

# **The morally disruptive future of reprogenetic enhancement technologies**

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## **Abstract**

Emerging reprogenetic technologies may enable the enhancement of our offspring's genes. Beyond raising ethical questions, these biotechnologies may change some aspects of future morality. In the reproductive field, biotechnological innovations may transform moral views about reproductive choices, what we consider to be just and even of equal standing.

**Keywords:** moral change, human genetic enhancement, reprogenetic technologies, ethics, morally disruptive biotechnologies.

## **The impact of emerging reprogenetic technologies in future morality**

The vast majority of births today share two characteristics—conception has occurred through sexual reproduction and the genes of the newborn have not been intentionally modified or selected. In the future, this may change. Reprogenetic technologies enable assisted procreation along with the influence of the offspring's genetic inheritance [1]. Although reprogenetics' current degree of impact is limited, it may be empowered due to emerging technological advances.

A major constraint of current assisted reproductive procedures is the limited availability of eggs, the procurement of which places a heavy burden on women. Creating gametes (i.e., sperm and eggs) from other cells may be one solution to overcome this problem. For example, induced pluripotent stem cells (iPSCs) might one day be used to dedifferentiate an adult somatic cell into a stem cell that can then be transformed into a gamete cell. If fertilised *in vitro*, these could exponentially multiply the available embryos.

Since the 1990s, embryos can be biopsied (whereby one or more cells are removed) for genetic testing, with the main aim of preventing inheritable diseases or abnormalities. Advances in (whole) genome sequencing technologies, together with the availability of a large number of embryos, may allow prospective parents to select the most desirable genetic profile from among their potential offspring. Whilst this technology would enable a significant amount of reproductive autonomy, embryo selection would be restricted to the combination of the parents' genes. However, looking further ahead, gene editing technologies (such as CRISPR/Cas9) could be used to rewrite part of the genome of the embryo to be implanted, the gametes before fertilization, or even to perform somatic editing after birth. In this way, genetic traits of the progeny could be directly modified, beyond the inherited genes from their parents.

These biotechnological advances may expand the number of people interested in reprogenetic practices, including those with no fertility problems and without known risk of transmitting genetic conditions. If these technologies prove to be effective and safe, some have predicted that sexual reproduction will yield to assisted reproduction in the not-so-distant future [2-3].

Amongst the diverse reprogenetic applications, genetic enhancement generates particular enthusiasm and concern. In the reproductive domain, genetic enhancement would mainly consist of editing the genes of a healthy embryo (or the gamete cells from which the embryo forms) to improve the traits, capacities or wellbeing of the future person.

There has been substantial ethical analysis of the risks and potential benefits of reprogenetic enhancement. Still, far less attention has been given to the impact that these technologies might have upon society's morality itself. In this article, we argue that reprogenetic enhancement technologies can lead to future moral changes. We offer a

broad account of prospective technology-elicited transformations of morality related to reproductive choice, justice and equal moral status. We finally address the challenges of conducting ethical analyses of future moral changes that may be triggered by reproductive biotechnologies (Box 1).

<b>Box 1. Morally disruptive technologies</b>
<p>The term ‘morally disruptive technology’ was coined by the historian of bioethics and medicine Robert Baker [12]. This term broadens the domain of technology’s transformative impact beyond the business domain on which the theory of disruptive innovations normally focuses. According to Baker, some technological innovations can also change morality. An important example is mechanical ventilation—a medical innovation produced in the 1950s that allowed assisted breathing by a mechanical pump. This biotechnology, together with artificial hydration, allows patients who would otherwise be dead to be kept alive. Historically, this milestone has had moral implications for the determination of (brain) death and the legitimacy of organ procurement for transplantation. Technology-induced moral transformations in medical issues can be distinguished according to different degrees of moral change: moral revolutions, moral reforms and moral drifts [13].</p> <p>It is important, moreover, to envisage possible moral changes that may occur in the future due to biotechnological developments [14-15]. This creates challenges to unidirectional bioethical approaches that go from current ethical theories to future biotechnological applications. This one-way analysis is limited since biotechnologies can change ethical values themselves. Indeed, there is a complex interaction between ethics, biotechnology and society—they mutually coevolve.</p>

**Disrupting reproductive choice**

If reprogenetic technologies eventually enable the enhancement of the offspring’s traits, we might plausibly predict that future parents will demand the freedom to do so. If so, one plausible moral change resulting from these technologies might be a considerable expansion of the degree of reproductive autonomy to which individuals might believe they are entitled. In principle, this type of autonomy can include not only the freedom to reproduce or not, with whom and when, but also what type of child to have [4].

Indeed, most parents already feel morally responsible for positively encouraging certain valuable features in their children. These biotechnological developments could extend this moral sense of parental responsibility long before birth. In deciding what kind of traits to enhance, different moral beliefs may come into play. For instance, future prospective parents may seek to bring into existence a child who can enjoy a life of greater well-being (following the principle of procreative beneficence [5]) or one who is better disposed to assist the well-being of others (the principle of procreative altruism [6]).

With freedom comes responsibility. People will then have the responsibility for their child's traits. If one rejects the acts-omissions distinction, as consequentialists do, then parents might be deemed responsible for failing to enhance their child's talents or abilities through genetic means, just as we might currently hold them responsible for failing to provide their child with the sort of nurturing environment that is necessary to flourish. So, whereas parents already have significant responsibility for their post-birth (and some pre-birth) behavior affecting their children, these technologies can extend it to include technological actions and omissions that impact the genetic makeup of their offspring. For this reason, reprogenetic technologies may challenge the morality of sexual reproduction.

## **Disrupting justice**

The great majority of births today are governed by genetic lottery—the largely random combination of parents' genes. As long as the ability to influence this kind of genetic luck is limited or absent, the genetic lottery may seem morally neutral—although some have rejected this claim [7]. However, reprogenetic advances may take us from the realm of chance to the domain of choice [8]. Morally, this is a significant change since it would render the (un)just distribution of genetic endowments and natural talents a matter of deliberate decision.

As a result, our sense of justice may also be affected by reprogenetic technologies. In a world with advanced genetic technologies, suffering from a congenital disease or a glaring positional genetic disadvantage would not be a misfortune, but an injustice. The shift from perceiving an event as a misfortune (an evil over which we have no control) to an injustice (an evil which we have the power and duty to prevent) is, morally, a substantial change in our sense of justice [9].

Another possible change relates to moral beliefs about accessing resources that are socially valued. Many people will want to benefit from reprobnetic technologies—and this may alter mainstream views about which innovations should be universally accessible and what citizens may have a right to demand. Depending on competing conceptions of fairness, access to these technologies may be prohibited altogether, given to the free market (through the ability to pay) or subsidised with public money, like education.

## **Disrupting equal standing**

The belief that all human beings have equal moral standing is a fundamental axiom of modern day ethics. However, history is also replete with examples which suggest that this belief has not always been endorsed, with instances of discrimination based on stressing differences in race, gender, nationality or sexual orientation.

In the long term, genetic enhancement technologies may have significant effects on the degree of genetic diversity across populations. This might raise the concern that these biotechnologies will change the prevailing moral view of equal standing, especially if the gap between enhanced and unenhanced humans widens considerably—although these innovations could also narrow this divide. Some theorists have accordingly argued that there are important disanalogies between societal inequality and biological inequality that might be evinced through the use of genetic enhancement [10].

However, we should be cautious about this possible moral change. After all, there are a number of significant inequalities between members of the human moral community, but we do not take the persistence of these differences to entail that we ought to alter our understanding of equal moral standing. On the contrary, our strong belief in their equal moral standing can inspire us to attempt to address unjust inequalities, perhaps through regulation or broader social change.

Another question is whether these technologies will accelerate the conversion into another (posthuman) species in the very long term. This is indeed a hypothetically plausible scenario [11]. If this happens, perhaps in the remote future there will be changes to the widespread view that humans occupy the pinnacle of moral status—which could be occupied by some improved descendant of our species. This raises whether an

emergent post-human species with higher capacities should be understood to have a higher moral status that outstrips that of humans, likewise many people believe humans today enjoy a higher moral status than non-human animals.

## **The ethical analysis of future techno-moral changes**

A first analysis strategy is to disentangle the foreseeable factual changes from potential moral changes and forestall their connections (Table 1). Anticipatory approaches need to carefully unravel the complex interaction between empirical assumptions about future facts and ethical arguments when discussing different future-oriented moral transformations. Distinguishing between what is possible and what is desirable can, therefore, facilitate the ethical reflection on biotechnology-induced moral changes.

Secondly, it is necessary to avoid Manichean positions. While bioprogressives praise the use of reprogenetic technologies to overcome some deficits in our present morality, bioconservatives warn of their impact on future morality. Both positions are likely to grow in the coming decades. However, it is difficult to predict whether comprehensive impacts will be for the better or the worse, all things considered. In order to avoid polarisation, it will be useful to assess to what extent these labels can be conducive to a better rational ethical debate in society.

Thirdly, uncertainty is inescapable. Some of these changes may never happen. Others that we have not foreseen may occur. Technical, legal and socioeconomic barriers may hold back these technological developments and derail ethical analyses. For example, genetic enhancement of some complex and behavioural traits may not prove possible. These ethical debates must thus abandon deterministic views on advances in reprogenetic technologies. Moreover, predicting differential impacts on the existing diversity of moral perspectives is difficult: techno-moral changes may not occur equally between countries or within societies. What is important is to recognise that we have the power to influence the processes of moral change by controlling technological uses and their social impacts.

Fortunately, our future is open. So, in addition to reflecting about the ethical use of these biotechnologies, we must move towards public deliberation about the future's most desirable moral changes driven by biotechnologies that we are willing to embrace.

Reprogenetic enhancement is a morally disruptive innovation. Whether this is for better or worse is entirely up to us.

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## **Declaration of interests**

None are declared.

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**Table 1. The morally disruptive future of reprogenetic enhancement technologies**

<b>Domains of techno-moral disruption of reprogenetic technologies</b>	<b>Potential factual changes</b>	<b>Potential moral changes</b>	<b>Key ethical concepts at stake</b>
Disrupting reproductive choice	<ul style="list-style-type: none"> <li>• A decrease in sexual reproduction and an increase in assisted reproduction (also in healthy couples)</li> <li>• More reproductive control</li> <li>• More power to affect the future identity and capabilities of the offspring</li> </ul>	<ul style="list-style-type: none"> <li>• Amplifying reproductive autonomy</li> <li>• Creation of new parental responsibilities</li> <li>• Diffusion of new moral views and norms to guide enhancement procreative decisions</li> <li>• Challenging the morality of sexual reproduction</li> </ul>	<ul style="list-style-type: none"> <li>• Procreative liberty and reproductive autonomy</li> <li>• Parental responsibilities</li> <li>• Reproductive values and procreative principles (e.g., procreative beneficence, procreative altruism or best interest of the child)</li> </ul>
Disrupting justice	<ul style="list-style-type: none"> <li>• From genetic lottery to deliberate selection</li> <li>• Decreasing chance, increasing choice</li> <li>• Promoting different fairness views about possible distributive scenarios for reprogenetic technologies (libertarian model, egalitarian, socioliberal approach, etc.)</li> </ul>	<ul style="list-style-type: none"> <li>• Challenging the moral neutrality of the genetic lottery</li> <li>• Impact on the sense of justice: from misfortune (or bad luck) to injustice</li> <li>• Debating the moral justification of different distributive models</li> </ul>	<ul style="list-style-type: none"> <li>• Sense of justice</li> <li>• Equality of opportunities</li> <li>• Fairness</li> <li>• Genetic inequities</li> <li>• Distributive theories (libertarianism, egalitarianism, etc.)</li> </ul>
Disrupting equal standing	<ul style="list-style-type: none"> <li>• Increasing or decreasing genetic differences between populations</li> <li>• Impacting on genetic diversity and genetic sameness of humanity</li> <li>• More power to influence (post)human evolution</li> <li>• In the very long run, accelerating posthuman speciation</li> </ul>	<ul style="list-style-type: none"> <li>• Rethinking the moral status of genetically enhanced or unenhanced individuals</li> <li>• Rethinking the human genome as a source of equal moral status</li> <li>• Rethinking the moral desirability of continuing the <i>Homo sapiens</i> species</li> <li>• Expanding or contracting the moral circle based on new biological differences</li> </ul>	<ul style="list-style-type: none"> <li>• Equality</li> <li>• Moral status</li> <li>• Duties towards future generations</li> <li>• Posthumanity</li> </ul>