepresenting Huxley's own messages.

Near the end of the first International Summit on Human Genome Editing, Ellen Wright Clayton remarked: ''We've heard occasional references to *Brave New World*, but frankly there's a huge and very rich popular literature right now that addresses these issues by mainstream authors and it's really too bad they haven't been heard.'' As a next step, it would be worthwhile to identify some fresh novels and stories that could help to fill in some of the gaps left by the usual literary references.

Some of the most acclaimed science-fiction novels include gene editing as a major plot element. These books span a broad range of settings, themes, and ethical issues. For instance:

- John Brunner's Stand on Zanzibar (1968), tackles the political implications when a populous Southeast Asian country sparks outrage from the West by announcing a genetic optimization program.[77]
- Marge Piercy's *Woman on the Edge of Time* (1976), is a feminist classic that explores how genetic engineering might be used in a society committed to racial and sexual equality.[78]
- C.J. Cherryh's *Cyteen* (1988), could be considered a more character-centric update of Brave New World, following two generations of scientists and subjects at a facility that produces people to fill different social roles.[79]
- Katherine Dunn's *Geek Love* (1989), a National Book Award nominee, explores norms of health and beauty in a group of children whose parents whimsically use mutagens to make them all as unique as different rose cultivars.[80]
- Margaret Atwood's MaddAddam trilogy (2003–2013), starting with *Oryx and Crake*, depicts a hypercapitalist dystopia dominated by biotechnology companies, where one scientist attempts to redesign a less exploitative species of human.[81]
- Paolo Bacigalupi's *The Windup Girl* (2009), intertwines GGE and climate change through the title character, who lives in an ecologically ravaged Thailand but has difficulty sweating because her pores were minimized for aesthetic purposes.[82]
- Richard Powers' *Generosity: An Enhancement* (2009), examines genetic exceptionalism and media hype over the purported discovery of a gene for ''happiness.''[83]

It would be well beyond the scope of this article to debate the merits of every possible alternative to *Brave New*

Box 1. Genetics on Film

While *Brave New World* is the most frequently referenced novel in the academic gene-editing debate, the most frequently referenced film is Andrew Niccol's *Gattaca* (1997). It follows a would-be astronaut facing discrimination in a world where most middle-class children are selected from embryos based on the genetic characteristics preferred by their parents.[84] Although the film's bioethical messages have also been criticized by some stakeholders,[85,86] there are reasons to think that overreliance on *Gattaca* presents less of an impediment to the CRISPR debate than *Brave New World*. First, the film is referenced only about a third as often as *Brave New World* in recent publications.[87] Second, it is much more scientifically accurate.[86] Third, the free-market scenario presented in *Gattaca* and its socioeconomic ramifications are more pertinent to contemporary concerns about CRISPR and other reproductive technologies. As a result, *Gattaca* has become very popular as a teaching aid in both secondary and postsecondary classes touching on bioethics.[88,89] Finally, there are so few films about human genetics that no superior alternatives to *Gattaca* readily present themselves. It would be preferable if more were available to choose from, but *Gattaca* seems to be a more than acceptable figurehead for the time being.

World, let alone discuss the portrayal of these themes on film (Box 1). This short list consists less of recommendations than examples of the diverse approaches to gene editing available in fiction. Some of the objections raised to *Brave New World* in this article surely apply to these novels as well. Further analyses might consider which scenarios best reflect contemporary ethical concerns, and how to deploy them for education or popularization purposes.

This task also raises some new questions. What characteristics are most valuable in a literary reference for emerging technologies? Which works are more popular among different sets of stakeholders? Should we prioritize newer and more scientifically accurate books over older ones? Does pertinence to contemporary bioethics outweigh literary merit? Finally, what are the best ways of bringing the opinions and experience of living authors into the debate? Moving past reliance on a work as entrenched in the public and scientific discourse as *Brave New World* seems difficult, but the effort could ultimately help to expand our perspectives on gene editing and its ethical implications.

Acknowledgments

I thank Profs. Robert Sladek and Yann Joly for their comments on the manuscript.

Author Disclosure Statement

No competing financial interests exist.

Funding Information

This work was supported by the Canadian Institutes of Health Research (CIHR) through Doctoral Research Award #146265.

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