Transhumanism: Possibility or chimera?

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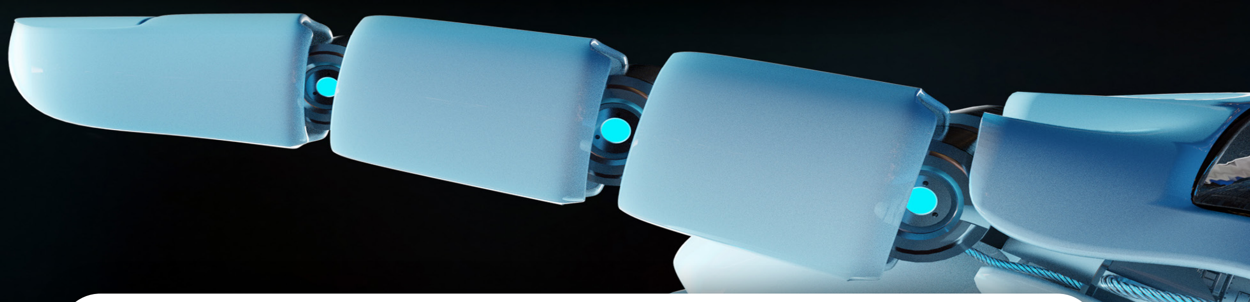
RESUMEN:

La Medicina siempre ha buscado mejorar la salud humana. Así, se han usado desde tiempos remotos aparatos artificiales, como prótesis y ortesis. La tecnología actual permite utilizar equipos enormemente sofisticados para restablecer la función de órganos dañados o incluso para reemplazarlos. La Biología molecular y celular ofrece otras prometedoras posibilidades, como la terapia génica y la medicina regenerativa. Hace años se predijo que se podrían aplicar métodos semejantes para adquirir nuevas capacidades y en este sentido, se acuñó el término "transhumanismo". Diversas propuestas transhumanistas se están llevando ya a cabo y existen algunos cyborgs, hombres o mujeres que con ayuda de componentes artificiales, han aumentado sus potencialidades. Evidentemente, la aplicación del ideal transhumanista plantea problemas técnicos y filosóficos.

Por ello, en este artículo se revisan las bases biomédicas que permitirían dotar a los seres humanos de nuevas capacidades, especialmente la terapia celular, la edición de genomas, el aumento de la longevidad, la criopreservación y el uso de interfaces cerebro-computador. Se distinguen las posibilidades con fundamento sólido de las puramente imaginativas. Luego, se consideran las implicaciones éticas y antropológicas de las propuestas transhumanistas. Especialmente, se enjuician: la contradicción que supone usar la libertad humana para sobrepasar la propia condición; las desigualdades derivadas de la limitada accesibilidad a los recursos tecnológicos; las objeciones a la modificación de células germinales, así como los riesgos del uso de sistemas cerebro-computador. Como conclusión, se presentan varias posibilidades de mejorar la condición humana sin renunciar a su naturaleza.



ABSTRACT:

The objective of Medicine has always been the improvement of human health. To this aim, non-natural implements, such as prostheses or ortheses, have been long used. Present-day technology allows the use of extremely sophisticated devices to repair or replace injured or damaged organs. Promising possibilities, such as gene therapy and regenerative medicine are also offered by the advances in molecular and cellular Biology. The option of applying these methods to make humans acquiring novel capacities was also predicted some time ago, and the term "transhumanism" was coined in this sense. Some of the transhumanist proposals are now turning into reality and some cyborgs, men or women supplemented with artificial components to acquire enhanced abilities, actually exist. It is obvious that putting transhumanist ideals into practice involves technical and philosophical issues.

In this report, the biomedical bases for endowing human beings with novel abilities are first considered. Then, cell-based technology, genome editing, increasing longevity, cryopreservation and the use of brain-computer interfaces are especially reviewed, emphasizing the distinction between techniques based on solid grounds and the fantastical ones. Afterwards, the anthropological and ethical implications of transhumanist proposals are considered. The contradiction of using human freedom to surpass the human condition; the inequalities imposed by the limited accessibility to technologic modifications; the concerns of using germ cell modifications and the risks derived from the use of brain-computer systems are especially judged. To conclude, several ways to improve human condition without renouncing human nature are offered.

1. MEDICAL SCIENCES AND HUMAN BODY

The Ebers papyrus, written in hieratic Egyptian around 1500 bC, during Dynasty XVIII, contains a description of some aspects of human anatomy. It also includes a relation of the prevalent diseases and also explains how to prepare custom herbal formulations to treat diabetes, asthma, eye and intestinal diseases, among other disorders. Though mixed with magical formulations, the Ebers papyrus is a clear exponent of how treating human diseases, disabilities and injuries has been the object of medicine since the most remote antiquity. Medical practice was not an uncommon occupation in ancient cultures and this papyrus is a single example of the interest that medicine aroused in those old times. Shifting to the Christian era, Pedanius Dioscorides (ca. 40-90), may also be mentioned. He wrote a five-volume book entitled *De Materia Medica* (On medical material), in which he described more than 700 medicines used in the antiquity. Apart from the pharmacological interest of the Dioscorides' work, he, being a surgeon of the Roman army, also had the opportunity of dealing with a variety of injuries and establishing the basis for future surgery. Many other examples of old medical practice might be mentioned, but those offered above may suffice to illustrate the idea that Medicine has always endeavoured to improve the human condition.

Turning our attention to recent days, the work of Joseph E. Murray (1919-2012) should be mentioned. This American surgeon was a pioneer of organ transplantation and carried out the first successful kidney transplant in 1954. He proposed that medicine, and especially surgery, had passed or has to pass four stages, four "R's": Remove, Repair, Replace, Regenerate. Actually, the first surgical interventions just involved removing the affected member, for instance, a gangrened leg or a severely injured arm. In these instances, implantation of prosthesis was the solution of choice to improve the patient's quality of life. The old wooden leg was step by step substituted with more and more sophisticated prosthesis and, presently, a patient can many often lead a normal life after leg amputation, and the same is valid for other body members.

Surgeons also tried to repair damaged organs, without removing them. For instance, elemental cataract surgery was already used in ancient Egypt during the Fifth Dynasty (2467-2457 BC) and Galen (2nd century BC) performed an operation closely resembling the modern methods. Obviously, surgical methods have considerably improved over time and now it is possible to surgically treat an ample number of pathological conditions. Repair of damaged organs may also be done by implantation of artificial devices. The simple hearing aids, or the more sophisticated cochlear implantations, are used to treat hypoacusia. Mechanical heart valves, which may be implanted by open heart surgery or in a minimally invasive transcatheter operation, have aided to save thousands of lives. This couple of examples may illustrate how technology has attended to the accomplishment of the second "R".

The third "R", replace, was, as mentioned above, the one pioneered by Joseph Murray, who was awarded the Nobel Prize in 1990 (Murray, 1990) (Leeson & Desai, 2015). Nowadays, organ transplantation is a common practice in most countries; more and more organs have been added to the list opened by kidney and millions of lives have been saved thanks to these interventions.

Gene therapy may be considered within the third "R" because it consists in a replacement at a molecular level. Monogenic diseases, namely, pathological disorders caused by the dysfunction of a single gene, can be treated by inserting in the patient a correct copy of the gene. Detailing the methods used for gene therapy is out of the scope of the present article. It may suffice to mention that the early procedures of *in vivo* transfer of genes, usually using viral vectors, were halted in 1999 due to the death of a patient in a trial of an adenovirus-vectored treatment for an enzymatic deficiency. This disgraceful event prompted the researchers to look for improving the safety of *in vivo* procedures, as well as to substitute them by *ex vivo* transfer. In the recent years significant advances have been reported in gene therapy, especially in the field of monogenic diseases (Papanikolau & Bossio, 2021). Specifically, several strategies to treat cystic fibrosis, caused by mutations in both copies of the *CFTR* (cystic fibrosis transmembrane conductance regulator) gene have been recently reviewed (Lee et al., 2021). Advances in the gene therapy targeted at some monogenic haematological disorders, especially β-thalassaemia and sickle-cell disease, have also been described (Mussolino & Strouboulis, 2021) (Ali et al., 2021), although much research is required to cross the gap from *bench to bed-side*.

The techniques for genome editing were soon envisaged as a promising resource in gene therapy. Among these techniques, the CRISPR-Cas technology stands alone. CRISPR is an acronym of "clustered regularly interspaced short palindromic repeats" and Cas stands for CRISPR associated protein. In 2012, Charpentier and Doudna suggested that the CRISPR-Cas system "could offer considerable potential for gene-targeting and genome-editing applications" [Jinek12] and since then this method has experienced a rapid and fruitful expansion, allowing the senior authors of this article to win the Nobel Prize of Chemistry in 2020. Nevertheless, the method was based in several previous findings, started by the Mojica's discovery in 1993 of a novel DNA organisation in Archaea, consisting of repeated sequences of 30 base pairs, separated by spacers of roughly 36 base pairs (Mojica et al., 1995). This organisation was afterwards found to be present in a wide variety of prokaryotes (Mojica et al., 2000). The whole history of the discovery and its relevance for the ulterior development of genome editing in mammals was reviewed in 2016 (Lander, 2016).

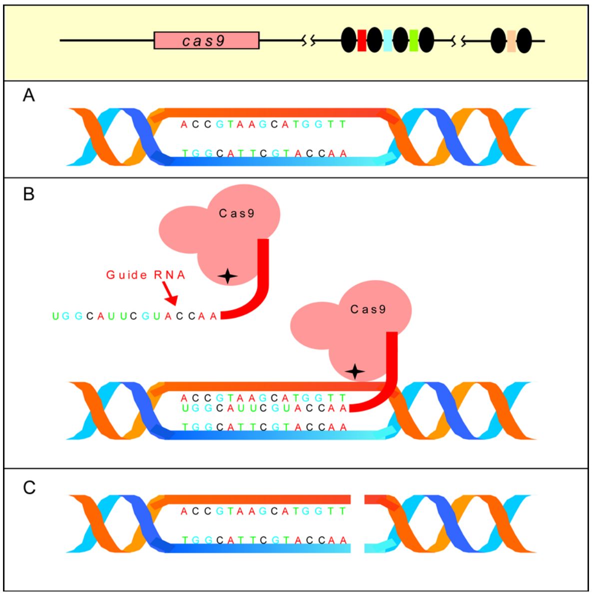


Figure 1. A simplified survey of the CRISPR-Cas technology. The box highlighted in light yellow contains a simplified outline of the CRISPR-Cas system from bacteria like *Streptococcus thermophilus*. The cas9 gene is indicated by a pink box. The ovals stand for the CRISPR repeats and the coloured rectangles interspersed among them represent fragments of the genetic material of viruses which have previously infected the bacterium. The remaining panels summarise the CRISPR-Cas technology. (A) Region of DNA to be edited. For clarity, the central helix turns have been displayed as separated strands. (B) The complex of Cas9 endonuclease and a manufactured guide RNA, with a sequence complementary to that of DNA is shown in the upper part of the panel, while the hybrid between the complex and DNA is depicted at the bottom of the panel. (C) After acting the endonuclease, a double strand break has been introduced into target DNA. The gap may be filled with an exogenous piece of DNA.

The simplest CRISPR-Cas system of bacteria consists of a locus in which the gene *cas9*, coding for an endonuclease, is in the vicinity of a series of the palindromic repeated sequences, separated by fragments derived from the phages, which have previously infected the bacteria. In this way, should a phage invade again the bacteria, the "memory fragment" may hybridize with the genetic material of the invader and the endonuclease destroys it. The CRISPR-Cas editing technology takes advantage of this mechanism. Briefly, a guide RNA complexed with the Cas endonuclease is delivered into cells and the endonuclease is directed to the DNA sequence hybridizing with the guide RNA, with the result of the cleavage of DNA. As guide RNA may be constructed to target any desired DNA sequence, the method provides a system to eliminate incorrect DNA and, with a further modification, the technique allows its substitution by the correct sequence. Obviously, the potentiality of the CRISPR-Cas editing technology in gene therapy is enormous, but much more research is needed to eliminate the possible deleterious consequences due to off-target effects and other negative outcomes. Figure 1 shows a simplified survey of the CRISPR-Cas technique.

Murray envisaged a fourth "R", regenerate, which might allow restoring the functionality of a damaged organ by ways other than surgically repairing or replacing it. The era of regenerative Medicine, as aptly called by Leland Kaiser (Kaiser, 1992), was beginning, and the interested reader may find a report of its early achievements in an early review (Sampogna et al.,2015).

Anyway, this issue will be dealt with later in the present essay.

2. TRANSHUMANISM AND POSTHUMANISM: BASIC CONCEPTS

In the previous paragraphs an outline of the application of medical and surgical procedures to heal human beings has been given. It is important to note that, even when artificial devices were used, all the above-mentioned methods were limited to restore the normal abilities lost by injuries or diseases.

The possibility of applying technical methods –surgical, biological, mechanical or electronic– to make humans acquiring novel capacities was also envisaged by some visionary people, often resulting in science fiction books or films. For instance, the plot of the Joseph Green's film "The Brain That Wouldn't Die" (1962) revolves around an unscrupulous doctor, who has developed a procedure to keep human organs alive after the death of persons. When his fiancée was decapitated in a car crash, the doctor kept her head alive waiting for a woman body to transplant the head onto it. More and more sophisticated plots, in which genetically-modified or robotized humans, and a panoply of half-human characters, are surely remembered by the fans of science fiction literature.

But the question behind those stories was: is it possible that a time arrive in which these fiction characters actually exist? In other words, may science make the human beings capable of acquiring unforeseen capacities? Julian Huxley (1887-1975) gave an answer to that question in an essay written in 1957 by saying:

> «The human species can, if it wishes, transcend itself — not just sporadically, an individual here in one way, an individual there in another way, but in its entirety, as humanity. We need a name for this new belief. Perhaps transhumanism will serve: man remaining man, but transcending himself, by realizing new possibilities of and for his human nature» (Huxley, 2015).

In this text, Huxley coined the term *transhumanism*. It seems plain that, in spite of his background as an evolutionary biologist, he did not pretend that the realization he mentioned involve evolving to a biological species other than *Homo sapiens*. Man would remain man. And yet, Huxley thought of the possibility that the human species, without renouncing to its nature, may transcend itself acquiring new possibilities. How can men acquire these new possibilities? In other paragraph of his essay, Huxley wrote:

> «The zestful but scientific exploration of possibilities and of the techniques for realizing them will make our hopes rational, and will set our ideals within the framework of reality, by showing how much of them are indeed realizable» (Huxley, 2015).

The road to a further development of the concept of transhumanism and to its putting into practice was opened. Actually, albeit the term was new, the bases of transhumanism, which in some sense support it, have already been laid some centuries ago. When René Descartes (1596-1650) established the *res cogitans-res extensa* (mind-body) dualism, he paved the way to posterior lines of thought, which tend to consider human body exclusively from an instrumental point of view and not as a constituent of the person. The Enlightenment thinkers, emphasizing the supremacy of reason, contribute to widen the gap implicit in dualistic doctrines. The transhumanist theses are supported by dualism. Actually, present day transhumanism considers human body just as a tool to achieve the improvements that technical resources may introduce in human nature. The limits that biology imposes upon human condition may, or even must, be broken and thus, our freedom will be a way to surpass human nature.

Humanity Plus, formerly the World Transhumanist Association gives this outline of transhumanist proposals:

> «*Technologies* that support longevity and mitigate the disease of aging by curing disease and repairing injury have accelerated to a point in which they also can increase human performance outside the realms of what is considered to be "normal" for humans. These technologies are referred to as emerging and exponential and include artificial intelligence, nanotechnology, nanomedicine, biotechnology, stem cells, and gene therapy, for example. Other technologies that could extend and expand human capabilities outside physiology include AI [artificial intelligence], robotics, and brain-computer integration, which form the domain of bionics, memory transfer, and could be used for developing whole body prosthetics» [https://humanityplus.org/ accessed on 3 September 2021].

Nevertheless, the central role of humanism, typical of European Enlightenment, has also been criticized by post-modern thinkers. Friedrich Nietzsche (1844-1900) stands as the first detractor of modern humanism. In the preface to his most known book, *Thus spoke Zarathustra*, Nietzsche wrote: «Man is something that is to be surpassed» [Nietzsche 1896]. He thought that man is a problematic being, half-way between animal and *Übermensch*, superman, who is to come. Some years later, Martin Heidegger (1889-1976) went one step further when, in his *Letter on Humanism*, asked himself: «How can some sense be restored to the word "humanism"?», to answer that: «this word has lost its meaning» (Heidegger, 1949). In this manner, Heidegger was opening the way to posthumanism, a branch growing from the postmodernity trunk.

Though intimately related, transhumanism and posthumanism are not synonymous. While transhumanism looks for improving or even to transcend human nature by means of scientific techniques, posthumanism is, basically, a philosophical doctrine, which aims to reshape the human condition, eliminating what remains of humanism in humans. And yet, there is a basic connection between transhumanism and posthumanism. The words of Robert Pepperell, author of the Posthuman Manifesto, may be clarifying:

> «What is meant by posthuman condition? First, is not about the 'End of the Man' but about the end of a 'men-centred' universe. In other words, it is about the end of humanism, that long-held belief in the infallibility of human power and the arrogant belief in our superiority and uniqueness. This 'end' will not happen abruptly. Belief in the ideals of humanism has existed at least since the fourteenth century and will continue to exist well into the future» (Pepperell, 2003).

Pepperell believes in technocracy as a mean to arrive to the posthuman condition, while Heidegger was decidedly anti-technocratic. Therefore, they may be considered as representatives of transhumanism and posthumanism, respectively, although the contact point between them is obvious from the above Pepperell quotation.

Some decades ago, these proposals would be surely considered just as an academic question, if not a science fiction plot as those mentioned above. Nevertheless, transhumanism is gaining adepts all over the world and some cyborgs –a portmanteau of *cybernetic and organism*– actually exist. The first one was Neil Harbisson, who suffers from achromatopsia, a congenital defect that results in colour-blindness. He received the implant of an "Eyeborg", developed in 2003, which allows him to perceive colours as sounds. The dancer Moon Ribas is recognised as the world's first cyborg woman. A sensor that detects seismic waves was implanted in her feet. It vibrates whenever an earthquake occurs over the world, so she can dance following the seismic rhythm. Harbisson and Ribas have launched the "Cyborg Foundation", which intends aiding humans to become cyborgs and to have the *rights of the cyborgs* recognised. They also claim that we all are in transition to become cyborgs.

Creation of cyborgs is only one of the transhumanism proposals, which include all the aspects comprised by the NBIC (Nanotechnology, Biotechnology, Information Technology and Cognitive Sciences) convergence. In this way, the possibility of artificially induce biological transformation of human beings to acquire novel possibilities, for instance, increased longevity or even immortality is contemplated. The link between the human brain and computers or artificial intelligence is also a goal that transhumanists wish to achieve, as manifested by the Humanity Plus statement quoted above.

It is obvious from the preceding paragraphs that in revising the possibility and the risks of transhumanism not only the scientific and technical aspects must be considered, but also the philosophical and ethical ones have to be taken into account. Actually, transhumanism has to be accessed on one hand from basic or applied sciences, and, on the other hand, by humanities (Fig. 2). The next section of the present article will deal with the technical possibilities upon which the transhumanist ideals are built; subsequently, some ethical and anthropological questions will be considered, but the philosophical issues of posthumanism will be only tangentially addressed.

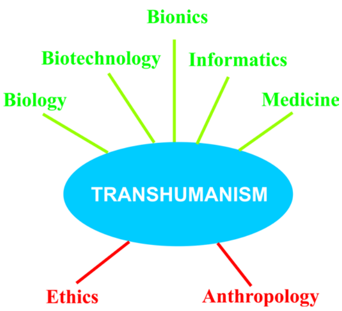


Figure 2. The connection of transhumanism with experimental sciences and humanities.

3. BIOMEDICAL BASES FOR AN IMPROVEMENT TO THE HUMAN BEING

The impact of prostheses and ortheses in the improvement of human health and in the recovering of lost abilities by diseases or injuries has been commented before. Actually, these devices, although with increasing sophistication, have been for long time in use. Organ transplantation has become a routine practice in many hospitals all over the world and the use of robotic surgery, often in its image-guided version (Wendler et al., 2221), is rapidly expanding. Nanotechnology is also profusely being used in medicine (Hayat et al., 2021). All these methods are being used and they are aiding to improve the health and quality of life.

Some other biomedical procedures to improve human health are presently under development. Regenerative medicine, whose early achievements were mentioned above when commenting the fourth "R" of Joseph Murray, must be first dealt with.

Cell-based therapy has been in use, especially in haematological malignancies, since the first successful bone marrow transplant in 1968, carried out by Fritz Bach (Bach et al., 1968). And when the first culture of murine embryo stem cells was established (Evans & Kaufman, 1981), the potentiality of stem cells to regenerate human organs or tissues was envisaged.

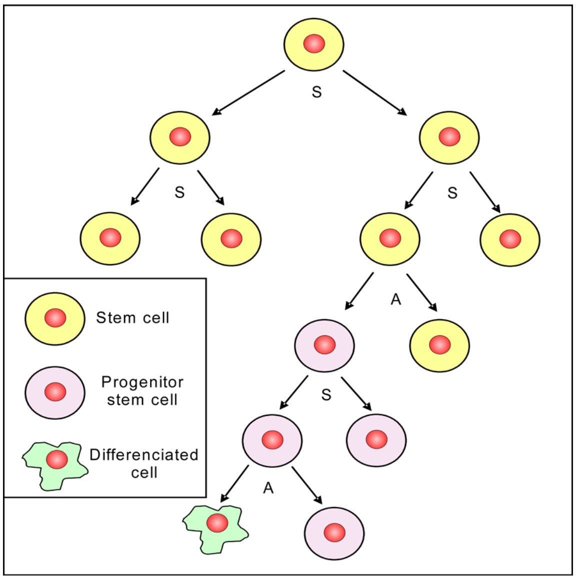


Figure 3. Division of stem cells. "S" stands for symmetrical divisions, giving rise to two identical cells. "A" means asymmetrical divisions, in which one of the daughter cells is identical to the mother cell, while the other one is phenotipically different and with a lesser potentiality. The inset shows the key referring to the nature of the cells.

It is not easy to give a precise definition of stem cells, but they can be described as non-differentiated cells with capacity for extensive proliferation giving rise to more stem cells (self-renewal), as well as for generating differentiated descendants (Siminovitch et al., 1963) (Fig. 3). Many, though not all, of the inner cellular mass of the blastocyst –a stage of embryo development that in humans occurs between days 5-9 after fertilisation– are stem cells. But this type of cells is not exclusive of embryos. First evidence for the existence of stem cells in adult tissues were obtained in 1963 (Becker et al., 1963) (Siminovitch et al., 1963) and, especially since the work of Catherine Verfaille's group (Jiang et al., 2002), stem cells have been found in almost all adult tissues. Moreover, these cells may, in many cases, be described as pluripotent, as they can differentiate to several lineages after adequate treatments (Jiang et al., 2002). The cells derived from bone marrow are unique in having a high degree of plasticity, which allows them to differentiate to a large number of cell types under appropriate stimuli (Aithal et al., 2021).

A novel landscape opened in the field of stem cells when, in 2006, Yamanaka's team at the University of Kyoto was able to reprogram murine fibroblasts to de-differentiate them and obtain embryo-like pluripotent cells [Takahashi & Yamanaka, 2006]. They aptly named these cells induced pluripotent stem (iPS) cells. One year later, they described a similar procedure from human fibroblasts (Takahashi et al., 2007). These important contributions led Shinya Yamanaka to be awarded the 2012 Nobel Prize of Physiology or Medicine "for the discovery that mature cells can be reprogrammed to become pluripotent". The plasticity of iPS cells to differentiate to most cell types has been afterwards reported.

At the present moment, the use of stem cells is mainly centred on regenerative medicine. There was an initial feeling that embryonic stem cells will be the panacea for many diseases. Nevertheless, both ethical and technical considerations have made of the adult stem cells the material of choice in most cases. Ethical concerns arise from the fact that human embryos have to be sacrificed to obtain stem cells from the inner mass cells. The technical caveats are based in the possibility of the growing of teratomas in the patient receiving the implant. A well documented case of a donor-derived brain tumour generated after implantation of foetal neural stem cells was early reported (Amariglio et al., 2009). Therefore, although iPS cells are steadily gaining relevance, a very large proportion of the active clinical trials using stem cells is carried out with cells derived from adults. The U.S. National Institutes of Health maintains a database of all the private or publicly funded clinical trials around the world, in which it is recorded that, out of the more than 7500 trials registered, only 1% is carried out with embryo stem cells, while 97.3% use stem cells derived from adult tissues. The remaining 1.7% corresponds to assays with iPS cells [www.clinicaltrials.gov, accessed on 3 September 2021].

The techniques described so far in this section fit into one or other of the four Murray's "Rs". But it has to be kept in mind that transhumanism aspires not only to restore the faculties lost by disease or other causes, but also to "improve" the human condition. What does improvement mean under the transhumanist perspective? Obviously, to acquire novel faculties, which are not naturally possessed by humans. Biotechnology may contribute to this acquisition in several ways. Genome editing might, in principle, allow modifying human genome. The first report of genome editing in humans was done in 2018, when He Jiankui, a Chinese researcher, announced that a couple of twin babies were born after genetic manipulation of embryos derived from *in vitro* fertilisation of eggs from a healthy woman and sperm from her human immunodeficiency virus (HIV)-positive partner. The embryo manipulation involved a CRISPR-Cas targeting of the *CCR5* gene, which encodes the most important protein used by HIV to enter human cells, to make this protein non-functional in an attempt to make the babies resistant to HIV infection. The scientific community reacts with extreme criticism to this experiment and the Nobel laureate David Baltimore, for instance, declared his "horror and dismay" at the Jiankui's work (Lovell-Badge, 2019). Apart from the ethical concerns about human embryo manipulation, the most relevant criticisms arose from the uncertainties of the technique derived from the possibility of off-target effects and from the fact that a modification of germ-line cells will be transmitted to descendants. Civil authority also reacted against this experiment and finally Jiankui was sentenced to imprisonment.

It is true that scientific community and civil authorities have condemned this first experiment of manipulation of germ-line cells with reproductive purposes, but one can wonder whether the ethical alarms were only based on the safety of the procedure. If it is so, and no other concerns were raised (see below), it is technically possible that, in a more or less distant future, the transhumanist dream of genetically modifying human nature will be fulfilled. In a similar way, the recent experiments of the Izpisua's group in which they created human-monkey chimerical blastocysts with no reproductive purposes (Tan et al., 2020) might in a future turn to raise hybrid offsprings.

As above mentioned, transhumanist thinking has entertained hopes of increasing longevity. Actually, life expectance is steadily increasing and the biological possibility of a further increase truly exists. The relation between the length of telomeres and aging has been long known and many attempts have been made to increase longevity through genetic modifications involving an increase of telomeres. Recently, the generation of mice with hyper-long telomeres derived from embryonic cells has been reported (Muñoz-Lorente et al., 2019). These mice not only show an increased longevity, but also have less incidence of spontaneous cancer than the unmodified mice. Of course, these or similar procedures might be applied in a future to humans, in spite of the profound ethical concerns that this intervention would imply. It must be noted, however, that lowering the incidence of mortal diseases and increasing life span do not imply that the immortality can been reached; it only simply means that death may be delayed. The biological complexity of human life and the intricate control mechanisms involved in its maintenance most surely result in a temporal limit for life, an asymptote to which scientific progress may approach but not trespass.

A reference to a science fiction plot in which the protagonist has discovered a method to indefinitely preserve organs, brain included, has been mentioned above. Cold is usually required to maintain for a few hours organs for transplant outcomes and the use of preservation solutions improve the conservation of organs (de Sousa et al., 2021). Several strategies to prevent the risks inherent to ischemia and re-perfusion of organs are in use and perfusion machines from normothermic (35-38ºC) to hypothermic (0-12ºC) temperatures are also being employed (Petrenko et al., 2919). These procedures allow a better and more prolonged conservation of organs. However, preservation of organs at sub-zero temperatures is still an unattainable objective and, although several research projects are under development, they are very far from clinical translation. Therefore, long-term cryopreservation of organs, though commercially offered by several companies is still, at least, of dubious efficacy, and it goes without saying that the cryopreservation of whole body seems a science fiction issue more than a scientific one.

To check whether brain functionality may be retained after a prolonged postmortem interval, a protocol involving a pulsatile-perfusion system of porcine brain has been used by Vrselja *et al.* (Vrselja et al., 2019). In their provocative article they showed that some molecular and cellular functions may be restored under normothermic *ex vivo* conditions up to 4 h post mortem. They concluded that tissue damage results more from the perfusion method than from ischemia per se. Nevertheless, in an experiment in which the brain of young adult pigs was exposed to 30 min of ischemia by clamping of cerebral arteries, subsequent perfusion restored some of the functions affected by ischemia but not the histological injuries (Lindblom et al., 2020). A more recent article (Nair-Collins, 2021) raised serious criticisms against the translational value of the pulsatile-perfusion techniques. Therefore, the question remains open.

The technological possibility of achieving the transhumanist goals has been so far restricted in the previous paragraphs strictly to the biotechnological methods. Cyborgs actually exist as commented above, and the option of extending their capacities to acquire novel unnatural abilities is not an imaginary possibility. To go a step further, one can wonder whether the proposed link between the human brain and computers is a possible objective. Links between brain and/or central nervous system and electronic devices are already being used for medical purposes. For instance, deep brain stimulation, which involves the surgical implantation of electrodes to stimulate specific brain areas, is being used for more than 15 years to treat the motor symptoms of Parkinson's disease (Anderson & Lenz, 2006). These devices were permanently approved by the USA Federal Drug Administration (FDA) in 2013.

A brain interface known as Wireless Artifact-free Neuromodulation Device' (WAND) has been implanted in a monkey to record, stimulate, and modify its brain activity (Zhou et al., 2019) and there is an increasing interest of using deep brain stimulation to improve fitness in the sports. An account of the possibilities and future outcomes has been recently recorded in a Royal Society Report [http://www.royalsociety.org/ihuman-perspective, accessed on 5 September 2021].

The psychological effects of deep brain stimulation have been recently reviewed and the authors conclude that more research on this subject is needed (Wilt et al., 2021]. Brain-to-computer implants are also under development to help people who have lost control of motor or other functions by disease or injuries affecting the central nervous system. The first clinical trial with these implants was reported in 2003 (Warwick et al., 2003).

The use of deep brain stimulation or of brain-to-computer implants for curative purposes cannot be classified under the category of transhuman (see below) and yet they open the door to true transhumanist objectives. For instance, it has been claimed that brain-to-computer implants, if carried out in two individuals, will allow thought communication between them through an intermediate computer. In a similar manner, some authors think that this technology might eventually result in an integration human and machine; in this way, they think, *Homo sapiens* will evolve to *Homo technologicus* (Warwick, 2016). The rapid advancement of neurosciences and the launching in 2013 of the Europe's Human Brain Project may result in a better knowledge of the mechanisms of brain functions. This is an ambitious ten-year project, which initially had an expected budget over 1 billion Euros and includes 134 partners in 19 countries. It may drive the convergence between the neurosciences and modern information technologies, but the complexity of human brain and of the relationships between mind and brain makes the integration human-machine a highly unattainable goal.

4. ETHICAL AND ANTHROPOLOGICAL IMPLICATIONS OF THE TRANSHUMANIST PROPOSALS

As previously mentioned, the transhumanist proposals transcend the limits of Biology and technology due to their philosophical implications. A first consideration refers to the use of the word "improvement" by the transhumanism ideals. The Oxford Dictionary defines it as "the act of making something better". A second word often used by transhumanist authors is "enhancement".

Again, we can turn to its definition, given by the Oxford Dictionary as "the act of increasing or further improving the good quality, value or status of somebody/something". In what sense are the transhumanism proposals trying to make the human condition better?

It is obvious that human health can be made better by medical resources, even when these resources are artificial. Technological instruments, such as a pacemaker, certainly makes better the health of a patient when the electrical conduction system of the heart fails as the much ruder wooden leg also made better the life of a person lacking one limb. The possibility of sharing thoughts with other people through brain-computer interfaces, would also mean an improvement? Or, reaching immortality would enhance human condition? Where the boundary between non-transhumanist and transhumanist improvement may be placed? It can be said that a non-transhumanist improvement maintains the human nature of the improved subject. A person wearing a pacemaker has not compromised his/her human nature. What did Huxley mean when, coining the term transhumanism as mentioned above, said that man will remain man, "but transcending himself, by realizing new possibilities of and for his human nature"?

To understand what transcending human means, it has to be first defined what a human being is and what an improvement may signify. Both questions are intimately related. The technological applications to human therapy mentioned above do not renounce the concept of human nature and, therefore, one can confidently say that they actually result in an improvement of human condition. Nevertheless, when technology tries to go behind human nature it is difficult to decide between enhancement and degeneracy because the criteria of evaluation have been lost. The changes introduced in that way will lack their axiological component and, actually, they will be deleterious, as the absence of evaluating possibilities involves itself a lack of value (Marcos, 2010).

These questions, as well as the setting of a boundary between non-transhumanist and transhumanist improvement, are not easy to answer, because they go deep into the debate on human nature. The classical Aristotelian concept of nature as "a source or cause of being moved and of being at rest in that to which it belongs primarily" inspired the philosophical thinking for centuries. It has to be noted that, for Aristotle, "rest" did not mean the cessation of an action, but the maintenance in the state acquired by the movement or action. Nevertheless, the concept of an immutable nature is not universally accepted. It commenced being questioned at the onset of Renaissance, but it was only after Nietzsche that many philosophers began thinking the human being as pure freedom, capable of self-determination and of being self-constructed after his/her own will. The posthumanism of Sloterdijk, for instance, is developed following Nietzsche and Heidegger (Sloterdijk, 2009) and the classical concept of nature is not accepted by this line of thinking.

Apart from the contradiction of using human freedom to surpass the human condition, several concerns have been raised over transhumanism from an ethical point of view. For instance, should that envisaged *Homo technologicus* be truly free, or rather his behaviour would be determined by technology? A second concern is that clearly the high-cost technology required to reach some of the transhumanism proposals would make these goals –if actually achievable– accessible only to a limited selection of people. In this way the already existing social and economic inequalities would be sharpened. For instance, Francis Fukuyama, well known for his ideas on the end of history, is very critical of the transhumanism and alerted to the social and juridical consequences that the modification of human being may imply, especially for underdeveloped countries and for the social equality (Fukuyama, 2002).

The use of DNA editing procedures in germ-line cells has also received serious criticisms. An example was previously mentioned apropos of the He Jiankui affair, but rejection of this type of experiments should be not only based on security concerns. The manipulation of germ-line cells itself imply serious ethical objections, because, apart from the doubts raised against the method itself, no one might compromise the future of his/her descendants.

From an anthropological perspective, the separation of memory and conscience from the body, which may result from some transhumanist proposals based on the brain-to-computer implants, involves a return to the dualistic doctrines, which consider human body as a simple tool to achieve some functions and not as a fundamental constituent of human personality. Moreover, the idea that all our thoughts and remembrances can be downloaded to a computer results from an extremely narrow view of human mind (Diéguez, 2017). Human intellect is able to comprehend the reality, and reality cannot be reduced to a series of data downloaded from an informatics device, incapable of posing questions.

And, finally, it must be mentioned that transhumanist proposals put aside the spiritual aspects of the human being. Whatever the sense that one give to the word "spiritual", it cannot be denied that it involves an important dimension of men and women. Many persons understand spirit as a synonym of soul; others may consider it just as the part of a person that includes their mind, feelings and character rather than their body. At any rate, it seems clear that this reality that distinguishes humans from animals cannot be disregarded when treating to ameliorate human condition.

5. ALTERNATIVE PROPOSALS

It would be unfair to finish a discussion on transhumanism by mentioning only its weaknesses. The desire of improving human condition not only is a reasonable one but also an aspiration of medicine, psychology and all the sciences dealing with man. So, if the transhumanism programme faces numerous and serious objections as commented above, alternative proposals must be put forward.

Man, after thousands of years of evolution, has reached a plateau in his biological conditions. Actually, the biology of the present day *Homo sapiens* is practically identical to that of the founder members of this species. Of course, this does not mean that the biological qualities cannot be improved. A simple examination of the athletic records, for instance, shows that the Olympic motto *Citius, Altius, Fortius* (Latin for "faster, higher, stronger") is not only a nice hendiatris, but also a reality, as we can observe how the records have been steadily broken. This has been achieved by training and adequate coaching, by a more profound knowledge of human anatomy and physiology and, of course, by effort and even by the suffering of athletes. The Olympic Committees do not allow using doping, artificial devices or other non-natural means to improve the records. In the same manner, the improvement of human physical capacities must be achieved by personal exercise and science and technology may continue aiding people to further develop their natural abilities.

Of course, in the field of human health it is obvious that every effort to restore and improve the wellbeing of every person –irrespective of the sex, race, age, and any other distinguishing characteristics– will be welcome. Science has much to do in this respect. To quote only a few lines of action in the field of biomedicine, further research in personalized medicine, in the safe applications of CRISPR and other techniques of genome editing and in cell therapy in somatic cells will certainly give hopeful results in the near future. In a similar way, the use of iPS cells in the understanding of the molecular basis of many diseases and in regenerative medicine will improve human health. The perfection of artificial organs, which are already being used, will result in the future in the restoration of the natural functions lost by disease. Tissue engineering is now making simple neo-organs from stem cells within matrix scaffolds, often constructed with 3D printers. It is necessary to improve the methodology to achieve a new goal in regenerative medicine.

The idea that we use only a 10% of our brain is a myth, often attributed to Einstein. But it is true that we can potentiate our brain activity by means of an intellectual activity, such as lecture, because, in this way, the number of neuronal connections will increase, with the consequence of an improvement of logical thinking. And this, in opposition to brain-computer technology, is an easy to develop activity, provided that education is accessible to everybody. Moreover, as mentioned above, it remains to be determined whether brain-computer devices alter human psychology (Wilt et al., 2021).

«L'homme est la seule créature qui refuse d'être ce qu'elle est» (Man is the only creature who refuses to be what he is) wrote Albert Camus (Camus, 1951), but man has not to renounce the human nature to enhance his brain capacity, his health or his abilities. As aptly wrote Velázquez, «El hombre debe llegar a ser lo que debe ser a partir de lo que esencialmente ya es» (Man must become what he must be from what essentially already is) (Velázquez, 2009)

Of course, to accomplish this objective every kind of resources that Nature or science offer can be used, provided that man do not cease to be what he must be, namely man, a member of human community or, from a biological point of view, an individual of the *Homo sapiens* species.

Perhaps, as Murillo pointed out, the modern rejection of the notion of nature can be explained by the difficulty in understanding that notion. Many transhumanists consider nature as "that what exists", or as "a series of facts subject to strict laws"; in other words, they think of nature as something merely factual. Nevertheless, the classical concept of nature points towards that what we must accept in something in such a way that it may be improved or worsened. Of course, to have a nature is to be in a determined manner, but it is not possible to be something natural without a specific orientation towards an end (Murillo, 2014). Again, this assessment may be in conflict with some philosophical schools, which reject teleology, but, if accepted, one may conclude that man must evolve not to destroy his nature, but to perfect it in order to achieve his end. According to Yepes-Stork, the end of man is to perfect to a maximum his capacities, especially the superior ones: intelligence and will (Yepes-Stork, 2096). This implies that not only the corporal capacities must be improved, but also the moral and sociological attitudes must be developed. The trite discourse on solidarity must turn into a real compromise to let every man and woman access better medical and educational facilities. The vulnerability of human beings has to be accepted as constitutive of the human nature. So, every effort to overcome the weaknesses of human nature without destroying it will be welcome. To answer the title question, transhumanism may be possibly in some of its proposals, but many of them would result not in an actual improvement of human nature, but in a chimerical one.

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