Post genetic revolution dynamics. How will modified and unmodified humans coexist?*

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Abstract

In this article I claim that the genetic revolution, that is, the advent of a series of highly transformative and disruptive genetic technologies, will happen in the coming years. Given the importance of this historical event, I argue that we must think in advance about the socio-ethical dynamics this revolution could entail. To do this, I first explore the ways in which this genetic revolution might unfold, and the socio-ethical problems it will face. Then, I describe possible social dynamics that will appear in a post genetic revolution scenario, using the example of Ecuador, a multiethnic society that had an abrupt social and genetical transformation that could resemble in some ways what the genetic revolution might bring.

Keywords: genetic technologies; bioethics; human enhancement; inequality; collective action problems

Resum. *Dinàmiques posteriors a la revolució genètica. Com coexistiran els humans modificats i els no modificats?*

En aquest article sostinc que la revolució genètica, és a dir, l'adveniment d'una sèrie de tecnologies genètiques altament transformadores i disruptives, tindrà lloc en els pròxims anys. Atesa la importància d'aquest esdeveniment històric, defenso que hem d'anticipar-nos per reflexionar sobre la dinàmica socioètica que podria comportar aquesta revolució. Per fer-ho, primer exploro les formes en què podria desenvolupar-se aquesta revolució genètica i els problemes socioètics als quals s'enfrontarà. A continuació, descric les possibles dinàmiques socials que apareixeran en un escenari posterior a la revolució genètica utilitzant l'exemple de l'Equador, una societat multiètnica que va patir una abrupta transformació social i genètica que podria assemblar-se en alguns aspectes al que la revolució genètica podria comportar.

Paraules clau: tecnologies genètiques; bioètica; millora humana; desigualtat; problemes d'acció col·lectiva

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Summary

1. Introduction

The completion of the Human Genome Project (HGP) in 2003 and the development of CRISPR gene editing technology in 2012 laid the groundwork for the genetic revolution that is underway. CRISPR gene editing is a form of genetic engineering (Boglioli & Magali, 2015) that allows us to alter an organism's DNA (Enriquez, 2017). Gene editing is still considered a developing technology, without the necessary safety and predictability; but this does not mean it will not reach that status in the coming years (Carapeto, 2022: 190). Although legal, ethical and scientific obstacles remain, it is clear that new genetic technologies have the potential to revolutionize many areas of our lives. In healthcare, which predictably will be the area where gene editing elicits more acceptance and where the first applications will be directed, these genetic technologies promise to drastically enhance our ability to predict, prevent and treat disease.

Personal genome sequencing and predictive genetic tests may allow us to prevent many medical risks; genome sequencing would also greatly help in reducing risks regarding reproduction, through preimplantation genetic diagnosis (PGD) and embryo selection. In 2012 CRISPR gene editing technologies became a reality, with the research of Doudna, Charpentier and Zhang and their collaborators. In 2018, in a controversial experiment, the first edited humans were born. Genetic research is advancing each year, making genetic technologies much faster and cheaper than ever. Sequencing a genome in 2003 took billions of dollars and lots of time; today it only costs about US$1000 and takes a few days. Gene editing is still in its infancy, but its potential is great. Even though we must be cautious, these new technologies have the potential to revolutionize medical practice in the near future, and have arguably started to do so. Genomic screening has notably enhanced our ability to predict disease risk and to improve prenatal and postnatal health care (Pathak, 2018). Genetically modified organisms (GMOs) have been making an impact in the food industry for years, and genetic biotechnology could also greatly contribute to eradicating hunger by making food cheaper and more nutritious (Ricroch, 2019), a particularly important prospect in developing countries where poverty is still a major issue.

The genetic revolution carries many promises, but also raises important concerns. One of the greatest fears, and arguably the most plausible problem we face with genetic technologies, is that they could exacerbate current economic and social problems. Genetic technologies would allow the rich and privileged to reinforce their economic and social advantages with genetic ones (Habermas, 2003). For example, wealthier couples could edit their embryos (or select embryos using IVF and preimplantation genetic testing (PGT)) to make sure their future child will have as many intelligence-related genes as possible, giving that child a substantial advantage in several areas, particularly access to jobs. Ethicists have dealt with this problem for a long time now, arguing that genetic enhancement could benefit the least well-off if it were made affordable to everyone. Subsidizing access to this technology could be considered a means of compensation for the unfairness involved in the natural genetic lottery (Harris, 2007; Dunlop & Savulescu, 2014). There is also a growing literature on genetic discrimination in employment and insurance (Joly et al., 2013), and in 2008 the Genetic Information Nondiscrimination Act (GINA) was enacted in the USA, which aims to protect people from genetic discrimination in health insurance and employment. Concrete proposals to address genetic inequality have been developed, for example the creation of a global institute for justice in genetic innovation, as well as the possibility of offering subsidies for genetic counselling and enhancement technology (Buchanan, 2011). In this very issue, Rueda presents a thorough analysis of the global governance of genetic enhancement technologies (Rueda, 2024).

While interesting and valuable, these approaches tend to be too specific and sometimes overlook the complex dynamics genetic differences create and how they result in all sorts of ethical and social problems. At the earlier stages, even just a perceived advantage, not real or significant, might suffice to create problematic social dynamics. For example, an inaccurate belief about the importance of a particular intelligence-related gene might make employers overvalue persons with that gene. Understanding how the genetic revolution might occur and what social dynamics, particularly inequality dynamics, will develop, is therefore an urgent priority. Even if some of the genetic technologies never become a reality, it is likely that at least some of them will become viable (Bognar, 2012: 14). Therefore, these issues must be tackled in advance, even if all these questions rely heavily on empirical and probabilistic developments.

1.1. Some initial caveats

There are a number of important issues related to the topic of this article that have been extensively analyzed and that will not be the subject of this work. The therapy-enhancement distinction (Roberts, 2014) is a well-known topic that I will leave aside. I believe the line between treatment and enhancement will only become more blurred as genetic technologies improve and become widely adopted (Alonso, Anomaly & Savulescu, 2020). As Carapeto explains, medicine is always expanding and now includes “preventive medicine, palliative care, sports medicine, contraceptive procedures, and fertility procedures”, showing how “the concept of treatment is constantly expanding, as medicine is highly elastic”

(Carapeto, 2022: 192). Reflections on what can be considered enhancement or whether enhancing humans makes them better in an absolute sense (Daniels, 2000; López Frías, 2014) will also be left aside. I will remain neutral on this, limiting myself as much as possible to talking about genetic technologies, without other designations. I will touch on several objections raised against genetic technologies, particularly the inequality problem. But none of these objections, criticisms and problems – and their corresponding responses – are, strictly speaking, the topic of this article. I will only discuss some of these matters to show how the genetic revolution will predictably unfold, and what scenario we might end up in when genetic technologies become widespread.

In this regard, the decision to talk about "modified" and "unmodified" humans might seem problematic, a variation of the therapy-enhancement distinction just mentioned. In a basic sense, it is. Every organism we know of has been "modified" in one way or another. Genetic modification is the norm of evolution; and even in the period of a lifespan, all organisms experience modifications, even at a genetic level, due to environmental factors (Charlesworth & Charlesworth, 2017).[1] Distinguishing between "modified" and "unmodified" organisms might seem futile, as shown in the case of sheep genetically edited to inhibit the myostatin gene, so making them indiscernible to Texel-variety sheep, which developed this inhibition through breeding techniques (Carey, 2019: 58-59). The same would probably happen with "modified" and "unmodified" humans. As we will see, this is part of the discussion: in a distant future, the distinction between "modified" and "unmodified" is likely to fade away. However, especially when gene editing technologies are first offered and only part of the population start using them, the distinction between "modified" and "unmodified" will likely be operative, despite being problematic. This article aims to answer the question of how we would arrive at that point, and what social dynamics might come about. To this effect, I will rely on the ongoing discussions on gene editing of recent decades; but also, on some historic cases which, despite being incommensurable with the genetic revolution, can shed some light on certain aspects of the foreseeable social dynamics this revolution will lead to.

In keeping with the spirit of the present issue of *Enrahonar*, this article assumes the premise that the ethics of gene editing should always go beyond the individual level to consider the social and political implications of technology. Indeed, since the first advances in the scientific knowledge of genes were made, the social impact of this knowledge and associated technologies has been a prominent theme of discussion. Even though proponents of gene editing avoid this word, the connection with the eugenics movement is too obvious to dodge (Buchanan et al., 2000: 345). The crucial difference between the eugenics movement of the 19th century/beginning of the 20th century and the genetic

1. As one reviewer notes, a relevant difference is that using genetic technologies will be intentional. While I agree, my point here is simply to acknowledge that even the "modified"/"unmodified" distinction could be questioned in a basic sense.

enhancement movement of today is the latter's stress on reproductive freedom (Rodríguez López, 2024). Instead of enforcing certain reproductive policies, today's defense of gene editing favors freedom of choice within a liberal framework (Agar, 1998). This is not to say that genetic enhancement in its present form is ethically unproblematic. Far from it. As Buchanan and colleagues explain, "reproductive freedom […] could be threatened not by the state but by a variety of other agents, ranging from social pressure to the actions of insurers" (Buchanan et al., 2000: 322). But at least it seems that we can prudently put away our worse fears regarding eugenics, or at least leave them in the background of our reflections.

As Anomaly notes in *Creating Future People: The Ethics of Genetic Enhancement*, "The ability to radically reshape populations through genetic enhancement is likely to influence our political institutions, opportunities and lives" (2020: 71). As Buchanan, Brock, Daniels and Wikler argue in their seminal work *From Chance to Choice: Genetics and Justice*:

> The social perspective on genetics will inevitably be revisited as the revolution in genetic science and medicine progresses. As genetics permeates our lives, as more and more people come into contact with genetic screening, testing, and, eventually, intervention, we cannot fail to appreciate the fact that these individual encounters have effects on others. (2000: 304-305)

These works, among others in the last few years, emphasize the moral and social implications of genetic interventions. Both works, as may others on this topic, implicitly and explicitly assume that a genetic revolution will happen in the near future, or that it is already on its way. Building on the growing literature on genetic enhancement and its social implications, I would like to explore plausible scenarios for the genetic revolution, its social dynamics, and how to prepare for them. As initially stated, this is a somewhat speculative approach. To reduce the uncertainty of this approach, I will draw on the genetic enhancement literature, on the tendencies shown by the present situation, and on some historical precedents we might use to predict the shape of our human future in the next decades.

2. Why we should assume the genetic revolution will happen

Genetic technologies such as CRISPR and PRIME editing technologies, genome sequencing and predictive genetic tests, particularly in their reproductive applications, will greatly impact individuals and societies. Even closer and more feasible, embryo selection using polygenic scores will start shaping populations in the next few years. As these technologies become more affordable and safer – as tends to happen with technologies (Carapeto, 2022: 193; Bognar, 2012: 29) – their use will only increase over time.

Even if there is reluctance at first, the safe and profitable use of a technology usually derives from its widespread use. Regarding gene editing, the dark past of eugenics might make it harder than usual for genetic technologies. However, the climate of opinion today does not seem as unfavorable as it was some decades ago (Buchanan et al., 2000: 322). For example, opposition to GMO-derived food is fading as its production and consumption spreads (Anomaly, 2020: 89). Cultural differences may also be relevant. In some places such as Singapore and Malaysia (Chee Khoon & Heng-Leng, 1984) or China (Renzong & Dikotter, 1999) eugenics does not have most of the negative connotations associated with it in the west. For some communities like the Jewish community, where genetic diseases such as Tay-Sachs are prevalent, genetic interventions tend to have much more acceptance (Buchanan et al., 2000: 305; Glad, 2011).

An even more relevant argument states that genetic technologies do not involve a radically different form of intervention. For example, for decades women have been selecting sperm in fertility clinics (Gignac & Starbuck, 2019). Through different sources we have access to dating patterns of both women and men, who routinely select certain traits in their partners (Gignac & Starbuck, 2019). This shows conscious and deliberate selection has been present for some time now. If genetic medical technologies become safe, refraining from using them could start to be seen as the irresponsible conduct of lazy parents (Anomaly, 2020: 52). The only notable difference from older medical and reproductive interventions is the speed with which genetic technologies might allow for some changes to take place (Anomaly, 2020: 52-53).

One last reason to believe genetic technologies will eventually spread and be accepted is the difficulty or even impossibility of banning these technologies. The main reason for this lies in the globalized world in which we live, where travelling is generally easy, a context in which medical tourism is an ordinary occurrence (Singer, 2009). Despite proposals to implement international treaties regarding genetic technologies (Annas et al., 2002; Nuffield Council on Bioethics, 2018), their applicability is expected to be minimal, among other reasons because it would be very difficult to identify who had or had not employed these services.[2] Moreover, some authors have argued that banning gene editing would only serve to reinforce natural inequality (Carapeto, 2022: 197), and even cause a double injustice, "the first genetic, the second regulatory, both of which prevent me from pursuing a desired life plan" (Cohen, 2014: 660). A related argument has to do with the emergence of black markets: in cases where there is strong demand for a product, strict regulation might only serve to benefit those able to bypass those regulations through their power and money (Anomaly, 2020: 49).

All in all, it is reasonable to assume that genetic technologies will appear and spread, and that a genetic revolution will soon arrive. As Anomaly puts

2. In this vein, as one reviewer points out, in the case of embryo selection, the criterion for selecting one embryo instead of another could never be known, if prospective parents wanted to keep that information to themselves. If legislation stated that you are not allowed to select for sex, or IQ, or some other trait, prospective parents could always argue that they selected for any other reason, or that they simply randomized the selection.

it, "assuming political stability can be maintained in at least a few productive countries, we have reason to believe technology will continue to advance, enabling genetic enhancements" (Anomaly, 2020: 70). As other authors argue, genetic technologies could even be indispensable for the continued survival of human beings (Powell, 2015).

3. How the genetic revolution might unfold

The dystopian projection, notably entwined with the totalitarian eugenics of the past, paints a bleak picture of uniformity and homogenization. From this point of view, genetic technologies will produce populations of quasi-clones with blue eyes and blond hair. This scenario is not impossible, but the liberal framework of today makes it considerably less likely. Nonetheless, Gyngell argues, genetic diversity, or at least the range of phenotypes that are explored, may be reduced by the implantation of genetic technologies (Gyngell, 2012: 10). This is a legitimate concern, although not a necessary outcome, as this author states. In fact, both regulation and ordinary societal necessities should avoid this type of outcome.

As Powell (2010) points out, people do not share a unique and common conception of the "good", and therefore children will be selected according to different criteria. As Savulescu argues, following a classical Millian insight about the importance of "experiments in living", genetic technologies would allow parents to conduct "experiments in reproduction" (Savulescu, 2006). This is already the case with traditional forms of enhancement such as education. Parents choose different forms of education, promoting the characteristics that they value (Gyngell & Easteal, 2015: 68), creating different skills in their respective children. However, as Gyngell observes, at least for some traits such as a good immune system, "we may expect very little diversity" (2012: 14), so we should not completely dismiss this worry regarding uniformity.

Even if reproductive freedom should generate a pathway to the genetic revolution like the above depicted, we should not dismiss the appearance of coercive or pressuring dynamics, even within the liberal framework of modern Western societies. As Buchanan and colleagues point out, lifting the genetic veil of ignorance (Buchanan et al., 2000: 326) could create a hostile environment. Particularly, the state, health insurers and employers would presumably be interested in reducing costs of genetically identifiable health care needs (idem: 323). This could take the soft form of providing genetic information and generating a climate of opinion favorable to genetic care (idem: 336). But it could also take the form of states limiting parents' reproductive rights to preserve public goods or prevent harms to other (Brock, 2005). Pressuring dynamics could also take the shape of decision architectures and nudges (Thaler & Sunstein, 2017) that favor (or deter) genetic intervention, including subsidies – indeed many authors have adhered to a proposal for subsidies as a key aspect of the implementation of gene editing technologies (see Buchanan et al., 2000: 325; Loftis, 2005; Allhoff, 2005). Finally, it could also take the form of coercive methods in which governmental agents, health insurers or employers could coerce or even force individuals to engage in genetic interventions.

In any case, I believe the genetic revolution, or more simply, the implementation of genetic technologies, will be a long, complex and nuanced process. Most plausibly, the use and acceptance of genetic technologies will be gradual and not massive. As different authors argue, intelligence – or general cognitive ability – will be the most desired and sought after trait, as it predicts "educational outcomes, occupational outcomes, and health outcomes better than any other trait" (Plomin & Stumm, 2018: 148); as well as social cooperation (Jones, 2016) and low propensity for crime (Beaver et al., 2013).

Intelligence, however, is not a simple trait, but one that involves complex networks of genes and gene-environment interactions – as occurs with most relevant and pursued characteristics. For that reason, monogenic diseases will be the first targets of genetic technologies. However, polygenic traits (traits that involve more than one single gene) will also eventually be targeted as our knowledge of genomics improves. Anomaly even predicts that, as the science and technologies move forward, attitudes will evolve and "parents will be expected to use IVF and PGT" (Anomaly, 2020: 89). I generally agree with this prediction, although I would like to emphasize the complexity and gradual nature of this process. Still today we know relatively little about polygenic traits, and particularly we still struggle with the pleiotropy phenomenon; that is, the manifold effects of genes, where an IQ improvement, for example, might end up impairing the immune system, or undermining some other desired attribute (Karlsson & Lindblad-Toh, 2008). As Carapeto comments, it is very difficult to talk about genetically superior or genetically deficient characteristics in an absolute sense (2022: 198). However, preliminary evidence suggests that pleiotropy tends to be good, not bad (Widen et al., 2022); bringing more unanticipated benefits than unanticipated disadvantages.[3] In any case, these difficulties, however, do not imply genetic technologies will not appear and be used; it only means their implementation and social implications will be complex and in many cases ambiguous. I will develop this point in section 5.

4. Socio-ethical problems of the genetic revolution

A reflection on the social dynamics of genetic technologies cannot ignore the various ethical problems that the genetic revolution is likely to bring with it. In particular, the central problem of inequality must be addressed (Temkin, 1993). Nevertheless, as stated earlier, in this article I do not intend to dwell on this lengthy discussion, but rather to point to certain ideas insofar as they indicate some of the possible developments and social dynamics derived from the genetic revolution.

3. I thank a reviewer for suggesting this idea.

A first and basic idea is that inequality has always existed and will likely persist in the foreseeable future. This is not to say we should not fight it, but acknowledging its existence is necessary. A second acknowledgement is that, regarding genetics, inequality is an unavoidable starting point. Thirdly and most importantly, genetic technologies need not be promotors of inequality, as they are usually charged with being, but could be a "counterbalancing mechanism with respect to some inequalities" (Carapeto, 2022: 198). In a more fundamental way, one could even contest that inequality is, *per se*, a bad thing (Anomaly, 2020: 36-37), and that some form of inequality might even be required for the functioning of society.

With respect to genetic technologies, what will probably happen is that after an initial period when only the wealthy have access to these technologies (with the possible benefits, but also the costs – economic and health-related – they will entail), the genetic revolution will spread out in a second wave which will probably foster equality in a way never witnessed before in history. One of the main reasonings that support this is what Buchanan calls the network effects of genetic enhancement (Buchanan, 2008), and Anomaly conceptualizes as positive externalities of these technologies for the unenhanced (2020: 46). For example, improving the intelligence of a few individuals could very possibly benefit the rest, if they conduct novel science, create new technologies or design innovative policies. This is, in essence, the logic Rawls exposes in *A Theory of Justice* (1971), in which he argues that it is not in general to the advantage of the less fortunate to reduce the talents of others. On the contrary, greater abilities can be seen as a social asset for the common good (Rawls, 1999: 92).

Also, the presumption that genetic technologies will come in waves, and that their access and utilization will spread, does not seem unwarranted. Other technologies such as the printing press, computers, the internet and smartphones have followed this trend. In this regard, I believe we should not overplay the fact that genetic technologies affect our organism. Other technologies have also greatly affected our bodies and genomic composition; and, in any case, we should not think of genetic technologies as a magic wand. The implementation and the safe and profitable use of genetic technologies will be a complex process, with ups and downs, that will not automatically create a superhuman species. Some, such as Bognar, do not agree with this position and consider it too optimistic (Bognar, 2012: 21). Bognar considers that the health gap between the better-off and the worse-off is now very big, and that genetic technologies will widen it (idem: 12). Even though some statistics prove this health inequality is real and concerning, the emergence of genetic technologies is not certain to have the negative effect anticipated by Bognar; and, more importantly, banning or restricting these technologies, as argued before, does not seem to be a viable solution, since it will only increase unjust inequalities by preventing the poor from accessing them while allowing the rich to access these technologies through travel and black markets.

4.1. Inequality problems

There are two concerns regarding genetic inequality: inequalities relating to access to genetic technologies; and inequalities in the outcomes produced by these technologies (Farrelly, 2004; Rothstein, 2007). These two forms of inequality, however, could become mutually reinforcing, if some genetic modifications end up being the prerequisite for access to other genetic modifications.

More specifically, the literature on the socio-ethical problems of genetic technologies has been concerned with two major problems: the creation of a so-called genetic ghetto, or genetic apartheid (Carapeto, 2022: 189); and the perceived threat to people with disabilities (Buchanan et al., 2000: 325-326). Buchanan and coauthors analyze these inequality concerns extensively in *From Chance to Choice: Genetics and Justice*. To summarize their argument, these concerns are articulated in various forms. For example, a basic concern is the worry that genetic technologies are fundamentally exclusionary, as they seek to eradicate disabilities and, following this line of objection, individuals with those disabilities (idem: 262). In this vein, the "loss of support argument" contends that as the population with some disability or disease diminishes, the help they get will also diminish. Another complaint of the same type is the "expressivist objection", that is, the claim that "decisions to intervene express negative judgments about people with disabilities" (idem: 272), even to the point of implying the idea that people with disabilities ought not to exist.

Lastly, the so-called "deaf culture argument" claims that conditions such as deafness are not a disability but a particular culture, with limitations but also opportunities, and thus condemns efforts to eliminate deafness and other perceived-as-disabilities (idem: 281). These inequality-based objections have been convincingly answered (idem). For the purpose of this article, what matters is how these lines of reasoning might create certain social dynamics.

4.2. Collective action problems

Other concerns regarding the social implications of genetic technologies revolve around collective action problems, most notably the problem of positional goods. As before, I will only delineate these ideas in order to prepare the subsequent discussion on the social dynamics of the genetic revolution.

Persson and Savulescu in *Unfit for the future* (2012) and more recently Anomaly in *Creating Future People* (2020) have stressed the importance of addressing the collective action problems of genetic technologies. Following Parfit's conceptualization in *Reasons and Persons* (1984), Anomaly defines this category of collective actions are 'each-we' dilemmas; that is, dilemmas in which each of us pursuing our own goals produces an aggregate outcome that is bad for all of us (Anomaly, 2020: xii). The main idea, as Diéguez puts it, is that "the sum of enhanced individuals [does not necessarily] lead to a better society" (2017: 156). A clear example of this is immuno-enhancement, which could "create immuno-monocultures that make it easier for mutated microbes to decimate populations" (Anomaly, 2020: 57). A very interesting – and troubling – case would be the plausible advantage of editing children or ourselves to be less cooperative than the average, especially if cooperativeness is notably enhanced through genetic technologies (Anomaly, 2020: 26). A simpler problem would be enhanced longevity, which could increase population to a point of making resources radically scarce (Bognar, 2012: 20).

However, the main collective action problem discussed in the literature is the "positional goods" problem. Absolute goods are beneficial even if everyone has them. Positional goods, on the contrary, only benefit the holder if other people do not have them (Carapeto, 2022: 193). One often-invoked example is height: being taller than average is usually beneficial in many respects, particularly in dating (Ellis, 1992; Courtiol et al., 2010). However, if everyone chooses to enhance their height, we will engage in an arms race that would harm all of us, as the benefits of being taller than others disappear in such a context and the human body functions deficiently when it surpasses a certain height threshold. Even if Carapeto is right and "the fate of most positional goods is to become absolute goods" (2022: 194), this is an important tendency that could model the genetic revolution.

To conclude this section, I will simply state that the previous problems are a real concern and should be considered in advance. However, none of them seems inescapable, and a mix of regulation and social learning should overcome most of them. The key point for this article is that many of the problems described could be central for the social dynamics of the post genetic revolution scenario I would like to analyze and comment on in the following section.

5. Modified-unmodified dynamics

5.1. Long-term scenarios

I will briefly consider long-term scenarios resulting from the genetic revolution. I believe projecting the far future is too difficult, as there are too many factors to be taken into account in order to make a minimally accurate and interesting prediction. However, I think three major possibilities can be identified: speciation, normalization, and extinction of the human species.

Speciation, the differentiation of a species into two or more species, is the result some authors foresee (Carbonell, 2023; Anomaly, 2020). This could happen due to differences becoming too large for modified and unmodified humans to live together productively and maintain a comparable moral status. Genetically modified humans could even start being considered transhumans (Brenner, 2013). Normalization, on the contrary, would entail that genetic and enhancing technologies will become so pervasive that they become the new *status quo*. Humanity will continue, drastically changed but also reinterpreted. Another scenario could be human extinction, a not-so-improbable outcome, as Gyngell argues (2012). The power of genetic technologies means that human eradication is not out of the question. I would cautiously argue that normalization is the most plausible scenario; but as I started by saying, these long-term projections seem overly difficult and minimally useful, so I will not dwell on any of them.

5.2. Short-term and medium-term scenarios

I believe it is better and more useful to focus on an earlier moment, when genetic technologies start to be introduced and their use becomes more widespread. Giving a concrete number of years for this scenario is very tricky, but so as not to be completely elusive, I will clarify that I foresee that this scenario will start appearing no sooner than ten years from the present (2033), and no later than 30 years (2053). This post genetic revolution scenario could show several different social dynamics, depending on several factors. Key questions will be: how genetically modified individuals understand themselves; how genetically unmodified individuals understand themselves; how each group (modified-unmodified) understands itself and the other; whether one, both or neither of the groups has a strong identity; whether each group (modified-unmodified) remains homogeneous or splits into several subgroups; what percentage of the total population would comprise the modified part, especially at an early stage; how quickly the modified minority would start becoming a majority, if such thing ever happens; how would the modified and unmodified differentiate between themselves, particularly if differences are not obvious at first sight, and so on. Things, however, could work out very differently. As argued in another article of this issue, we could witness the conformation of a global human community based on the principles of cosmopolitanism (Rodríguez-Alcázar and Bermejo-Luque, 2024).

The problem with all these questions is that they are highly speculative. However, I believe that they must be addressed in advance, since one of the expected characteristics of the genetic revolution, and a decisive one, is that changes could come rapidly and abruptly, and we might not have enough time to react adequately. To alleviate the shortcomings of this speculative approach somewhat, I would like to lean on an historical case that has some interesting and surprising resemblances with the expected genetic revolution. This is the case of the American indigenous populations of central and south America which, in around the 16th century, abruptly started receiving a genetically diverse input from Europe, primarily from the Spanish monarchy. To be more specific, I will use the example of Ecuador, even though many other American countries formerly under the Spanish Empire's dominion would also be worthy of analysis for the same reasons. The identity issues and social dynamics experienced by Ecuador for decades will be a suitable example of what the genetic revolution could cause. Some points stand out in this comparison.

5.2.1. Modified-unmodified hierarchical relationships

It can be expected, as some authors have predicted (Fukuyama, 2002), that genetically modified individuals will believe themselves to be superior, or at least radically different, to unmodified individuals. In a concurrent movement, the unmodified could develop an inferiority complex. Despite the more than probable tendency for "geneticism" (Thoday, 1965), the belief that genes are solely responsible for our traits, one key point that should be emphasized is that, in many cases the problem will not lie "in our genes, but in their interpretation on a social level" (Buchanan et al., 2000: 332). At the earlier stages, genetic modifications might not even entail clear and significant advantages, just perceived advantages. This is, in a way, the case of the Ecuadorian population (Poloni Simard, 2006; Stolcke & Coello, 2008). *Mestizos*, the descendants of Spanish-Indigenous progenitors (and therefore the, comparatively speaking, genetically modified population), constitute the majority of Ecuador's population (60%). Even though it is clear that *mestizos* are not genetically superior, this majority has historically subjugated the minority of Indigenous Amer-Indians (30%) and Afro-Ecuadorians (8%). Up until the 1970s, indigenous persons were denied access to certain places such as cities' main squares (Huarcaya, 2014). Until 1995, indigenous women were unable to participate in beauty contests (Moreno Parra, 2007). Even later, this discrimination against indigenous women continued under the requisite of being 1.7m tall. This kind of covert bigotry is also the type of discrimination the genetic revolution could generate. However, we can also take Ecuador as an example of how this discrimination can be tackled, as the development of indigenous rights of recent decades shows. The regulations and policies developed in Ecuador (Guzman, 2018) could be taken as an example for future policies and regulations on genetic inequalities.

5.2.2. Struggle for identification

One crucial point is that *mestizos* are not genetically superior, only different. Even more interestingly, *mestizos* are different in an ambiguous and problematic way: *mestizos* are always unsure how European – usually associated with white skin color – and how indigenous they are; what percentage of "white" and "indigenous blood" runs through their veins. In Ecuador this situation resulted in the different ways in which the *mestizo* population tried to whiten itself, be it through external appearance, like cutting their typical indigenous braid; or by the display of certain practices, like refusing to speak *kichwa*, the indigenous pre-Columbian language. These dynamics could be exacerbated in the case of genetically modified individuals, who could experience major identity crises regarding their self-understanding, their relatedness to unmodified individuals, and how this relatedness should or should not inform their relationships towards them. The "expressivist problem" we saw earlier could become a very real issue. As Buchanan and colleagues argue, even if individuals themselves do not see themselves as primarily modified-unmodified, and even if this attribute is not a key aspect of their self-perception and personal identity, interactions and external pressure might force them to put this characteristic at the forefront of their identity. (Buchanan et al., 2000: 329)

5.2.3. Inclusive-exclusion dynamics

During the early decades of Ecuadorian history, *mestizos* constructed a peculiar narrative of inclusive-exclusion in which they tried to negate indigenism by affirming miscegenation as the only Ecuadorian reality. All Ecuadorian citizens were automatically considered *mestizos*, regardless of their ethnicity, provenance or practices. Some authors have argued that this was a deliberate effort to whiten the population and therefore gradually obliterate the indigenous lineage (Roitman, 2009). In any case, what this movement undoubtedly concealed was a differentiation among *mestizos*: even though everyone fell under the *mestizo* category, some were considered "true *mestizos*" (basically white) and others were considered "false *mestizos*" (basically indigenous). A post genetic revolution society could also develop covertly discriminatory movements of this kind. Maybe, a movement of normalization such as the one described in the previous section, in which genetic technologies and genetically modified humans are argued to be the *status quo*, might disguise problematic social dynamics such as the ones that took place in Ecuador.

5.2.4. Identity movements

In response to the movement of *mestizo* affirmation described in the previous subsection, a strong indigenous movement has developed in recent decades. Today being an *Indio*, formerly a disgraceful condition, has become a source of pride. One point that could be raised in this regard is that these minority affirmative actions could also be a strategy to maintain unacceptable inequalities. As is sometimes the case with indigenous movements in Ecuador, the genetically modified majority could allow or even promote these kinds of movements as a way to dissimulate poverty and inferior well-being, arguing that these characteristics, identified and combined with a certain belief in genetic purity, are respectable and should be preserved – a reasoning strongly resembling the "deaf culture argument" mentioned before. Another related possible social dynamic is that a post genetic revolution society might also promote some type of arms race, genetically editing itself as much as possible only to further differentiate itself from others, even in the absence of any objective reasons for doing so. A different and troubling problem, in this regard, could be the concealment of certain inequalities. Gender inequality is still a major issue in Ecuador. One characteristic that paradoxically harmed feminist movements in Ecuador was that the Indigenous movements overshadowed feminist movements (Lavinas, 2014). This could also be a problem of the post genetic revolution society, where some inequality problems might be overshadowed by other more visible discussions.

5.2.5. Inequality of access to employment, healthcare and education

A crucial social dynamic that took place in Ecuador was the process by which the *mestizo* population slowly and covertly established a differentiated access to jobs, healthcare and education, in which indigenous people were left with the worse opportunities (Post, 2011). This kind of discrimination could become a major issue in a post genetic revolution society, in which unmodified people could see themselves unable to access public institutions due to their (real or perceived) comparatively lower intelligence and general capacities. As Buchanan and colleagues put it, "unequal access to enhancement technology would function to exclude them from the dominant cooperative scheme" (2000: 297). In the case of genetic technologies, additional aspects should be considered. Collective action problems such as the ones described earlier, and particularly the "positional goods" problem, will surely inform this dynamic of access to jobs, healthcare and education. Also, modified humans could be seen as cheats who prefer the easy way to success (Carapeto, 2022: 197). However, the unmodified could also be labeled as irresponsible or lazy, in the same way as we tend to see people who today refrain from engaging in cognitive enhancements such as education (Carapeto, 2022: 190). As I noted earlier, if genetic technologies create a significant advantage regarding employability and participation in social life, even more efforts should be devoted to anticipating and ameliorating this key issue, particularly through subsidies. However, we cannot disregard the possibility that, on the contrary, genetic technologies could, through regulation, help the genetically disadvantaged (Buchanan et al., 2000: 303; Savulescu, 2009) – for example, by allowing the use of genetic enhancements only insofar as we experience some sort of genetic disability compared to a certain genetic standard (Carapeto, 2022: 197). Nonetheless, defining this "regular genetic standard" might prove very complicated (Farrelly, 2004). At any rate, if the distinction between modified and unmodified persists and grows; if the gap in ability and capabilities between the modified and unmodified becomes too big; and especially if cooperating and coordinating becomes too burdensome (Gyngell & Easteal, 2015), the problem might become unsolvable and, as Anomaly argues, actual separation into two communities could be the only solution (Anomaly, 2020: 86).

6. Conclusions

The genetic revolution is on its way, and its first results may begin to be seen in the next few years. Although it is impossible to predict the future, it is appropriate and advisable to try to anticipate certain developments. This is the only way to avoid being caught unprepared and to sidestep the most dreadful consequences.

In this article I have argued that the genetic revolution – i.e., the advent of a series of highly transformative and disruptive genetic technologies – is something that is taking place and will take hold in the coming decades (1&2).

After showing why I maintain this position, I have pointed to the paths that are likely to lead to this genetic revolution (3). I have then briefly considered the main ethical and social problems that the implementation of genetic technologies will bring with it, most notably the problems related to inequalities and collective action problems (4). Finally, taking Ecuador as an example of a multiethnic society, I have described possible social dynamics that will appear in a post genetic revolution scenario (5).

Although some of the details are speculative, I consider it useful to have a relatively clear picture of the possible developments of the genetic revolution and their social implications. The reference to the historical example of Ecuador, with its obvious limitations, also seems to be a significant and original contribution to the debate. Faced with such an important and decisive problem as the ethical and social consequences of the genetic revolution, any help in thinking about and clarifying the different aspects of the conundrum should be welcomed.

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