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Transhumanist Genetic Enhancement: Creation of a ‘New Man’ through Technological Innovation I

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Abstract

The transhumanist project of reshaping human beings by promoting their improvement through technological innovations has a broad agenda. This study focuses on the enhancement of the human organism through genetic modification techniques. Transhumanism values and a discussion of their philosophical background provide a framework to understand its ideals. Genetics and ethics are employed to assess the claims of the transhumanist program of human enhancement. A succinct description of central concepts in genetics and an explanation of current techniques to edit the human genome serve to assess the capabilities and limitations of editing techniques. Potential benefits and liabilities of human enhancement through genome editing are discussed to appraise its feasibility. Ethical considerations of genome editing inform a reflection on the implications of introducing heritable changes in the genome of individuals. It is concluded that the transhumanist program is underpinned by a large number of hypotheses rather than by sufficient evidence.

Introduction: characteristics of transhumanism

Transhumanism is ‘a new paradigm for thinking about humankind’s future’ (Bostrom 1999). It is proposed as a philosophy and a movement with a scientific agenda to overcome human limitations and weaknesses by means of technological innovation (Bostrom 2005a). ‘Transhumanism is a class of philosophies of life that seek the continuation and acceleration of the evolution of intelligent life beyond its current human form and human limitations by means of science and technology, guided by life-promoting principles and values’ (More, 1990). Its principles and goals are found in various Transhumanist Declarations of the World Transhumanist Association (1998, 2002), Humanity+ (2013), and London Futurists (2013).
Transhumanism ideals echo the ancient desire to improve the human condition. The aim of the transhumanist program is to reshape human beings through the improvement of their capabilities in the context of the notion of happiness proposed by the English utilitarian John Stuart Mill (Bostrom 2005a), by means of evolving current technologies and developing new ones. Consequently, transhumanists advocate investing in research on technologies that will better cognition, achieve anti-aging, provide choice for reproductive technologies, etc. They claim that taking a ‘fact-driven, scientific, problem-solving approach’ to the big questions of the structure of the world and the role and future of intelligent life in it, will not divert their attention of from ‘present-day scientific, technological or social developments’ (Rifkin 1983). Transhumanists regard themselves as a body of persons who strive ‘to decrease ignorance and make humankind as a whole more rational’ (Bostrom 1999). ‘No principle is beyond doubt, not the necessity of death, not our confinement to the finite resources of planet Earth, not even transhumanism itself is held to be too good for constant critical reassessment’ (Bostrom 1999).

The landscape of possible interventions is vast, e.g. super-intelligent machines, recalibration of pleasure centres that would establish life-long emotional well-being, medication to remediate and enhance personality, space colonisation, molecular nanotechnology, extended life spans, uploading our consciousness into virtual reality, and more. Such a universal program covers most aspects of the life of individuals and society, so it is challenging to give a systematic appraisal of transhumanism (Pellissier 2015). This task is all the more difficult because the views of transhumanists are under constant revision and development, and there is little consensus about goals or how to achieve them. Transhumanists do not rule out specific restrictions on emerging technologies so as to lessen the prospect of existential risks. A solution proposed is the control of differential technological development, a series of attempts to influence the sequence in which technologies are developed. In this approach, planners would strive to retard the development of potentially
harmful technologies and their applications, while accelerating the development of beneficial
technologies, especially those that offer protection against the damaging effects of others
(Bostrom 2003). A common transhumanist position is a pragmatic one where society takes
deliberate action to ensure the early arrival of the benefits of safe, clean, alternative technology,
rather than fostering what it considers to be anti-scientific views and technophobia that hinder
development. However, it has not been explained how this social control will be made
compatible with the entrepreneurial-spirit and respect for autonomy and individual choice that
are basic transhumanist values.

It has been objected against the transhumanist program that the accelerating trend in
modernisation in which technology is used to transform the ‘natural’ into the ‘artefactual’,
could lead to the manufacturing and enslavement of ‘monsters’ such as human clones, human-
animal chimeras, or bioroids (genetically engineered humanoid-like organism created by
artificial means); but even lesser dislocations of humans and non-humans from social and
ecological systems are considered problematic (Lee 1999). Transhumanist personhood
theorists argue that, provided they are self-aware, human clones, human-animal chimeras and
uplifted animals would all be unique persons deserving of respect, dignity, rights,
responsibilities, and citizenship (Evans 2015).

This work appraises the transhumanist theme of ‘enhancing the human condition and
the human organism’ (Bostrom 2005b). This approach confines the work to a reasonable scope
that includes ‘radical extension of human health-span, eradication of disease, elimination of
unnecessary suffering, and augmentation of human intellectual, physical, and emotional
capacities’ (Bostrom 2005b) in all of which genetic enhancement plays a central role.

The review is structured in four sections. Transhumanist thought is based on a specific
way of perceiving human beings; thus, together with the Introduction, the first section concisely
explains its ideals and proposals, provides an overview of the cultural context where
transhumanism emerged, and indicates its various connections to contemporary currents in anthropology.

The alteration of the human species promised by transhumanism relies on the ability to modify the human genome for “enhancing the human condition and the human organism” (Bostrom 2005b). To appraise some transhumanist views, the second section of the study includes a precis of present-day understanding of human genetics, tools to modify the human genome, and fundamental scientific and technical problems of enhancing human beings through manipulation of their genome.

Attempts to enhance the human condition by genome editing have raised a large number of ethical issues, many of which are currently under discussion. The third section of the study addresses ethical concerns voiced against types of human genetic enhancement promoted by transhumanism, and highlights relations of transhumanism with eugenics. Disquiet with ethical issues spans a wide range of ideas at the individual, social and entire humanity levels; hence, the exposition in this study is necessarily limited to only a few of these issues. The final section of the study offers a brief discussion on philosophical, scientific and ethical implications of transhumanism.

**Anthropological considerations**

Proposals for the transhumanist program appeared in the last decades of the 20th Century coinciding with a shift from modernity to postmodernity. An overview of how human beings are understood in Modernism will serve to place in perspective the transhumanist agenda of enhancing human persons. A summary of discussions around several transhumanist anthropological and social arguments will complete the exposition of the cultural debate about this program.

**The cultural context**
In history and philosophy, modernity refers to a way of thinking about the world that originated in Europe during the 16th Century. Through the centuries it evolved in various directions, but the basic cosmological, anthropological and ethical principles of the different currents of thought remained common (Bristow 2017).

The beginning of Modernism is Rationalism. The latter holds a criterion of truth based on the act of the human reason rather than on the reality of the world to be known: reason is the measure of reality and is different from the world (Dea et al. 2017). A consequence of this segregation is an understanding of the human person in whom reason has greater importance than the will and affectivity, and a separation in the structure of the person between corporeality and mind or spirit. It is an anthropological dualism in which the body is a part of the world different from myself, and it is real when being thought by my “I”. The body is not the person, but rather possessed and available to be acted by the person.

Nature is reduced to its physical and biological dimensions and becomes a limitation that human beings must overcome to achieve true freedom. This change in attitude regards nature as something that should be modified or altered through instrumental reason, including the corporeal elements of human beings themselves (Bristow 2017). Empirical rationality is not capable of absolute verification of ethical questions and reduces ethics to an instrument for weighing and calculating consequences that determine the morality of human actions: the correctness of personal actions is given by their usefulness, which in turn is decided by the will of the person (Pastor and Garcia 2014).

Roots and theoretical bases of transhumanist ideas

An interesting ethical precept in transhumanism is the moral obligation to proceed to an advanced state of humanity. This arises from the urgency of avoiding human suffering, in particular disease and death, and the complicity of a society that does not use every resource available to eradicate aging and mortality (Harris 2007), and that causes serious damage to
nature in the Anthropocene. Thus, the ‘human body becomes the transhumanist target of
innovation as a result of its unacceptable vulnerability to injury and death’ (Hall 2017).

Human enhancement means, in general terms, the augmentation of human traits. This
broad definition encompasses everything from ordinary activities such as learning to highly
specialised biomedical procedures such as genome editing. A transhumanist definition of
human enhancement is the practice of adding to, protecting, or maximising capabilities by way
of technological interventions on the body. Various aspects of life could be improved through
medicine, science and technology to the extent that the resulting beings may not be
recognisably human (Agar 2007).

Transhumanism is clearly utilitarian. Its agenda is justified by the personal and social
improvement foreseen in the eradication of human limitations and constraints associated with
the present corporeal human condition and in the strengthening of positive human capacities
through science and technology. Eventually, it questions what human beings are and what they
can be by removing the boundaries between therapeutic action that advances individuals, and
enhancement that would result in substantially different human beings (Pastor and Garcia
2014).

Eugenics and transhumanism are not necessarily related, but the aims and intended
means of both programs overlap. For instance, both propose the elimination of embryos and
fetuses with congenital abnormalities to enhance the genetic pool (eugenics) or to promote
directed human evolution (transhumanism). The eugenic bent of transhumanism is also
manifested in the use of genetic therapy not only for therapeutic purposes, but for introducing
modifications in the genome that would be transmitted to descendants and eventually could
originate different beings. A transhumanist justification of this approach is to speculate that
there may be values presently unknown owing to current human limitations and consequently
are not wanted, or even wanted to be wanted, which could become known and lived by
transhumans. Thus, the right way of favouring human beings is by enabling us to realise our ideals better, and that some of our ideals may well be located outside the space of modes of being that are accessible to us with our current biological constitution’ (Bostrom 2005b). It should be noted that this response is based on hypothetical ideas about values of whose existence there is no evidence, ideas that will be the intellectual foundation of a program with completely unknown outcomes. Exploration of transhuman or posthuman modes of being by introducing irreversible changes in human beings has not been properly justified owing to the lack of evidence of the existence of those modes of being, or if they existed, of their compatibility with the human mode of being.

Transhumanists argue that ‘complex social and political circumstances along with hope for change, can be reduced to one dimension -the biological’ (Hall 2017). In such biological reductionism, relevant information about individual or social circumstances is read through features and facts about the body and leads to the assumption that modifying material human qualities through technology will release the intellect from its limitations. Establishing such a hierarchy between mind and body devalues persons with cognitive disabilities. Following the agenda of the modernist project, transhumanism strives for maximising human freedom by increasing our physical capabilities, and by aiming to go beyond our present condition marked by bodily imperfection, and intellectual and ethical limits. This emphasis on the individual’s freedom conveys a picture of self-contained human beings that minimises mutual dependence, devalues the importance of interpersonal relations, and belittles persons who are dependent on others such as those with disabilities.

Modernism centres the ethical life of the person on autonomy, understood as that of a free consciousness that self-constructs according to criteria it gives to itself. If the good of humanity rested on the production of transformed beings starting from the human model, the actions leading to these new beings would be ethically justified. A deep contradiction underlies
the ideology of striving for the good of humanity by overcoming the present limitations of
human beings without having a clear notion of what is their optimal condition; its inadequacy
is manifested by focussing only on some of the characteristics of human beings. This project,
based on technoscience, becomes an irrational proposal that starts from zero and searches for
something different without wanting to confront the fundamental reality of the human being,
and indeed seeking to overcome that reality.

*Debates on several transhumanist anthropological and social views*

Arguments in favour or against human enhancement coincide on the importance of
authenticity, uniqueness, and equal opportunity for all human beings (Hall 2017). Detractors
of enhancement indicate that humans rightly seek to express their authentic selves, and not to
be pre-fabricated humans. A transhumanist answer is that the quest for authenticity and respect
for human beings means embracing change through directed evolution: a refusal is tantamount
to anti-humanism.

The unique place of human beings in the natural world is supported by both sides. For
‘bioconservatives’, authentic human living means respecting the boundaries of what is
considered unique to human nature; enhancement would threaten what is valuable to humanity
or the social world in which human beings live (Fukuyama 2002, Habermas 1998, Kass 2002,
Sandel 2007). In contrast, transhumanists argue that humans are unique in being able to draw
lessons from history, and the need for enhancement is one of them, hence it has to be taken
seriously (Bostrom and Sandberg 2011).

Equality of opportunity is approached by human enhancement supporters from the
understanding of a just action as one in which a person exerts control over his circumstances
(Buchanan *et al.* 2000). Technology that becomes available to intervene in the human body
should be used not only to nullify inequalities resulting from natural or social lotteries, but
should also be applied to the ‘genetic lottery’ in order to provide equality of opportunity.
Important implications of this reasoning are that the areas in which we can achieve control are potentially without limit, and that outside those areas only chance operates. Singer discusses the possible negative effects of enhancement if it is not regulated; in a global marketplace, it would be available only to already-advantaged persons with ready access to wealth, and through heritable changes, the advantage of the wealthy will be entrenched by passing the advantageous traits to their descendants. In his view, advantaging the wealthy over the poor violates the principle of equal opportunity (Singer 2003). A derived problem could be that social regulation of enhancement requires deployment of significant resources and can give rise to eugenic programs.

Debates about genetic modification technologies rely on a particular understanding of genetic biological causality. Transhumanists argue that the effects of genetic modifications on the phenotype would follow a probabilistic determinism and not a strong determinism, and thus will not prevent the person from making free choices or pre-determine his behaviour or life plans (Resnick and Vorhaus 2006). Opponents of genetic enhancement respond that even if this is correct, it does not address the issue of a biological reductionism that sets the stage for judging quality of life through genetic profiles; some transhumanists regard genes as the primary site of human improvement, and, thus, of social and political improvement. They take for granted that technological interventions on the body, in particular genetic interventions, have the power to enhance traits, thus placing a significant amount of personal and social responsibility for quality of life on the genetic make-up (Hall 2017).

**Genetics**

Transhumanists predict that future generations will be born with fewer genetic vulnerabilities to disease and with genetic enhancements that will make individuals more fit and intelligent than ever before (Heine 2017). Genetic engineering to enhance the human organism is one of the central technological options for effecting this change. A key
technological tool in a program of genetic enhancement is editing the human genome in ways that will bring about the traits sought by individuals. Genome editing refers to a variety of methods for changing the genome in animals, plants, bacteria, etc. To assess the transhumanist program, it is necessary to review current knowledge of genotype-phenotype relations and techniques developed to introduce changes in the genome.

**Editing the human genome**

Introducing changes in the deoxyribonucleic (DNA) nucleotide sequence of the genome (genotype) of an organism can lead to changing its biophysical characteristics (phenotype). In human beings changes in DNA sequences can result in reducing the risk of developing some diseases and in physical traits such as eye colour and height. Genome changes are effected by inserting, deleting, modifying or replacing specific DNA segments of the genome.

The possibility of genome editing for altering specific phenotypic traits has to be based on knowing what genes are related to traits of interest and how they need to be altered to obtain the desired outcome. A central goal of genetics is to understand the links between genetic variations and traits and diseases by using reverse or forward genetics. Reverse genetics is the determination of the function(s) of a gene by correlating phenotypic effects with variations in DNA sequences. Forward genetics is determining the genetic basis of a phenotype.

Altering human traits by genomic editing poses a number of theoretical and practical problems which are reviewed in this section; conceptual and ethical problems are discussed in the next section.

**Genome-wide association studies**

Single-nucleotide polymorphisms (SNP) are variations in an individual nucleotide building blocks of DNA sequences; ordinarily, they do not have an effect on health or development. In humans, they occur throughout the genome with an average frequency of one every 300 nucleotides. Reverse genetics genome-wide association studies (GWAS) assess
connections between traits and SNP used as DNA markers that may help to establish an
individual’s likelihood to develop a specific trait. These studies have become a powerful tool
for investigating the genetic architecture of human disease and have succeeded in identifying
phenotype-associated genetic markers in genomes where genetic variant nucleotides that
introduce changes in the sequence are present (Bush and Moore 2012).

Genome-wide association methods assume that: (i) non-random associations of alleles
(single copies of a gene) at different loci in a given population (linkage disequilibrium) would
enable one or few SNP to act as surrogate markers for the association(s), and (ii) these markers
would be placed near to genetic variant(s) causing trait change(s). These assumptions are
statistical and pinpointing causal mutations in subsequent fine-mapping studies remains a
challenge (Wang et al. 2010). A common difficulty is that significant SNP resulting from these
analyses fall in non-coding regions of the DNA that may regulate gene expression even though
the actual regulated gene is unknown.

Seldom do GWAS reveal neat or consistent gene-to-trait relationships that allow
decisive treatment. Instead, these studies usually find ‘many assorted genes of tiny
significance’ (MAGOTS) (Dobbs 2015). Tens and sometimes hundreds of gene variants are
carried by most (but not all) people with a specific condition whose individual effects on the
condition are often unclear, a fact that does little to predict the risk of a given individual having
the condition merely by the presence of these variants. The genetic contributions for common
diseases and conditions usually come from MAGOTS because a disease caused by a gene
variant that plays a large role in causing it tends to be rare, since carriers of such variants often
die without leaving offspring. The consistent evidence from GWAS for most human conditions
has led to the formulation of the Fourth Law of Behavioural Genetics: ‘A typical human
behavioural trait is associated with very many genetic variants, each of which accounts for a
very small percentage of the behavioural variability’ (Chabris et al. 2015).
Rare and low-frequency coding variations that contribute to traits arising from many genes pose a serious obstacle to correlating genes with traits. Even with an apparently straightforward highly heritable physical characteristic like height, genetic manipulation to achieve a desired outcome would be a tall order. It has been estimated that height is influenced by as many as 93,000 genetic variations. A study identified 697 of them located within 423 loci that together explain only about 20% of the heritability of height (Wood et al. 2014). As is typical of complex traits and diseases, most of the alleles that affect height discovered so far are common and mainly located outside coding regions, complicating the identification of the relevant genes or functional variants (Marouli et al. 2017).

**Genes and traits**

To correlate genes with traits, there are other fundamental problems. The expressivity of a genotype is the degree to which its phenotype can differ between individuals (Miko 2008a). Even for characteristics that are controlled by a single gene, it is possible for individuals with the same genotype to have different phenotypes. In the case of a genetic disorder, people with the same disease genotype may have stronger or weaker forms of the disorder, and some may never develop the disorder at all. Penetrance is the frequency of occurrence of a particular trait or condition amongst individuals who carry the same gene variant (Miko 2008a). Thus, in a group of people with a disease-causing genotype, some might develop a severe form of the disorder, while others might have a milder form. In incomplete penetrance, individuals with a certain genotype may or may not develop a phenotype associated with it.

Genome editing would need to aim at achieving specific ‘optimal’ or at least ‘improved’ sequences that would enhance a trait. The differences in genetic variants of many genes present in specific normal functions of individuals and in diseased states are known, for example in cystic fibrosis. This knowledge cannot be extrapolated to assume that there are ‘best genes’, an optimal way(s) for genes to be. Often, genetic variants that predispose to specific risks or
supposed weaknesses in particular functions are precisely the same ones that turn out to have small fitness advantages in other functions. It is difficult to get an advantage without risking disadvantage.

Heritability estimates based solely on genetics leave out cultural factors that have a great influence on the phenotype. Population variations in many traits cannot be explained only by differences in genes. Even if genes cause much of an individual trait within a population, this does not mean that differences of the trait between populations are caused by the same genes.

**Epistasis and polygenes**

Two important difficulties in correlating genes with traits are: (i) the association of more than one gene with a particular trait, and (ii) the association of a gene with more than one trait. Epistasis is a phenomenon in which the presence of one or more ‘modifier genes’ affects the expression of one gene (locus); that is, the expression of the latter is dependent on the genetic background.

Investigations of the genetic basis of Alzheimer's disease have indicated that the ε4 variant of the gene *APOE*, encoding apolipoprotein E4, was associated with a higher risk of developing the disease, but not all carriers of this variant develop the disease. It was noted also that having two copies of *APOE4* increased the risk of Alzheimer's. The findings suggested that other genes and/or gene-gene interactions are involved in the development of the disease. To determine whether epistasis occurred, both the size and the statistical significance of interactions between pairs of implicated genes were measured, and 27 significant epistatic interactions were found. Some interactions were synergistic indicating that the pair of genes together increased the risk of the disease, and other interactions were antagonistic indicating a protective relationship between the two genes. Thus, complex epistatic interactions are associated with Alzheimer's disease, and genes act through pathways that affect one another (Lobo 2008a).
Polygenes are non-epistatic genes that interact additively to influence a phenotypic trait. Polygenic inheritance occurs when one characteristic is controlled by two or more genes. Often, as discussed above, the genes are many in number but small in their individual effects (Glazier et al. 2002). Many allelic combinations are possible, and as a result the frequency of these phenotypic traits follows a pattern of a normal continuous distribution; height, weight and skin colour are examples of multiple gene inheritance. The phenotypic expression of polygenic characters can undergo considerable modification by environmental influences; thus, a person may have a genetic tendency to be underweight or obese, but his or her actual weight will depend on diet and exercise, and these factors often play a greater role than genes. The enormous complexity of polygenic traits does not allow to predict that polygene studies will ever map all the quantitative trait loci present in the human genome; nonetheless, the development of new analytical and statistical tools and continued progress in obtaining more complete descriptions of the architecture of these loci indicate that a complete mapping cannot be ruled out.

**Pleiotropy and the Omnigenic Model**

A second major difficulty in determining correlations between genes and traits is that many genes are associated with more than one trait. Pleiotropy occurs when one gene influences two or more seemingly unrelated phenotypic traits (Paaby and Rockman 2013). It should not be confused with polygenic traits in which multiple genes contribute to a single phenotype; but commonly, polygenes are pleiotropic adding a further complication to establishing their contribution to the phenotype. For example, the amino acid tyrosine is needed for protein synthesis, and is a precursor for the neurotransmitters dopamine and norepinephrine, and for thyroid hormones. Mutations in any one of the genes that affect tyrosine synthesis or metabolism may affect the synthesis of various proteins and metabolites, neurotransmission,
growth and development, etc.; such mutations can have an effect on almost every physiological process and on multiple body systems (Lobo 2008b).

The contribution of genetic factors to the regulation of brain dopaminergic activity is widely acknowledged, but the genetic basis of the resultant cognitive phenotypes of executive function of the frontal lobe have yet to be identified. The gene COMT encodes the enzyme catechol-O-methyltransferase involved in the degradation of several catecholamines, and is especially relevant in the metabolism of the neurotransmitter dopamine engaged in several brain and cognitive functions; in particular, COMT is implicated in information processing in prefrontal-related working memory tasks (Mier et al. 2010). An SNP in an allele allows COMT to have three type variants: AA, GG and AG. The A allele can increase dopamine levels by four-fold in the prefrontal cortex and affects executive functions such as cognitive flexibility, impulse control, abstract thought, and ability to follow rules or task structure (Bruder et al. 2005). The AA variants result in the highest dopamine levels, the GG variants in the lowest levels, and the AG variants are somewhere in the middle. Dopamine levels increase under stress, and individuals with the AA variant (5% of humans) will have too much dopamine, consequently they will be jittery and perform worse under difficult conditions (Blasi et al. 2005). Moreover, the dopamine D4 receptor encoded by the gene DRD4 has been implicated in prefrontal functions and an SNP in DRD4 has been found to affect the transcriptional efficiency of the receptor it encodes (Okuyama et al. 1999). Statistical analyses employed to detect the genetic contribution of multiple genes to executive function demonstrated gene-gene interactions between SNP in COMT and DRD4 that influence significantly this function making their collective editing a highly problematic (Mitaki et al. 2013).

The problem of controlling potential effects of editing genes may be practically insoluble if the Omnigenic Model of genetic networks is correct. It posits that the networks regulating genes are so interconnected that any gene expressed in a given tissue is going to have
some impact, no matter how infinitesimal, on the function of that tissue. Importantly, genes with interconnected functions are not neatly arranged in discrete clusters but may be spread out all over the genome (Boyle et al. 2017).

**Epigenetics**

The approximately 25,000 genes identified in the human genome are widely regarded as the instruction book for the human body. But genes themselves need instructions for what to do, and where and when to do it. Those instructions are not always found in the nucleotides of the DNA itself but frequently on an array of chemical markers and switches, known collectively as the epigenome, that lie along the length of the DNA double helix; epigenetic switches and markers help switch on or off the expression of particular genes. The epigenome could be regarded as a complex software code capable of inducing the DNA hardware to manufacture an enormous variety of proteins, cell types, and individuals. The epigenome is just as critical as DNA to the healthy development of humans and is sensitive to cues from the environment that can affect the body and brain of individuals throughout their lives (Watters 2006).

Epigenetic signals from the environment also could be passed on from one generation to the next, sometimes for several generations. Epigenetic changes wrought by one's diet, behaviour, or surroundings can work their way into the germ line and echo far into the future (Morgan and Whitelaw 2008). In epigenetic inheritance, genetic inheritance is not altered, but gene expression is. This mechanism of intergenerational transfer of experience may affect a wide array of personality traits, including temperament and intelligence (Harper 2005).

**Phenotype predictions from genotype**

‘Gene as fate’ has been conventional wisdom, but the findings of current genetics may prove this notion outdated. For better or worse, epigenetics appears to be a measure of control over human genetic legacy. This is not entirely surprising because individuals inherit more than
just DNA, they inherit chromosomes from the parents, and chromosomes are only 50 percent DNA. The other 50 percent is made up of protein molecules, and these proteins carry epigenetic marks and information. (Morgan and Whitelaw 2008).

Regarding how genes shape the traits and diseases that matter most to us, from intelligence and temperament to cancer and depression, consideration must be given to a complex web of interactions of genetic, epigenetic and environmental influences that shape our phenotype. Phenotypes are not genetically predetermined, and as an individual develops it is possible to give more weight to some influences than to others. But the core issue is that no single influence determines our traits. If a trait is strongly influenced by the environment as the individual develops, e.g. height, then, owing to the interactions between genes and the environment, estimates from the genetic background alone fall far off the mark.

Genetic predictions of phenotypic variations have both fundamental and practical limitations that further research will make better known, but improved knowledge will not alter the intrinsic limitations in our ability to change traits through genetic manipulation.

**Genome editing**

A common proposal of transhumanism and eugenics is to improve the human genetic pool by genome editing. Editing in somatic cells will introduce changes limited to the treated individual; if performed in germline cells the changes will be inherited by future generations.

The objectives of genome editing can be summarised as: (i) eliminating for therapeutic reasons undesirable traits of genetic origin, (ii) preventing risk of severe illness, or (iii) enhancing traits considered desirable such as intelligence or a more effective immune system. Difficulties in some instances to make categorical distinctions between therapy, prevention or enhancement should not lead to the erroneous conclusion that the three types of action are equally principled, because the ethical evaluation of actions is not reducible to their intent; the ethics of actions is characterised also by their nature, circumstances and outcomes. There are notable
dissimilarities between genetic interventions and less invasive medical practices with the same objective; e.g. there is a vast distinction between genome editing and taking medication to reduce cholesterol levels. Regardless of the similarity of the intent, the actual nature of the action makes them significantly different.

Somatic genome editing

It is acknowledged widely that reducing the number of people who suffer from debilitating diseases will improve the human genetic pool, but there is no consensus on this view. The benefits for individuals are clear, but there are questions about the potential collective negative effects on the human genome. Treatments of some diseases by somatic genome editing are already in clinical development for disorders of the haematopoietic system (Mussolino et al. 2017, Rangajaran et al. 2017), and in particular, sickle-cell disease (Tasan et al. 2016), and severe X-linked combined immunodeficiency (Schiroli et al. 2017).

Conceptually, multisystemic or extremely early onset diseases may require editing of somatic cells of a fetus prior to delivery because postnatal interventions would come too late to benefit the child or are technically very challenging. Also, the great developmental plasticity of the fetus might make more effective fetal editing than postnatal editing; for example, it would be simpler to revert a disease-causing variant that affects every neuron in the brain in an early fetus than in a newborn infant.

Germline genome editing

Genetic modification of the germline occurs when for example, foreign DNA is introduced into parent gametes or an early embryo; these modifications will be passed to the offspring and consequently to future generations. Interest in editing the genome of germline cells stems from the number of inherited pathological conditions caused by mutations in single genes.
Germline genetic manipulation could be used not only for therapeutic purposes but also for human enhancement. A fundamental conceptual problem is to define which genome editing is an improvement of the genetic pool, because at a very basic level it could mean the imposition of arbitrary standards of perfection.

Some traits generally regarded as beneficial are physical stamina, strength, speed, mathematical ability, dexterity, and acuity of vision; they are all related to health in ways that command universal assent as to their desirability (Caplan et al. 1999). Nonetheless, there is no agreement as to what is their optimal level of proficiency. Examples of genetic investigations on general intelligence indicate it has a genetic component. ‘But it's really, really important to realize that while twin studies can show us that genetics are making a difference as to why people are different in terms of intelligence, it cannot tell us anything at all about which genetic differences are making a difference, or how.’ (Henig 2015). Given all feasible genetic information about a person, it is not possible to predict intelligence. There are too many traits bound together, too many ways that genes might be expressed (Inglis-Arkell 2010).

Thus at the level of Genetics, genomic editing for train enhancement poses extraordinary problems that need to be solved before asserting that it is a path to improving the gene pool.

**Ethical problems of human enhancement**

**Transhumanism, eugenics and disability**

The *Oxford English Dictionary* defines ‘eugenics’ as the science of improving a population (in particular humans) by controlled breeding for desirable inheritable characteristics. It is similar to a definition given by Francis Galton, the originator of eugenics: ‘the study of agencies under social control that may improve or impair the racial qualities of future generations, either physically or mentally’ (Galton 1908). Stated in this way, the
coercion of controlling breeding together with the subjectivity of desirable characteristics makes eugenics morally difficult to defend.

Some critics of transhumanism see eugenics, social Darwinism and master race ideologies as warnings of what the promotion of enhancement technologies might unintentionally encourage. Some fear future ‘eugenics wars’ as the worst-case scenario: the return of coercive state-sponsored genetic discrimination and human rights violations such as compulsory sterilisation of persons with genetic defects, the killing of persons institutionalised for physical or mental deficits, and, specifically, segregation and genocide of races perceived as inferior (Annas et al. 2002). Transhumanists emphatically insist that their program is different from 20th Century eugenics. The major transhumanist organisations strongly condemn the coercion involved in such policies and reject the racist and classist assumptions on which they were based, along with the pseudoscientific notions that eugenic improvements could be accomplished in a meaningful time frame through selective human breeding (Bashford and Levine 2010).

Instead, most transhumanist thinkers advocate a ‘new eugenics’, a form of egalitarian liberal eugenics (WTA 2005). ‘Yet if we are to build a “Triple S” civilisation of superhappiness, superlongevity and superintelligence, then humans will need genetically to edit our legacy source code. Every child born today is a unique genetic experiment. The outcome of such reckless genetic experimentation is a world of unimaginable suffering. However, the genetic crapshoot of traditional sexual reproduction will shortly be replaced by the era of “designer babies”’ (Pearce 2017). Acknowledging that the creation of a ‘Triple S’ society via premeditated government design would not be socially acceptable, it is suggested that individual prospective parents take responsibility for the genome editing of their children (Pearce 2017). But this scenario is unlikely to lead to a society of better persons. Individual choice will influence what particular persons will be, and not what a population will be. In
time, individual selections could determine the sort of people there are, but not being methodical, it will not be possible to predict that a ‘Triple S’ civilisation will be built. To achieve the desired improvement in a population requires methodical selection through social regulation, that is, the ‘old eugenics’.

Critics of transhumanism consider that it has the same aim as eugenics, the redemption of man through technology. ‘It is precisely a matter of improving the “quality” of individuals, as one improves the “quality” of products, and therefore, probably, of eliminating or preventing the birth of everything that would appear as abnormal or deficient’ (Hadjadj 2011).

To avoid some of the problems with the classical definition of eugenics, a simpler one has been proposed: ‘Eugenics is the attempt to improve the human gene pool’ (Wilkinson and Garrard 2013). This definition of eugenics requires (a) an explanation of the meaning of ‘improving the human gene pool’, (b) a moral justification for attempting to improve the gene pool, and (c) what form, if any, of this attempt can be morally acceptable (Wilkinson and Garrard 2013).

This simple definition of eugenics is compared to accepted non-coercive practices designed to maintain population health which are construed by transhumanists as eugenic or partially eugenic. ‘These include incest avoidance; providing genetic counselling to people with inherited genetic disorders; discouraging cousin marriage; or encouraging women to have children only in the optimum years for doing so (avoiding both teenage pregnancy and “post-menopausal motherhood”’) (Wilkinson and Garrard 2013). The comparison is made to assert that these practices aim ‘to improve population health, or improve the genetic pool’ (Wilkinson and Garrard 2013). Implicit in this statement is the view that improving the health of the population is sufficient to enhance the human genetic pool. But, as discussed in the section on Genetics, a comprehensive correlation between human traits and genes has not been demonstrated, and is not universally accepted. ‘Heritability and psychobiological association
cannot be the basis for establishing whether behaviour is genetic or biological, because to do so leads only to the banal tautology that all behaviour is ultimately based in the genotype and brain’ (Turkeheimer et al. 2003).

Transhumanism has had to address criticisms of its implied discriminatory views on disability. The Equal Value Principle (EVP) states that we ought to value disability and non-disability equally (DRC 2001). An interpretation of this principle is that we have to value disabled people equally to non-disabled ones. In defence of transhumanism it is argued that ‘The fact that we sometimes try to avoid bringing a child with a disability into the world says nothing at all about how we should treat existing people who already have disabilities; just as the fact that we may attempt to cure some of them has no implications for how we should treat those who can’t be cured’ (Wilkinson and Garrard 2013). The validity of this statement depends on how disability is avoided. If embryos with genetic defects are discarded, it is because they are considered less valuable than those without defects. Only by denying that embryos are people one could conclude that this approach is not a violation of the EVP.

The Expressivist Argument formulates another problem with transhumanism: ‘choosing not to conceive or bear a child with a disability expresses and sends out a very negative message about people with disabilities, one that says that it would be better if they had not been born’ (Wilkinson and Garrard 2013). To defend transhumanism – and eugenics – against the charge of discriminating against people with disabilities it is argued that, other things being equal, it is better to create children with fewer, rather than more, functional limitations. Since this could be said of any one it fails to send a message exclusively to people with disabilities. Nonetheless, if prospective parents chose *not to create a child at all* in preference to creating a child with a disability, this would indeed suggest, in some circumstances, that the world would be a better place without people with disabilities in it. To conclude that this cannot be morally wrong because anyone has the moral right not to have
children, is incorrect. The moral appraisal does not revolve around the morality of deciding to have or not to have children, but around the reasons for that decision.

The justification of transhumanism for selecting out disability to avoid the harm inflicted on a child that will be born with disability is unsound. Employing a current definition of harm as making someone worse than he/she was before, or making someone worse off than he/she otherwise would have been, renders the transhumanist reasoning void if the only chance of existence of that child is to be born with disability. ‘It is hard to maintain that the child has been harmed by being created. Most people with disabilities are glad to be alive and would prefer to exist than never to have been born. So, in the light of this, it seems perverse to attempt to prevent such people from existing in the future for their own good, or in order to avoid harming them’ (Wilkinson and Garrard 2013).

A more impersonal utilitarian justification of eugenics for selecting out disability is based on overall levels of wellbeing. If consideration is given to the overall amount of wellbeing in society, it appears that choosing an embryo with potential disability entails choosing a lower overall level of wellbeing in the world than choosing one without disabilities. This argument implies than on average, disabled persons have worse lives than non-disabled persons, but this assertion requires examination. The idea of disability contains an implication of reduced capacity to flourish, because something does not count as disability if it does not in some way hinder a capacity for having a high quality of life. This reasoning can be answered in two ways: (i) ‘the disabled person, or her circumstances, can overcome her disadvantages and have a flourishing and highly worthwhile life’. In fact, there are many such cases, ‘famous examples include the profoundly deaf Beethoven, who gave humanity such incomparable music; the blind poet Homer; the paralysed physicist Stephen Hawking, and countless other less dramatic but no less genuine cases of lives containing both disability and high levels of wellbeing’ (Wilkinson and Garrard 2013). (ii) There is an association between ‘flourishing’
and ‘quality of life’, but neither is easily or simply measurable, and both contain a strong subjective element; thus, to measure wellbeing using either or both concepts is highly problematic. ‘So people who are disabled don’t always have lower levels of welfare than those who are not disabled, and in those cases where individuals do have a poorer quality of life on account of their disability, much of this differential can be reduced by appropriate physical and social arrangements’ (Wilkinson and Garrard 2013).

Editing the genome

Theoretically, it would be possible to use somatic genome editing not for therapy or prevention but for enhancing phenotypic traits like muscle strength or memory. To evaluate the ethics of somatic enhancement it has been compared to taking drugs to enhance physical or intellectual performance. But the notion of attaining competitive advantages that go beyond known human capacities such as ‘genetically altered athletes lifting SUV, or hitting 650-foot home runs, or running a three-minute mile’ (Sandel 2004) commonly is considered unethical.

The ethical appraisal of therapeutic or preventive somatic genome editing needs to include a consideration of the practices chosen to correct the origin of the disability. Some methods of somatic genome editing are widely accepted; these techniques hold great promise for treating or preventing many diseases, and for improving the safety, effectiveness, and efficiency of gene therapy techniques now in use or in clinical trials (Charo et al. 2017). In contrast, genome editing of germline cells for therapy, prevention, or enhancement is a contentious issue.

Two methods envisaged to avoid having a child with disability are: (a) prenatal testing with abortion of an infant with a genome known to result in an inherited disorder, and (b) heritable genetic editing including in-vitro fertilisation with germline genome editing, pre-implantation genetic diagnosis (PGD), and transfer to the uterus of the prospective mother only of embryos free of genes likely to cause disease or disability. It is argued that the message of
PGD does not discriminate against disability, because choosing not to implant embryos with genetic disorders is like trying to discourage teenage pregnancies. This reasoning is logically fallacious in comparing a not yet existing future situation (future teenage pregnancy) with an existing situation (embryos with genetic disorders). It is materially fallacious considering that embryos are merely possible people with no human rights or needs. It is formally wrong in denying the humanity of embryos; human embryos are human, what else can they be?

Moreover, the comparison of non-implantation of embryos with genetic disorders and teenage pregnancy itself enshrines an inner contradiction. It is suggested that the underlying motivation for embryo selection is the welfare of the future child, but if the embryo (a merely possible person) is not in any way a child (a real person), then the choice on the basis of the welfare of the future child is meaningless. This lays bare the true root of PGD ethics: choosing between embryos (merely possible people) is in fact choosing between children (people), and consequently, suggesting that one child is somewhat substitutable for another. Another problem with these practices is that ‘Talents and traits aren’t the only thing that are genetically complex. So are most physical diseases and psychiatric disorders. The genetic message is not carried in a 140-character tweet; it resembles a shelf full of books with chapters, subsections and footnotes. So embryonic editing is unlikely to prevent most medical problems’ (Belluck 2017).

Independently of various legal frameworks that may allow abortion and PGD, important ethical objections are levelled against them based on the absence of a clear definition of the status of the human embryo and the human fetus. It is unsatisfactory to address this issue by having recourse to negative descriptions such as ‘not human’, ‘not fully human’, ‘not a human person’, or the like. The matter that must be determined is what embryos and fetuses are, not what they are thought not to be. Facile descriptions such ‘a bunch of cells’, or ‘human-like’, give account of aspects of the physical reality of an embryo or a fetus, but are equivocal
insofar as they are applicable to biological entities that cannot be equated to an embryo or a fetus. Ethical appraisals based on inappropriate concepts are bound to be ambiguous, and thus require arbitrary rulings not based on consistent reasoning founded on factual information. Equivocal descriptions are useless to understand what is a human embryo or a human fetus and inadequate as foundations to develop and establish legal frameworks about the treatment of these human beings.

Germline editing for enhancement would not be about avoiding the transmission of heritable diseases, but about employing medical means for the non-medical end of giving birth to children with particular desired genetic configurations, to make them ‘better than well’ (Sandel 2004). To describe as morally acceptable enhancement eugenics practices simply because they would not involve coercion or violence is an arbitrary reduction of what is moral or immoral. In the case of human beings, using them as means towards ends is widely recognised as unethical. Having children is considered a good action, but the motivation of that action could be such that they are used as means: children created as objects of the parents’ design, or as products of their will, or as instruments of their ambition, are attempts against the dignity of the offspring. These attitudes may not harm specific individuals, but treating a human being as a means towards something else remains morally objectionable.

**The human gene pool**

To assess the ethics of germline genome editing, the human gene pool needs to be considered globally. No two humans are genetically identical, but on average, the genome of an individual is 99.5% similar to any other individual. The *Homo* genus has limited biodiversity at the genetic level; the results of studies on human genetic variation in 850 individuals from 40 populations yielded an estimate of global population differentiation due to genetic structure (fixation index) of ~11% (Xing et al. 2010), lower than found between populations of many other species. On a world scale a ‘kinship between two individuals of the same human
population is equivalent to kinship between grandparent and grandchild or between half siblings’ (Harpending 2002). Thus, there is not much genetic diversity to lose. If a few models of ideal human beings were to limit the genetic diversity of the human species, it would curtail the capacity of humans to change in the future, and would leave the human population extremely vulnerable to changes in the conditions of the world.

Considering that genetic diversity is related to the survivability of populations, compelling evidence is required which demonstrates that the implementation of germline altering technologies will not threaten the continuity of human populations. Analyses of the genetic diversity argument in models that leave the decision to use germline genetic editing either to individuals or to the state show that there is no convincing evidence about what the effects of these reproductive techniques will have on genetic diversity of human populations. The method to produce the proof required is through human experimentation and this involves unacceptable ethical violations and unavoidable pragmatic difficulties. Animal experiments are ruled out because not all species respond to germline editing in the same way. The fact that it is not possible to obtain such experimental evidence leads many authors to the conclusion that germline altering technologies should be prohibited (Wolfe 2009).

Discussion

A problem for transhumanism is that there are clear limits to the ability to enhance the human body. The need to fill gaps arising from insufficient knowledge of human genetics is one of the arguments put forward by transhumanists to promote more research to achieve their ideals. But there is a fundamental difference between filling in gaps due to lack of knowledge, and having knowledge that demonstrates the impossibility of reaching specific outcomes through genetic manipulations. Several examples of the latter were given in the section on Genetics. Lack of solid scientific understanding makes many transhumanist proposals a priori flawed.
Generally, the advancement of knowledge requires generating hypotheses, but hypotheses are not facts. Care is needed in building provisional hypotheses based on previous ones; this approach may be acceptable under specific circumstances and is subject to obtaining evidence for the initial hypotheses. However, it is not rigorous to erect new hypotheses simply by transforming previous ones into facts. In this respect, it is essential to appraise transhumanist reasoning and conclusions for their factual versus hypothetical content. Postulation of realms of awareness to which ordinary humans do not have access may be methodically appropriate to develop ideas, but evidence of the existence of these realms must be provided at some stage.

A program with a plan of action aimed at achieving specific objectives demands provision of substantive evidence for the original premises, the more so when such a program results from simply linking chains of hypotheses.

Human relations are founded on the equality and ethical behaviour of individuals. The abilities of individuals do not define their basic status as members of society; disabled people are fundamentally equal to anyone else simply because they are human. This notion is hardly compatible with the transhumanist belief in the need to ‘enhance’ human beings by using embryo selection techniques to avoid the risk of bringing into the world persons with disabilities, or by considering the birth of persons with ‘enhanced traits’ as a better outcome. It is difficult to see how a view that exalts the value of ‘human enhancement’ as a prerequisite for the progress of humanity will accord the same ethical treatment to all human beings.

A reductionist anthropology ‘objectifies’ persons. Individuals become things ‘to be improved’. The technical methods proposed by transhumanism challenge their self-determination, question their integrity and agency, and disregard their subjectivity. Comparisons with the development of persons sought through physical and spiritual means, education, mentoring, etc. are misleading. Transhumanism is not scientifically literate humanism, but a fundamentally different project. The only issue that transhumanism has in
common with conventional humanism is its desire to improve persons -- not the questionable means it proposes.

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