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Vulnerability at the Heart of the Ethical Implications of New Biotechnologies

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Abstract
Starting from research on biotechnology and its applications to living organisms, this paper presents the key features of modern-day synthetic biology, as well as its main ethical implications. The analysis of the paradox of the concept of robustness in the creation of microorganisms through synthetic biology leads us to address the topic of vulnerability, applied to man, but also to all other living beings. The concept of "enhanced human being" will strengthen the link between complexity and vulnerability as inherent features of living beings. Reflecting upon the importance of considering vulnerability applied to man's three-fold dimensions – physical, psycho-social and spiritual – and their interaction with their environment, we will define a type of anthropology which may constitute the basis of the study on the ethical implications of synthetic biology. This will lead to present the purpose of an ethical limit to the temptation of « all-mightiness », which the concept of enhanced human being could entail, and vulnerability as a defining feature of all living beings.

Keywords
Synthetic biology, Ethical implications, Biotechnology, Enhanced human being

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1. Introduction to the purpose of this research project

The works of the philosopher Jacques Ellul, who so clearly defined the "*Système technicien*" (Ellul, 1977) and warned us of its dangers (technology is, for itself, its own goal), taught us that technology alters the relationship of man (the technicised individual) to the world, the relationship to human beings, the relationship to the self, and to others. Man transforms nature, which, in turn, transforms Man himself. The latter thus inevitably questions the meaning of his action. His brilliant technical skills, particularly in the field of life science technologies, call for great moral abilities to ensure true long-term development to the benefit of humankind.

The second Vatican Council expresses this vigilance in the following extract of the *Gaudium et Spes* constitution (Second Vatican Council. GS 4, 2):

> "Today, the human race is involved in a new stage of its history. Profound and rapid changes are spreading by degrees around the whole world. Triggered by the intelligence and creative energies of man, these changes recoil upon him, upon his decisions and desires, both individual and collective, and upon his manner of thinking and acting with respect to things and to people."

Exercising human power thus represents a major ethical issue.

Considering ethical implications of technologies today is a key step to enable the technicised individual to meet his responsibilities by becoming aware of the transformations he triggers. Man is therefore called to show courage of action. This work on ethics however implies solid anthropological knowledge. This shared research, currently in progress, thus derives from this requirement: at a time when man works to "create living organisms" and in the context of synthetic biology, how should anthropology be considered?

This study will start from the research on synthetic biology, and its possible application to human beings as well as to bacteria and other living organisms, even if ethical implications differ from one situation to the other.

- In this study, I will present the key features of modern-day synthetic biology (for a detailed description of life science

technology today, we may refer to Magnin, 2013) as well as its main ethical implications.

- I will then analyse the paradox of the concept of robustness in the creation of microorganisms through synthetic biology.
- This will lead me to address the topic of vulnerability, applied to man, but also to all other living beings.
- I will then call into question the concept of "enhanced human being", advocated by some scientists, particularly transhumanists. This strengthens the link between complexity and vulnerability as inherent features of living beings.
- I will also reflect upon the importance of considering vulnerability applied to man's three-fold dimensions – physical, psycho-social and spiritual – and their interaction with their environment. Based on this, I will define a type of anthropology which may constitute the basis of the study on the ethical implications of synthetic biology.
- This will lead to present the purpose of an ethical limit to the temptation of « all-mightiness », which the concept of enhanced human being could entail, and vulnerability as a defining feature of all living beings.

2. Modern-day life science technologies

Today's most provoking ethical issues seem mainly related to the field of life science technologies. Biotechnology can be defined as the range of methods and techniques based on living beings (animal cells, plant cells, microorganisms, etc.) or parts of them (genes, enzymes, etc.) which are used for industrial purposes. The development of Genetically Modified Organisms (GMOs) is one of its controversial examples. Other than GMOs however, a whole new kind of genetic engineering is also developing, with promising projects ahead.

In 2010, the researcher Craig Venter made a greatly advertised announcement on the website of the famous magazine *Nature:* he had "created the first living synthetic cell" (actually a natural bacteria cell activated by an artificial genome). This ground-breaking announcement symbolises the start of a new era for the creation of living organisms, both at the level of the laboratory as for the industry, with very promising

applications in medicine as well as in the field of energy and materials. This takes place in a very competitive economic context. The race to patents is on at full speed, with one underlying question: do we have the right to patent living beings?

At the time of modern biotechnology, man is indeed capable of not only modifying living beings, but also of creating pieces of artificial living beings, such as viruses, DNA fragments or bacterial genomes. Some even think of an "artificial life"! The development of synthetic biology is also soaring in labs, particularly since its application to the scale of the billionth of a metre (nanometre). Multiple possibilities of creating living beings therefore open up. We thus now speak of molecular manufacturing technology and a new form of bioengineering.

The term "technoscience" was used for the first time at the end of the 20th century to describe new technologies at the heart of current debates: nanotechnology "N", biotechnology "B", information technology "I", cognitive sciences "C" (including neurosciences). Their convergence, referred to as "NBIC", is based on the integration of these different technologies on blocks of matter on the specific nanometre scale. We now "build the world one atom at a time" on this scale which erases all distinction between inert matter and living matter. From this point, a new form of bio-engineering based on nano-biotechnology began to develop. It enables to change the behaviour of natural living beings, but also to think about other livings organisms, different to the ones nature shows us. This synthetic biology will be used as a key example in this study to analyse modern-day ethical implications of new biotechnologies, other than the classic medical bioethical questions related to the embryo and reproduction techniques.

3. Ethical issues

Just like every time we temper with living beings (from plants to human beings), but even more so when we create it, major ethical issues arise. If, as the philosopher Paul Ricoeur declared, "*Ethics is the movement of freedom itself in the aim of good life, in the relationship of the self to others and through a balanced use of social institutions"*, a real research study on ethical implications, directly linked to the development of new biotechnologies proves to be, if I may say so, crucial. This modern-day "technoscience" (we create science

from technological achievements, which upturn the prospects of classic science and bring science and industry even closer) shapes our relationship to nature, to the world and to ourselves. Among the numerous questions raised at the crossroads between biological science and philosophy, with an economical and legal background, the following levels can be distinguished:

- With regards to the balance between benefits and risks, biosafety issues arise: what happens if newly created microorganisms get loose and mutate? In addition, at a time when we are able to create new and particularly dangerous viruses, how should "biosecurity" be handled in the context of terrorist threats? *Act so that the effects of your action are compatible with the permanence of genuine human life on earth* recalls the philosopher Hans Jonas in "The Imperative/principle (of) Responsibility" (Jonas, 1997).
- We can also question set aims when this technology is applied to human beings. One of the revealed objectives is to overcome the human limits (repairing, but also "enhancing" man's muscular and brain capacities), which, in itself, is not a new concept in history. Until which point can human limits however be "surpassed" and at what cost? Is the aim to humanise, or to flee human finiteness, in denial of death and destiny of man? It is actually through the "power of being ourselves" that the philosopher J. Habermas (2002) assessed the impact of biotechnology. "Objectifying" action (introducing new technologies in man) affects both our power to be ourselves and our relationship to others. To that effect, we can think of the impact of brain implants on personality. We find ourselves facing the usual fearful issue of limit, with the transhumanist vision of a limitless *homo novus*.
- Finally, the relationship to living beings and to life is transformed. Synthetic biology challenges our vision of what is natural and what is artificial, what is alive and what is inanimate. It questions our responsibility in the generation of new biological living beings. Will living beings become functionalised, "objectified" following a "utilitarian" vision? A specific vision of performance is here subjected to a critical

study. Is life worth living through the functionalities / performances of living beings? "What is life" and how can we respect it if it appears as an artefact, the product of a human construction? We are therefore called to reconsider the difference between life and the functions of living beings (from livings to lived experiences): the functionalities of living beings must be differentiated (even if they are linked) from the use of these functions in a life of which man is partly aware. The philosopher Michel Henry (1996) expresses this thought: *Life feels itself and experiences itself in its invisible interiority and in its radical immanence.* This "power to feel" corresponds to the experience of "*the fact of being oneself*", which Michel Henry interprets as the fact of being a Self. Life is thus an invisible and incessant movement towards the self, to expand the self…

4. The robustness of microorganisms created through Synthetic Biology

To create living microorganisms via metabolic engineering, we often substitute a bacteria's natural genome by an artificial genome, which creates new metabolic techniques that are likely to produce molecules of interest[1]. It is therefore theoretically possible to design a minimal genome that codifies the basic functionalities of a desired living being, after inserting it in the natural bacteria. Furthermore, this artificial "minimal supporting structure" may be completed by new combinations of nucleic acids, true "made-to-measure" modules resulting in other metabolic functions. In a way, we are transforming bacteria into a micro-factory, and for several good causes: to create biofuel for instance, or reduce the levels of carbon and CO2 emissions, in the case of planes for example.

We therefore attempt to define *the robustness* of these microorganisms, a quality which prevents them from mutating, in order to always fulfil the same functions. For this purpose, we keep them in a specific ecosystem. In addition, to avoid the risk of letting these bacteria escape into nature, their robustness is designed to normally prevent them from entering into competition with natural strains or exchanging genetic material with the latter. By altering their ecosystem, they should therefore quickly disappear due to this rapid change. The very weak "programmed" ability of these

modified strains to adapt protects the natural environment from their potential harmful impacts.

We therefore realise that robustness, which firstly appears as an interesting quality for the micro-factory, causes the death of a living organism if it changes its environment. Yet one of the defining features of living beings is the ability to adapt to environmental changes, particularly by mutating. The more the level of robustness is high, the tougher these adaptions become. Robustness therefore here underlines a biological system's insensitivity to the physical and chemical transformation of its environment. As we will see later on, the evolution of species in fact needs a dynamic balance between robustness and adaptability.

5. The vulnerability of living beings

We can now speak of a "form of vulnerability", which may seem specific to all living beings, whether the latter is "weakened" by an illness, or perfectly sane. We can already notice that we say, for instance, that a stone is fragile but not vulnerable, whereas we speak of human vulnerability.

A living being capable of mutating and adapting to a change of environment requires an internal-external exchange process, an "interaction with its environment" which transforms it whilst contributing to the environment at the same time. This change by the environment is profound and is actually part of the mutation. It is not about a simple exchange with an internal-external interface, but a true external influence on internal things, even in gene expression as shown by epigenetics[2] (a branch of genetics which studies gene expression and its conditions, which is fast-developing today).

A form of vulnerability thus appears. A "non-vulnerable" living organism could not grow, adapt, let itself be shaped by its environment and shape the latter in return. On the contrary, a vulnerable living being lets itself be attained, penetrated by external effects which transform it internally, and not only through a simple interface effect. A commonly used example to illustrate this form of vulnerability is the fertilisation of an egg. An invulnerable cell is like a fortress. It cannot be fertilised or divide itself to create a complex living organism. We can indeed provide numerous similar examples for the living being which evolves, by

interacting with other living beings and its entire environment. Living beings let themselves be attained and consequently possess an "adaptive plasticity".

We state that the aforementioned form of vulnerability is an intrinsic feature of living beings, even if its level can greatly differ from one living being to the next. It is this theory that we are testing in this study (i.e. vulnerability as an ontological feature of living beings) to then analyse the specific vulnerability of a singular living being, man.

6. Different levels of vulnerability[3]

When applied to man, vulnerability shared by all living beings acquires a specific dimension. The concept of vulnerability, as it is usually understood, is often associated to a form of fragility, and the fate of a few specific individuals, such as people nearing the end of life. We also think of individuals who are physically or mentally handicapped, or experiencing social vulnerability, linked, for instance, to precarious employment conditions or difficult family situations. We can already establish that vulnerability is defined by different aspects and can influence individuals in very diverse ways. Yet, remaining attached to this common representation of vulnerability as the specific fate of a few unlucky individuals or people who have not yet reached their full degree of development, means taking a double risk: condescendence regarding handicapped individuals on the one hand, and confusion between vulnerability of living beings and fragility on the other.

There is then also a risk of confusion when fragility and vulnerability looks similar. It makes sense that a child is more fragile than an adult, or that a handicapped individual has less resources to face the threats of mental, physical, or social life. Yet, if the fact that some people are more fragile than others is obvious, it does not mean, however, that the strongest individuals are less vulnerable. In other words, if there are different degrees of fragility (glass is generally more fragile than steel at room temperature), vulnerability could be an ontological feature of all living beings and, in this way, it ensures our complete equality.

A living being can only live if it meets an external reality which affects it and which it can affect in return. This also means that a living being is only alive if it is likely to be hurt by reality. This is what living means: being

affected by the world, bearing our mark and sealing it with our desires which are injuries, and our acts which attempt to be cures.

Asserting that vulnerability is an ontological feature of living beings does not simply mean that living beings are fragile realities because they are threatened by death or illness. It means that a living being is alive because it is vulnerable, and that this same vulnerability is what makes it a living being. We believe that this idea of vulnerability in all living beings (with its specific features when applied to human beings) is particularly relevant to start our work on the ethical behaviour required to take care of living beings in this era of new biotechnologies.

7. Enhanced man or simplified man? Complexity and vulnerability

Transhumanist movements today advocate not only a "repaired" human being, through new biotechnologies applied to personalised medicine, but also an "enhanced" human being through the contribution of convergent technologies (nano-scale implants and other systems which improve biological performance).

The philosopher Jean-Michel Besnier, in reaction to this vision of enhanced man, speaks more and entirely freely of the "simplified human being" which we agree to become under the influence of scientific visions and technical innovations (Besnier, 2012). According to him, this voluntary servitude is surprising and calls for a rebellion: that of men fighting for their complexity and interiority as symbols of human freedom. He quotes Einstein by saying that we must make things as simple as possible, but we should not oversimplify them. According to Besnier, this oversimplification of living beings of which solely the functional biological performances count, is dehumanising. He expresses his desire to resist to the dogma of "robotising" efficiency and the "maximisation" of man in simple yet very instrumental tasks, deriving from a type of humanity solely structured around the "rational agent". The dramatic story of the South-African sports champion, Pistorius, illustrates this simplifying limit.

We will therefore keep in mind the critical study (simplifying reductionism that disregards the complexity of living beings) on the nature of human enhancement considered by transhumanist currents. And particularly since biology itself teaches us a little more each day on the

"complexity" of vulnerable living beings, via epigenetics (described above) and brain plasticity (as mentioned below).

Thus recent scientific discoveries in the field of epigenetics seem to support the reciprocal relationship between biology and psyche. They show that certain genes are inhibited whilst others, on the contrary, express themselves strongly, according to their environment (gene distribution) and the behaviour of living beings themselves. For human beings, we emphasise that nutrition, exercise, stress management, pleasure and social networking can bear an influence on epigenetics. The traditional "over simplifying" dualism separating biology from psyche can no longer be accepted. This leads the scientist Joël de Rosnay to state the following: "*Who could have thought that, less than ten years ago, our body not only depended on the "DNA programme", but also on the way we lead our everyday lives?"* (Rosnay and Papillon, 2010: 117). Epigenetics opens up new horizons: what man will pass on to his descendants is partly the result of his behaviour!

Current studies on brain plasticity also seem to reveal a close link between the functionalities of living beings and the experiences they have lived.[4] The organisation of neuronal networks influences lived experiences, but in return, changes according to what a living being has lived. What it shows, in particular, is the brain's ability to remodel connections between neurones through the appearance and disappearance of synapses. Thus using or re-educating one's brain capacities (training - learning, thus psyche) influences the biology of the brain itself. This constitutes a good example of the link between living beings and their lived experiences. In this instance as well, living beings let themselves be influenced and transformed by their lived experiences, whilst also being an influence on the latter. From epigenetics to brain plasticity, we find ourselves at the heart of a complex and vulnerable humanity. This type of vulnerability establishes the relationship, for humans, between biology, psyche and the mind, and highlights its importance.

8. The vulnerable human being: body, psyche and mind.

The human being is a complex whole composed of body, psyche and mind. This whole constantly interacts with the environment, ecosystems as we say today, found in nature, social relationships or culture. St Irenaeus (*Adversus Haereses*. V. 6. 1.) already said, in the 2nd century:

> Flesh which has been moulded is not a perfect man in itself, but the body of a man, and part of a man. Neither is the soul itself, considered apart by itself, the man: but it is the soul of a man, and part of a man. Neither is the spirit of a man, for it is called the spirit, and not a man; but the commingling and union of all these constitutes the perfect man.

The profound respect for these three features, constantly interacting with each other and their environment, is underlined by the links which researchers today establish between biology and psyche, with epigenetics on the one hand, and studies on brain plasticity on the other. This three-fold anthropology seems more than ever a suitable "backdrop" for a reasonable use of technology today. In this context, one of the most important ethical criteria considered when assessing the impact of life science technology on human beings, will be that of promoting the whole, the unity and commingling formed by body, psyche and mind (features of the human being).

We can then question the impact of a particular technological intervention on the human being in terms of harmony or disharmony between these three features, whilst taking into account, as a backdrop, the vulnerability of all living beings, itself induced by biological researches today.

9. Conclusion: towards an ethical limit that respects living vulnerability.

In his famous book on the imperative-principle (of) responsibility, H. Jonas (1997) already presents a link between what he called "vulnerability" (vulnerability mixed with fragility) and responsibility, and more specifically in the field of ecology:

> "Responsibility (in the face of technological power and its impact on nature) is incumbent upon us due to the power we exercise every day… The things I am responsible for, are naturally the consequences of my action – as far as they impact a living being… it is the vulnerability, the fragility, the precariousness of a living being over which I have power which calls for my responsibility… it is after all the accusation of this warning, showing these living beings of the future as our victims, which morally prohibits us from the selfish alienation of emotions, generally justified by the object's distance."

Being responsible for living beings today and tomorrow, as R. Schaer (2013) said, means considering the latter's complex and vulnerable nature, in the context of new possibilities bought by synthetic biology and other technosciences, offering both advantages and risks. Modern-day technological power requires us, more than ever, to act responsibly faced with the vulnerability of living beings (human beings in particular) with differences between bacteria and men.

It is in this context that we can consider an "ethical limit to technological all-mightiness", particularly faced with the dangers of transhumanism encouraging human reductionism that is particularly worrying and denies the vulnerability of all living beings. The "promise of immortality", which is popular today, is a symbol of this phenomenon. Ethics do not ban or impede scientific and technical development, but identifies what helps man to makes modern-day technology more efficient for the respect of life and living beings. This research on the ethical impact of new biotechnologies remains to be completed, little by little, in direct consultation with philosophers and scientists working together in this field.

This shared responsibility can shed light on the true meaning of the term "performance". Purely technical performance only applied to a biological context is, today, too simplistic. We already see this in world health issues: the interaction between biology and psyche is much more discreet and complex. New study opportunities develop here, not only on the limits of technological all-mightiness, but also on the new meaning of "performance".

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[1] Studies of the TWB (Toulouse White Biotechnology, INRA, Toulouse, France) Consortium for instance.

[2] See for instance Tost, J. *Epigenetics*. Horizon Scientific Press, 2008 and Morange, M. *Epigenetics,* Studies No 4210. November 2014. 45.

[3] This paragraph is inspired from the conference of Y. Martin, *VULNÉRABILITÉS : Quels enjeux pour la psychiatrie aujourd'hui ?* (Translation: VULNERABILITIES: what are the challenges faces by psychiatry today?") 23 November 2013, Strasbourg (website)

[4]See *Le cerveau, comment il se réorganise sans cesse*, Les dossiers de La Recherche, no. 40, August 2010

Biographical note

Thierry Magnin is both Professor in Physics and a Catholic priest, presently Rector of the Catholic University of Lyon, France. He has a Ph.D. in Physics (solid state physics) and a PHD in Theology (Moral philosophy as a ground for a new dialogue between science and religion). He has written about 200 papers in solid state physics and three books on the relation between science and religion: *Quel Dieu pour un monde scientifique?* (Nouvelle Cité, 1993); *Entre science et religion* (Le Rocher, 1998); *Paraboles scientifiques* (Nouvelle Cité, 2000). He received a prize from the academy of science in France, and is a member of the SSQII programme.