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The Ethics of Synthetic Biology - at the Confluence of Ecoethics and Technoethics

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Abstract: In the case of synthetic biology, the responsibility of humanity for the creation of new technologies that interfere with the processes of natural selection and evolution of species can be invoked, thus annihilating the complex ecological balances and possibly leading to uncontrollable genetic mutations. The big ethical questions are raised by the fact that viral genetic material is hybridized with synthetic genetic material, as well as with the genetic material that underlies the DNA of various living cells, that might interfere with synthetic genetic material - either due to errors in the handling of genetic content or the inability to predict the evolution of synthetic biological systems, an evolution beyond any mathematical modeling that would allow the estimation of biological risks given by the appearance of new species - partially or totally synthetic - and especially by their spread in ecosystems. In this article we will plead for an ethical modeling of technology and a wider communication between ethicist and bio-engineers in order to estimate the directions of technological evolution, especially in the case of synthetic biology.

Keywords: *synthetic biology, ecoethics, technoethics, the ethics of synthetic biology.*

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1. Introduction

Attempts to propose an ethic that addresses synthetic biology in particular, given the particularities of this new branch of science and technology, have generally been made from the perspective of the ethics of scientific research, thus creating models of good practice and codes of ethics for professionals in the field or, respectively, works that review the ethical issues that may arise in the future - thus being elements of prospective ethics - which are generally tried to be solved in a principled manner, with the current tools of applied ethics.

Researchers such as Erik Parens et al. (2009) from the Hastings Center in New York believe that this particular area of ethics in synthetic biology should be treated with research tools specific to the ethics of new emerging technologies, as they are in fact a continuum of ethical interest, compared to the changes that technology brings in the quality of human life but also in the evolution of human society.

This type of new technologies, which produce a paradigmatic societal change (El Karoui et al., 2019), i.e. have the ability to produce civilizational changes - we are talking here about genetics, robotics, information technology -, are often called disruptive technologies (El Karoui et al., 2019). This ability of biotechnology in general and synthetic biology in particular to create civilizational change has of course a pragmatic component - that of building living biological products, based on a computational design (El Karoui et al., 2019), an epistemological one - to change the onto-epistemic accent of the universe -, as well as a civilizational one - which credible ontological models could be based on intelligent design and which presuppose the creation of the world, at least the living one, on Earth, as an intervention of higher civilizations acting in a manner analogous to that used by researchers in synthetic biology, either to create life on various planets (Kitadai & Maruyama, 2018) – including Earth - or to intentionally alter the genome of some species, including in order to raise them to self-awareness (Levin et al., 207).

Special mention must be made of the anthropocentric dimension of synthetic biology, which places human design at the heart of the "new creation" thus entailing a huge responsibility that, mishandled, can bring serious disturbances in the ecological balance, that sometimes might even be irreversible.

1.1. Towards an ecoethics of synthetic biology

Concerns about ethics have become important on the public agenda with the understanding of the impact that human activity has on the environment and that this impact must ultimately be treated in an ethical manner, basing any analysis on the moral significance of human action and on personal, collective, corporate or societal liability. Robert Elliot asks a number of questions about the degree of ethical acceptability of industrial development, with consequences for the preservation of the environment and biodiversity, starting from a case study on Kakadu National Park in Australia, an ecosystem of special ecological importance due to biodiversity and endangered species. The area is considered by the locals as a sacred space, with a high spiritual significance. At the same time, the Kakadu National Park is located in an area rich in resources of gold, palladium, platinum, uranium - the exploitation of which brings particularly important material benefits, at the cost of the partial destruction of the environment and biodiversity. Mining is also considered by the aborigines to have a desecrating effect on the site (Elliot, 2012).

Under these conditions, eco-ethics specialists are called upon to decide on the possible solution to the ethical dilemma regarding the choice between the economic value and the spiritual-human and environmental value of the region. A situation similar to that presented by Elliot can be exemplified by the situation of Roșia Montana in Romania, an area rich in gold, silver and uranium deposits - the exploitation of which can lead to advanced environmental degradation, including radioactive pollution. On the other hand, the exploitation of gold deposits creates jobs and a relative prosperity for the inhabitants of the area.

Such situations in which human activity has a major impact on the environment, have led to the emergence of ecology as a science but also of ecoethics (environmental ethics) as a way of analyzing the desirable behavior regarding nature. If environmental legislation sets out guidelines for practices and procedures permitted or prohibited in the exploitation of resources, eco-ethics comes to justify the attitude that humanity must have towards the environment and towards the complexity of the situation that involves values other than ecological or economic - such as cultural, spiritual, aesthetic.

In such situations, eco-ethics should allow for the use of principles that transcend mere interests, allowing for the balancing of different and otherwise irreconcilable values. The questioning of liability, for example of the polluter, is usually based on empirical arguments - such as the imbalance

of ecosystems or the predictable consequences of pollution in a given region in the short or long term.

On the other hand, proponents of industrial development, for example, also claim responsibility - in the context of sustainable development and the rational exploitation of resources, in order to ensure well-being in certain regions. Both sides of the issue can be transposed to synthetic biology products, citing on the one hand, the risks of this technology, and on the other hand the huge benefits it already brings and will be able to bring even more in the future.

An ethic focused on the value of environmental responsibility, including the use of synthetic biology, should address the principle of moral responsibility for the consequences of actions, knowing that the degradation of ecosystems, for example, or of the environment will lead to a decline in the quality of life of the inhabitants of an area or the entire planet. In addition, the environmental responsibility that the eco-ethicist invokes in the case of artificial production of living systems is of interest, and the researcher can be invested with responsibility for the nonmaterial and nonmediated effects that his action entails, including major cultural changes, changes in lifestyle, advanced artificialization of the entire natural environment and its anthropology.

In the eco-ethical approach, one can invoke moral responsibility in the form of a moral guilt regarding the destruction of wildlife, of nature in general, and thus one can formulate a principle of respect due to any living being but also of respect for future generations (Elliot, 2012). Robert Elliot asks a series of questions to which ecoethics and society in general are called to answer:

- How important is society to the extinction of certain species as a result of human activities?
- How much importance is given to killing wild animals, either directly, for example, or indirectly, by destroying their natural habitat?
- Is humanity aware of the risk posed by soil erosion, and if so, are measures being taken to prevent this?
- Is due importance given to the quality of aquatic life and its richness and diversity both on the planet and in the watersheds near industrial sites?
- Is there a dynamic balance between economic and social development, be it sustainable, and the risk of extinction of some species?
- Is the extinction of some species considered ethically acceptable due to negligence or lack of responsibility, or as a price of regional economic development (Elliot, 2012)?

In relation to these, in the case of topics related to synthetic biology, we should ask a series of additional questions, such as:

- Is the responsibility to create new species acceptable?
- Is the responsibility of artificializing nature and transforming it into an artifact acceptable?
- Is it acceptable to lose the sacredness of nature?
- Is it acceptable for human researchers to assume a demiurgic role and "play God"?

Peter Singer outlines 4 directions for the development of ecoethics that we will address in the following subchapters.

1.2. Anthropic ecoethics

Anthropic eco-ethics - or human-centered environmental ethics - and its implications for environmental change entails that, in the human-centered ecoethics, moral value is given only to the human being, the protection of the environment having no other role than the preservation of some factors that definitively influence the quality of human life.

According to the Kantian tradition, the human being is the only one who can develop a moral consciousness and, as such, can stand as a subject of moral evaluation, as an end in itself and not as a means. Thus, environmental policies are applicable and justified only when the development of a particular industry currently affects or may affect human beings in the future, either directly or indirectly. This approach also requires accountability for the well-being of future generations and, as such, focuses on the "polluter pays" principle.

The utilitarian side of this approach is to maximize welfare in the context of sustainable development. This form of ethics emphasizes the quality of human life and therefore, ecological decisions must take into account the risks to the quality of life of people living in the area affected by either pollution or the decline of biodiversity that prevent the development of traditional activities - hunting, fishing, etc. Climate change is considered, as well as possible floods due to deforestation, cultural stress caused by the change of the area, especially when it has a sacred value for the community, or diminished leisure opportunities.

All these elements of discomfort are balanced with the positive elements brought by environmental changes such as mining or forestry, urbanization, etc. In general, measures are introduced such as the relocation of communities, the obligation for environmental measures to be taken by polluters, and the compensation that polluters pay to the injured parties. This ethical approach stems from the premise that only the human being is

morally significant and as such only this should be taken into account when discussing responsibility, the rest of nature being eventually given into possession to the humans or to one's own technological inventiveness by a more or less benevolent deity (Elliot, 2012).

This perspective is the most widely used in the ethical understanding of synthetic biology, nature being seen as a resource for man and humanity, and interventions regarding it, including by creating new species but also by changing the genome of some species, can be allowed as long as no major adverse effects are foreseen on human individuals or humanity in general.

Bioethical principles such as beneficience, non-maleficience and equity in access to research results are applicable, while the principle of respect for autonomy is rather replaced by the principle of responsibility and responsible research.

1.3. Ecoethics centered on living systems

Ecoethics focused on living systems - including animal welfare - as well as care for species conservation means that in the field of ecology centered on living systems, we are also talking about a direction centered on life in general, which includes, on the one hand,, the bioethics, but also the ethics of biomedical research. Ethics centered on living systems extends the moral significance and moral value of all living systems, including animals, to which, however, a different moral value is given, depending on their relative perception as sentient beings. In other words, higher evolved animals have a lower value than humans but a higher value than other animals, which are less evolved on the evolutionary scale.

For example, animal experiments may be justified, but harm to animals should be minimized and the suffering of animals should be minimized as much as possible, and those animals which are less sensitive to the harm produced by the experiment should be preferred. Primates are thus superior in moral value to other mammals, vertebrates to invertebrates, animals to plants, macroorganisms to microorganisms.

Depending on the level of sensitivity and closeness that we subjectively attribute to a species with self-awareness, some species are considered to have more "subjective interests" that are protected by legislation against cruelty to animals, the widespread use of animals for scientific experiments, etc. (Caviola et al., 2018).

We are facing an utilitarian vision, which has its starting point in the “estimation of the superior interest” that one species has over another, in granting additional rights. People's self-awareness allows them to perceive

subjective interests beyond the right to life, creating a system of legally regulated rights as human rights.

The right to life and the elimination of cruelty to animals are generally recognized to higher evolved animals who signal that they are endowed with pain receptors, and that they have a minimal awareness of their own self. As such, there are discrepancies between the use of animals generally considered sensitive, as a source of food for humans, and the treatment of other animals as pets, that are granted almost human-like rights, sometimes having a subjective treatment identical to that of a family member. Such an argument about self-interest in animal life is often invoked in promoting vegetarianism as a renunciation to the use of animals as a source of food.

Addressing this issue, Schaefer and Săvulescu even question whether it is morally acceptable for a vegetarian who justifies their food choice by refusing to sacrifice animals to be used as food to consume meat raised in the laboratory in cell cultures. The authors argue that such meat, synthetic, has, from the cellular point of view, the same nutritional value, but also tastes as that of animal meat, without having to sacrifice an animal to obtain it (Schaefer & Savulescu, 2014). The preservation of biodiversity and the reduction of pollution are not exclusively aimed at the well-being of human beings but of animals themselves, when human activity harms them or endangers their individual or species existence.

Such an approach can be demonstrated by environmental policies aimed at the existence of protected areas, winter feeding of wild animals, especially large herbivores, but also the construction of walkways over highways and roads to allow wild animals to cross these roads. from one side of their habitat to the other, without diminishing their necessary living space. The destruction of natural habitats affects animals and not just the ecosystem, and care for living systems is based on the value of life itself and not just human life. However, the protection to which different animal species are entitled is not the same and does not depend solely on their ability to feel pleasure or pain.

The interests of various species are considered to have different moral value, depending on a number of characteristics of the species. For example, endangered species receive greater moral significance in terms of "interest in the survival of the species" - and as such receive different protection (Elliot, 2012).

In our view, the attribution of different interests to endangered species is not necessarily a reference to the animal and its interests, as neither the particular individuals of the species nor the species itself are aware that

they are an endangered species and that therefore, they should not be of additional interest. However, this interest can be attributed to people who subjectively intend to preserve biodiversity, being aware, for example, of the unique value of each species - both for the ecosystem to which it belongs and for living systems in general.

Ecological awareness attaches interest to different species in order to transfer the moral burden of deciding on the future of a species from human shoulders to abstract animal interests. For example, in the case of the Carpathian brown bear, a species once considered endangered, protection has been put in place to ban hunting. Lately, this ban has been replaced by the establishment of hunting quotas that allow the hunting of a certain number of specimens.

It is very difficult for us to understand to what extent the interest of the bear species is to be hunted according to certain quotas, when rather the interest of this species would be to be protected - for example by building walkways over the roads that cross the forests and especially by reducing deforestation that massively impoverishes the food sources from which the representatives of this species can benefit. Basically, hunting quotas are set up, specifying that the bears have multiplied, when in fact - the area in which they can live has decreased. As such, we are faced with a decision based on economic interests, but legitimized by so-called ethical reflections on the interest of the bear.

Ethics in general, and ecoethics in particular, are sources of legitimacy for public policies that are unfortunately not based on real ethical reflection, but questioning the ethics and moral value of species provides the gift of calming the guilt which otherwise some human individuals would have to face in order to morally legitimate ecological disasters. We find the anthropological foundations of this approach of compassion for living beings originating in Buddhism, but increasingly widespread in contemporary Western society through New Age-type movements. Unfortunately, many local or global environmental actions are ethically justified but are not based on a real understanding of the ecological balance, being unilateral measures that only rarely and randomly achieve the desired results.

The creation of new species requires an ethical perspective based on respect for biological diversity, and this approach to living systems is consistent with the general approach of synthetic biology based on systems theory and complexity.

1.4. Life-centered ecoethics

Life-centered eco-ecosystem or ecosystem-centered eco-ethics includes, by extension, mineral systems and mineral resources, but also ecosystems as a whole, beyond the concern for the various areas that are more or less at risk of pollution, contamination, destruction, etc. This kind of ethics emphasizes the interdependence between ecosystems, showing that environmental protection cannot be achieved unilaterally and that, for example, the care for whale rescue must be accompanied by air, forest and water quality, etc.

Life-centered ethic gives moral significance to all living things - animals, plants and single-celled organisms and, moreover, gives moral significance to various ecosystems, the biosphere being endowed with a special moral value. This approach originates in the adaptation and transformation of shamanic, tribal beliefs, recovered in the XXth and XXIst centuries. The connection with nature, with the habitat and even the deification of nature, in some cultures, creates a special relationship with it, in which the human being must integrate, without disintegrating the former.

Nature itself has moral value, and all its components - including man and humanity, as distinct forms of life in nature - borrow their moral value from nature, to the point where individuals belonging to tribal cultures perform rituals of atonement, but also to request the acceptance of a species to have its specimens hunted. Hunting aims to feed the individual and the tribe and cannot be used, for example, as a sport. The recovery of these tribal ethical elements in post-industrial culture is still fragmentary and limited, in the form of an extreme ecology, or in the case of vegan, minimalist movements, etc. In the case of these theories, different moral meanings and values are assigned between the different components of the biosphere, but the paradigm emphasizes the recognition of the moral significance of any living being and even significant nonbiological existences, such as minerals, but especially landforms, water, etc. This ethical approach is reminiscent of traditional thinking, which places sacredness on nature and its components.

We notice that the cult of water is still relevant today - for example, in the Hindu religion, in the form of the worship of the river Ganges, anthropomorphized in the form of the goddess Ganga. Neo-paganism and Wicca movements, tributary to animism, consider that some parts of nature (plants, especially trees) are not only living beings, but also endowed with a certain degree of consciousness and, as such, have an interest for survival, but also have a certain degree of participation in the divine, passing on the

divine or at least extraordinary influences to both people and other nearby beings. These systems of ethics, in their philosophical form, move away from the traditional or New Age significance of this paradigm, emphasizing the value of the complexity of biological systems, as a foundation for the allocation of moral value.

In addition, an additional moral value is assigned to organisms - complex or simple - that have an increased capacity to fill a niche in the biosphere. In other words, this value is assigned to the biological uniqueness of organisms. The moral value is thus different, depending on the significance for the ecosystem and biosphere that the extinction of that class or species would have. As such, bees would have a higher moral value than a certain species of mammal, as the disappearance of bees would lead to the almost total destruction of ecosystems in the absence of pollination processes.

The environmental impact assessment of human actions aims at the general results of human action on any component of biodiversity, being oriented towards ecological balance, awareness of the social responsibility of each individual and of communities, but also of human organizations, such as corporations. Although ethical responsibility often remains a mere legitimate statement, it is often accompanied by concrete actions, not only to protect the environment, but also to enrich it - such as afforestation. The aim is to create a global consciousness, and it is also intended that ethics and environmental protection be part of that global consciousness.

It is aimed at a transhumanity or even a posthumanity, which, not in spite of, but precisely on the basis of technological development, would be able not only to protect nature, but to be an active component of it, helping various species to fulfill their own development potential (Ferrando, 2019). In the radical forms of this panecologism, it is refused to give moral value to any human intervention on the environment. From this perspective, synthetic biology should be completely rejected, as a brutal intervention on nature and as an embodiment of man's will to subordinate and even displace nature.

However, in a post-humanistic approach, artificially created species could have the same moral value as natural ones, with which they share habitats, only if they are exposed to evolutionary vulnerabilities in the same way as natural organisms. The intervention of synthetic biology should be complementary to nature and not completely a substitute for it.

Saving some species, by intervening on their genome or bringing extinct species back to life, can be an action congruent with nature, while the

extreme instrumentalization of the biological would be unacceptable in this ethical perspective.

1.5. Holistic ecoethics

From a certain perspective, the holistic perspective on the environment - or ecological holism - is considered to be the true ecological ethic, as "only such an ethic provides adequate moral protection for the environment. Ecological holism considers two categories to be morally significant: the biosphere as a whole and the complex ecosystems that make it up" (Callicott, 1979).

We are no longer talking about the different moral meanings of the species, but about the ethical significance given to the interactions between ecosystems, the moral value being considered a subjective attribute, practically representing a social construct dependent on the context in which the analysis is performed.

Ecological holism is the result of an understanding of the dynamic interaction between ecosystems, which are viewed from the perspective of complexity theory. The science of complexity starts from the theory of computability, including sub-domains such as electronic engineering, biology, but also ecology, aiming to create conceptual frameworks (Sîmbotin, 2020) for understanding complex systems, including complex, efficient and adaptable profiles. The science of complexity analyzes evolutionary processes, which occur either in physical, biological, or social systems, in a multiscale manner, distancing itself from the linear and fragmentary approach specific to traditional sciences and an epistemology based on the cause-effect relationship (Siegenfeld & Bar-Yam, 2020). In complex systems, interactions and not structure play a key role, and they are dependent on the context in which they take place. In other words, evolutionary interactions must be understood in the complexity paradigm, as being based on an indissoluble link between the organism and the environment, its rupture leading to a decrease in the complexity of the living system.

Ethics based on complexity theory favors interactions aimed at increasing the synergy of the system with the environment in which it operates. Applied to synthetic biology, this paradigm proposes the ethical acceptability of these technologies, as being correlated with the increase or decrease of the complexity that the new living system brings to the biosystems with which it interacts.

2. The bioethical approach of synthetic biology

In the study of bioethics, several series of ethical principles are formulated, meant to guide the medical activity, as well as the research activity when human subjects are involved, when it comes to the development of public health, etc.

The English philosopher R. M. Veatch formulates a series of bioethical principles, among which we mention: the principle of benevolence, of the autonomy of the person, of honesty or correctness, the tendency to avoid death, the principle of justice.

For his part, Ramon Lucas proposes, as fundamental principles of bioethics: "(1) the consideration of life as an absolute and inviolable value; (2) the inseparable link between life, freedom and truth; (3) knowledge for treatment, not for manipulation: intervention in accordance with nature is allowed, but intervention against nature is not allowed, i.e. non-natural intervention is prohibited; (4) the technical advances in medicine cannot be fully accepted morally; (5) the laws must protect the good of the person; (6) double-acting action (the action must be in itself good or indifferent); the negative effect cannot be the cause or the means of creating the positive effect, without the existence of alternatives; the positive effect must be proportionally higher than the negative effect" (Ţîrdea & Gramma, 2007).

The bioethical approach to synthetic biology is generally built around ethical principiism, as formulated by Beauchamp and Childress (2012) (Presidential Commission for the Study of Bioethical Issues, 2010). The principles expressed by them include the principles of beneficence, non-maleficence, respect for autonomy and justice or fairness.

The principle of beneficence presupposes that the activity in the biomedical field must be carried out only in order to increase the well-being of biological systems, especially human ones. In the field of synthetic biology, this principle requires that any changes made to living systems, including the creation of new living systems, take into account the increasing well-being of living systems, especially human individuals. Thus, we could conclude that the modification of the biobricks should not be done randomly, but based on a design created to improve the situation of living systems, especially for human benefit. Whether we are talking about medical or energy applications, environmental protection, etc., the purpose of intervention on living systems must be positive, designed to improve their functioning - generally in favor of people, but possibly in favor of other living systems that require such a protective intervention.

The principle of non-maleficence is aimed at avoiding activities with negative consequences for living systems, especially human ones. Applied to

synthetic biology, this principle should aim to take precautions to reduce or eliminate any risks of misuse of this technology, including through bioterrorism. The same principle may signify the need for prospective reflection on the effects that syn-biotic organisms may have on the environment, once released into the wild.

The principle of respect for autonomy refers to the obligation of medical practitioners and researchers to facilitate the expression of the will of the participants in the biomedical act, be it therapeutic or research. In the case of synthetic biology, ethical risks have been reported regarding the possible misuse of such technologies to the detriment of human autonomy, such as the use of mRNA-based vaccines. The misuse of this technology is related to the ethics of public health rather than the actual ethics of the development of that technology, but in the case of vaccines it can be considered as consistent with the responsibility of the correct and sufficient testing of the product manufacturers and, respectively, correct and complete information to the public on the advantages and limitations of technology.

With regard to the mRNA vaccines used to prevent Covid-19 infection, some of the most virulent criticisms made by the media and the public have been for insufficient testing of both the vaccines and the technologies used to obtain the vaccines. The urgency and "compassionate use" of vaccines were justifications for placing them on the market before all the classic steps in vaccine development had been completed (Sandu, 2020).

The principle of justice or fairness applies both to equitable access to health and to the results of innovative technologies for all sections of the population, including those considered to be disadvantaged. In the case of synthetic biology, the open access publication of research results in the field is such an application of the principle of equity in the dissemination of research results. Access, at reasonable costs, to products obtained through synthetic biology is also a requirement for the application of this principle. In the case of mRNA technology, vaccines have been made available, at least in Europe, to all interested parties free of charge, with their costs being transferred to the Member States and the European Union, respectively.

The same was not true in Asian or African countries, where the population did not receive free vaccination, despite the high rate of infection in countries such as India. These countries, however, have problems in implementing health equity in general, because innovative therapies did not originate in those countries, therefore they were inaccessible to the people in those regions.

Mandatory vaccination is an inequity and, at the same time, a violation of the principle of respect for autonomy, justified by the primacy

of beneficence, in the context of the general confidence in the non-maleficence of this therapeutic approach and the primacy of the public good.

In view of the above mentioned arguments, we find that the principles of bioethics are in a dynamic interdependence and that, in the event of a conflict between the principles, their priority must be established. Usually, one of the principles is considered to be a priority - either charity (especially when we talk about the public good), or respect for autonomy (when we talk about the individual approach to health issues).

Conclusions

The specialized literature in the field of synthetic biology proves to us that the field is in full affirmation and polarizes many energies - both in terms of the development of the technologies themselves and in the field of their social and philosophical reception. However, its reception is dependent on partially inadequate philosophical paradigms, as there is still no ethical construction that can at least capitalize on both the ecological and the research ethics side and that can respond to the challenges that this technology raises. In general, the consulted literature responds to the social fear generated by this technology, but it supports either a conservative side or a libertarian side. Ethics approaches this new science in a technicalized way, partially able to provide guidance to researchers and even respond to the momentary social fear, but we believe that this technology - especially the identified ontological implications - requires a philosophical approach that emphasizes the radicalism of these scientific research that can address the need for moral guidance when most of the values of traditional ethics are questioned.

The consulted literature somewhat bring into focus ethical and philosophical motives related to the philosophy of technologies in general, such as human dignity in the context of technological change, risks to society and the need for biosecurity, possible inequities that will be generated by limited access to such technologies, together with the issue of the Luciferic sin of daring to join the Divinity in the construction of new species. A conservative approach leaves society unprepared for the future, while an overly liberalized approach paves the way for abuses, including those of an ethical nature, abuses that can have incalculable consequences as long as we talk about an ethics of the species.

Synthetic biology and the synthesis of biomaterials can be a powerful help in understanding the mechanisms of structural changes in viral DNA, such as the evolution of COVID-19. On the other hand, we believe that

synthetic biology will not soon pass into the stage of production of standard synthetic organic materials and biotechnologies capable of interacting with both living and non-living substances, materials that may be needed in the construction of human-machine interfaces, even biocircuits capable of being incorporated into organic prostheses that would possibly include nanotechnologies.

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