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POST NON-CLASSICAL SYNTHESIS OF KNOWLEDGE IN MODERN BIOTECHNOLOGIES

The article is devoted to modern biotechnologies: genetic engineering technologies, particularly CRISPR, PGD technologies, IVF, etc. Modern biotechnologies differ fundamentally from traditional technologies. The latter were created on the basis on applied scientific knowledge. Modern biotechnologies directly arise from the field of fundamental research grounded on interdisciplinary and transdisciplinary methods.

The modern biotechnologies are considered in the context of the post non- classical type of scientific rationality, which was developed during the modern global scientific revolution to explore holistic, complex human dimension systems capable of self-organization and self-development. The norms of scientific research of this modern type of scientific rationality were established for nonlinear science, particularly for the theories of self-organization whose variable nonlinear dynamics is described by nonlinear equations with several solutions chosen by chance. That is why the explanation of a certain state of the self-organizing system should take account of system's specific choice of the version of further movement; therefore, it is a description by its logical structure. Even in modern physics, nonlinear theories are descriptive because nonlinear equations are solved by means of numerous approximation methods, describing specific systems in specific conditions of their existence. Thus the contraposition of fundamental theories with the applied ones, which is typical of linear physics, is becoming less relevant. Hence, long-standing critical remarks against biological theories for their inconsistency with idealized hypothetical-deductive standards turn out to be inadequate and misleading in terms of the specifics of biological objects. Ultimately, biology has been provided with the norms of scientific research of the holistic complex systems, which are self-organized and self-developing, in conformity with the nature of living things. From this it follows that biological theories may well be and are descriptive.

Given that the article deals with technologies, the problem of the relation of the artificial and natural take center stage. Exploring this problem, we relied on Herbert Simon's classical work entitled "The Sciences of the Artificial", which was once devoted to cybernetics in the main, though it has wider application. The artificial is created on grounds of human aims, whereas it works according to natural laws. Unlike technique that designs artificial devices, it is critically important that technological processes are not "designed", but originated under certain conditions, and they often deal with the aspects of self-organization. In addition, it is vitally important for biotechnology that any design in genetic engineering should not disrupt the processes of self-organization in living organisms. The nonlinearity of these processes provides a possibility of human intervention that is due to the fundamental variability of such processes, when the intervention creates conditions for a favorable choice. However, a risk remains. Moreover, the definition of favorability is not always clear. Thus, value aspects are irrevocable and they require an appeal to ethics and humanitarian research in general.

Keywords: philosophy of science, biotechnology, genetic engineering, CRISPR, post non-classical synthesis of knowledge, nonlinear natural science, interdisciplinarity, transdisciplinarity, ethics of science.

Introduction

Dealing with ecological or socio-technical challenges should involve a wide variety of natural, tech and humanitarian knowledge. The understanding of a complexity as the process of self-organization is supposed to serve as the unifying basis for their synthesis. (Dobronravova, 2011). That is why technologies do acquire particular importance. The fact is that fundamentally complex systems cannot be "constructed" of separate parts. They are formed as a whole in the course of their development owing to self-organization in nonlinear media. It is possible to create conditions for such self-organization as the process of coherent movement of elements of the environment to attractors inherent in this environment and to promote the choice of what is appropriate for a certain goal from among the attractors. Setting relevant goals is a separate matter of choice of the areas of human activities by state and interstate institutions, entrepreneurs and corporations in view of economic and environmental requirements and interests. Awareness of available choices is based on the explication of obvious socio-cultural trends, hidden myths, fears and hopes for the future, expressed by artists, philosophers and publicists, as well as exploited by politicians, and advocated by public figures and social activists. Presently, this article deals with the new technologies that are currently creating a field of the opportunities among which people choose the goals of and tools for their activities. Also the article deals with the how a synthesis of knowledge happens while the technologies are being developed. Their creation and use not only change human life, but alter the very understanding of what is a living being and what is a human being. The new understanding is based on the post non-classical synthesis of knowledge about living things – a multidimensional notion of the living world including humanity.

Sources

The wording "post non classical synthesis of knowledge" entered the mind of one of the authors of this article (Dobronravova, 2019) when she read about the views of Academician Vyacheslav S. Stepin (Stepin, 2017) on the relationship between classical, non-classical and post non classical science. He emphasized that the simple systems, which make up objects under study of classical physics, are in the first place epistemologically, not ontologically. Self-organizing complex systems studied by the superstring theory and the unitary gage theories of high energy physics, are ontologically starting points in the formation of our universe. The planetary systems, whose motion is studied by classical mechanics, are the result of long self-organization, and the way used by classical mechanics is based on idealization. Classical mechanics solves the problems of two material bodies, for example, the Sun and

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one of the planets. Other planets are considered to somewhat disturb conditions of the study of interaction between two bodies. That is, the systems, which are the subjects of classical and non-classical science, are always the result of simplification of complex systems under study. As Vyacheslav Stepin put it, they are the fragments or aspects of the existence of complex self-developing systems.

Therefore, when it comes to the study of complex self-organizing and self-developing systems, knowledge about their fragments or aspects, which have been previously studied with the help of other types of scientific rationality, need to be taken into account. Moreover, the very possibility that those fragments or aspects of the existence of complex systems could be abstracted and studied separately should be substantiated by new knowledge, new insights. That means a synthesis of knowledge should be made. It can be called the post non-classical synthesis because the above possibility arises exactly based on the post non-classical type of scientific rationality aimed at studying complex human dimensioned self-developing systems.

It is especially important to use such possibilities when considering modern biotechnologies. Among the examples of a post non-classical synthesis of knowledge about emerging biotechnologies, which this article deals with, is the genetic engineering technology called CRISPR evaluated by scientists as the most outstanding discovery of the last decade. In 2020 Emmanuelle Charpentier and Jennifer Anne Doudna received the Nobel Prize in Chemistry for devising a method of genome editing (figuratively called "genetic scissors"). The use of this method offers the prospect of curing cancer and hereditary diseases. CRISPR is an acronym for "clustered regularly interspaced short palindromic repeats". Specifically, it is taken to mean the repeats of fragments of nucleic acids where a sequence of nucleotides of one chain coincides with a sequence of complementary nucleotides of the second chain, if you read the latter in the opposite direction (Komisarenko, 2020). The CRISPR gene editing technology is a symbol and at the same time the indicator of a post non-classical synthesis of modern scientific knowledge and social practices. The fact of the matter is that genome editing techniques are built on the CRISPR-Cas9 system. Cas9 are the enzymes (ferments) that enable detection of the corresponding DNA and its fragmentation. Strictly speaking, these are fragments produced by bacteria when they are attacked by viruses. Cas9 carry around those stored fragments like a mug shot. When these Cas9 fragments come across a virus, they see if the virus's RNA matches what is in the mug shot. If there is a match, the Cas9 enzyme starts chopping up the virus's DNA to neutralize the threat. (A simple guide to CRISPR, 2020). Techniques based on the comparable Cas9 mechanism are promising as well, capable of cleaving RNA molecules (instead of DNA). Indeed, Cas9 bacteria can be reprogrammed to target the RNA viral genome that leads to the inhibition of a viral protein biosynthesis in a cell. This is the potential path plotted to the development of techniques for fighting dangerous viruses. Humanity is blazing it in the forefront of a fight against the present-day pandemic. Under the circumstances, not only vector vaccines but also messenger RNA vaccines (Pfizer-BioNTech, Moderna) have become efficacious. The messenger RNA of the virus enters a cell (as a result of vaccination) whereby coronavirus spike proteins are synthesized, in response; the human immune system is activated while the RNA and coronavirus proteins are destroyed. The immune memory remains active, which allows the person to fight off the virus if it returns in the future.

Methodology

Living objects are represented in a scientific discourse as complex integral systems that self-organize and self-develop. Their research requires interdisciplinary approaches and transdisciplinary strategies, taking account of the value regulatory frameworks of research and practices. This creates conditions for a new post non-classical synthesis of knowledge about the alive. Reflecting on how such synthesis is made in biology, it is possible to discern similarities to what is happening within the post non-classical type of scientific rationality in other disciplines. Thus synthesized on the basis on the post non-classical type of scientific rationality, knowledge substantiates the partial knowledge of complex systems, which has been acquired earlier in the form of preliminary theoretical generalizations. As we have already noted, Vyacheslav Stepin gave particular emphasis to this circumstance in terms of physics and cosmology (Stepin, 2017). Also, it is not a feature that post non-classical theories of complex integral systems can be descriptive, as one of the authors of this article wrote (Dobronravova, 2017). Given the transdisciplinarity of many theoretical models in nonlinear science, specific examples of the post non-classical science, which deals with previously acquired knowledge, may be different in the application of such models in different scientific disciplines. Thus, examples of such synthesis have been provided in quantum physics of the alive (Dobronravova, 2019; Sitko, 2011).

Predicting the future of complex self-organizing objects is problematic because nonlinear equations have several solutions, and randomness plays a major role in system's choice of one of them. Therefore, the description of a specific choice by chance by the system of one of the possible variants of nonlinear dynamics of the movement of elements of the environment in which self-organization takes place, with relation to one or another of possible attractors, is the explanation of a real necessity for a new complex whole. Integrity and complexity are the integral features of biological systems. This means the post non-classical type of scientific rationality is adequate to their scientific development. No wonder theoretical knowledge at all stages of the development of biology had the features, which only nonlinear theories acquired in physics.

In fact, regarding examples of theoretical generalizations in classical biology – the classical theories of biology: cell theory and the theory of evolution – have been criticized by mathematicians and physicists for "descriptive" nature, for the inconsistency of these theories with standard hypothetic-deductive theories: the said biological theories are not strict deductive constructions, and they do not perform a prognostic function. However, the idealized hypothetic-deductive model, as it became clear long ago, does not work in physics also, therefore critical opinions on theoretical biological knowledge were methodologically unjustified and they did not take account of the specifics of the living. As far as the structure of the modern theory of the alive on the methodological basis of synergetics is concerned, there is no need for an unambiguous forecast because it is fundamentally impossible at bifurcation points. Thus, the modern theory of the alive can be and is descriptive.

Results

Subsection 1. Interdisciplinary and transdisciplinary nature of a synthesis of knowledge within modern biotechnologies.

The synthesis of knowledge is possible not only within one discipline. General scientific programs and approaches have a certain heredity. Thus, the concept of self-organization, which is actively used in synergetics, was first considered in the general theory of systems and cybernetics just for the case of homeostasis as a dynamically stable existence of systems with negative feedback. The peculiarity of the post non-classical picture of the alive is that the synthetic integrity of vision is achieved through the creation and influence of biotechnologies in their use in research and social practices. Modern biotech is the glaring example of a transdisciplinary synthesis: biotechnologies as a complex whole are included in another complex system – the NBIC technological system. It is a merger of four scientific and technological spheres: N – nanotechnologies; B – biotechnologies; I – information technologies; C – cognitive sciences (Sidorenko, 2015). Accordingly, the post non-classical synthesis of knowledge is made through research on the complex self-organizing systems that have civilizational influences, namely NBIC technological systems, artificial neural networks, and artificial intelligence in general.

Modern biotechnologies differ essentially from traditional technologies. The latter were created with the help of applied scientific knowledge. Modern biotechnologies arise directly in the field of basic research, which requires the use of quite sophisticated research techniques and technologies. They are interdisciplinary within their scientific framework as well as transdisciplinary in terms of their use in practice and their impact on human and civilizational development. Indeed, biotechnologies combine the knowledge of many natural sciences, and the use of biological objects and processes in various practical aspects of human life.

Biotechnologies have the following transdisciplinary features: they are built on interdisciplinary scientific knowledge (biophysics, biochemistry, molecular biology, etc.) and includes a set of non-scientific practices that have socio-civilizational components, particularly industrial practices (food industry, drug manufacturing, metal corrosion control, etc.). Scientific research in the realm of modern biotechnologies uses the practices of DNA modification, cloning, cell and gene engineering, among others. Modern biotechnologies are capable of acting on the human body – its reconstruction and construction. Therefore, the post non-classical synthesis of biological knowledge, medical knowledge and medical practices is governed by moral values. This applies to the practices of transplantation, IVF (in vitro fertilization), plastic surgery, etc.

A convincing example of the synthesis of basic research and social practices is modern assisted reproductive technologies – in vitro fertilization (IVF), genome-wide association studies – the analysis of associations of genotypes with phenotypes (GWAS). In particular, the PGD technology – preimplantation genetic diagnosis – enables screening of embryos for health problems such as Huntington's disease, Marfan's syndrome, cystic fibrosis, and other known genetic disorders (Marcello de Araujo, 2020).

Subsection 2. Relationship between the artificial and the natural in the synthesis of knowledge within modern biotechnologies.

As can be seen from the above examples, among modern biotechnologies are the practices of manufacturing new biological objects based on experimental interventions at genetic and cellular levels, namely designing biological systems. Thus, the latter acquire artificial c levels, namely designing biological systems. Thus, the latter acquire artificial characteristics. As a result of the post non-classical synthesis of knowledge, the complex wholes develop – artificial biological, more precisely, biotechnological systems. Belonging to the biological environment, they can be considered natural and have characteristics of a complex whole, capable of self-organization and self-development. Because of designing, such systems are artificial, without losing the above characteristics – complex integrity, the ability to self-organize and self-development and to nonlinear behavior, which means the behavior of such systems is notoriously difficult and quite impossible to predict at the bifurcation point. Therefore, the experimental creation of artificial biotechnological systems, which is based on the latest techniques of genetic engineering (in a broad sense), molecular biology and neurobiology, is human intervention in the fundamentals of the alive as a complex whole that can be fraught with unexpected consequences.

Therefore, a researcher, a society increasingly "takes control" of human life processes. In a comprehensive analytical review of possibilities, problems and prospects of the CRISPR genome editing technology, S.V. Komisarenko and S.I. Romanyuk emphasize the large-scale capabilities of this technology in various fields of science and social life. At the same time, however, they point out that "it would be very tempting to edit only one nucleotide base in DNA and thereby cure a patient of a serious hereditary disease, such as hemophilia". It is unknown how the human body would react to intervention in the genome. Therefore, the ability to edit human genes has immediately raised a number of ethical issues, which are especially thorny in case of editing the genes of a human embryo (Komisarenko, 2020).

A lot of useful information about the artificial-natural relationship was provided by Herbert A. Simon in his classic work "The Sciences of the Artificial". (Simon, 2014). It is expedient to point out several Simon's considerations, which seem to be universal. First, it is a remark that "the artificial has no dispensation to ignore or violate natural law. At the same time, it is adapted to human goals and purposes. It is what it is in order to satisfy our desire to fly or to eat well. As our aims change, so too do our artifacts and vice versa."(Simon, 2004, 11-12). Regarding the relationship between the natural sciences and the artificial, he wrote: "Natural science impinges on an artifact … in the structure of the artifact itself and the environment in which it performs. …An artifact can be thought of as a meeting point an "interface" in today's terms between an "inner" environment, the substance and organization of the artifact itself, and an "outer" environment, the surroundings in which it operates. If the inner environment is appropriate to the outer environment, or vice versa, the artifact will serve its intended purpose. Thus, if the clock is immune to buffeting, it will serve as a ship's chronometer." (Simon, 2004, 16). These considerations echo Bruno Latour's thoughts expressed in his work "Science in Action" (Latour, 2013) about actants – technical systems that are the link between actors-researchers and objects under study.

It is clear that successful designing activities are limited by lack of the knowledge, which has been already acquired

by humankind. A change in the properties of materials at higher temperatures or pressures is becoming more and more apparent as humanity is moving towards the production of greater energies. Accidents and catastrophes set these limits in a deplorable or even tragic way. This is especially dangerous when it comes to technology. Explosions at chemical plants, accidents at nuclear power plants force us to turn to knowledge accumulated by humankind or to explore the unknown. Thus, synergetics warns of a possibility of the development of nonlinear processes with positive feedback when volumes of reacting mixtures or the size of nuclear reactors increases.

Discussion and conclusions

Query, how does the post non-classical synthesis of knowledge differ from the synthesis that has gradually accompanied mankind throughout its history? After all, regarding the specifics of the objects of post non-classical science – complex systems capable of self-organization and self-development –humanity has long worked with such systems as well. Consider, for example, the experience of centuries-old selection of plants and animals. When creating artifacts, any synthesis of knowledge is post non-classical because it is related to human interests and values. It is the assessment of the value orientations of the subject of knowledge that serves as a basis for ensuring objectivity in the post non-classical type of scientific rationality.

It seems natural that a comparison between science and technology implies natural knowledge in the main. However, the further away, the more obvious becomes the validity of Claude Levi-Strauss' opinion expressed in his famous prophecy: "If the twenty-first century is to be, it is going to be a century of humanities or not at all." As is known, the ecological crisis has become global because the spontaneous development of the economy has spread globally what had only local consequences so far. Karl Marx aptly described these consequences, "… culture that develops spontaneously and is not consciously controlled leaves a desert behind it..." This is not a figurative expression. The Sahara, which emerged once upon a time, or the Aral Sea, which dried up before our eyes, are obvious consequences of this development. In the recent Report to the Club of Rome "Come on!" (Weizsäcker, Wijkman, 2018), a call for a change in the attitude to nature is based on a need for a change the concept of "empty world" to understand its fullness of people and products and the waste of human activity. It is a matter of the concepts of humanitarian nature. Not only conceptual changes, but also the elaboration of adequate practices require the development of the humanities and social sciences. It is impossible to initiate the actions, which would help eradicate pernicious practices (such as burning dry grass that causes raging fires today), without the knowledge of human psychology. Knowledge of our own nature be it physical or spiritual becomes a condition for the survival of humankind on our planet as well as for life on this planet in general. A discernible modern trend towards the convergence of natural sciences and humanities gives grounds for cautious optimism.

The coronavirus pandemic has convincingly demonstrated to humanity that the impact of biotechnologies goes far beyond research, laboratories and research institutes. Modern biotechnologies literally capture the important aspects of human existence, becoming not only its attribute, but also a condition for human life. The fact that genetically engineered vaccines have turned out to be highly effective in combating the coronavirus in the context of the present-day pandemic is not only a remarkable event in scientific life, but also it has acquired both civilizational and world-outlook significance. Accordingly, the creation of artificial biotechnological systems as a post non-classical synthesis of knowledge about the alive is inextricably linked with a need to include value-conscious principle as fundamental regulatory requirements in the process of research and practical manipulations of the living and, above all, a human being. In particular, moral principles may play the role of permits for or prohibitions on research. This means that not only scientific knowledge, but also moral requirements are capable of guiding, inter alia, the modern study of the living in general. The range of biotechnologies identified in our article, and the biotech spectrum that has not been considered, though it has great capabilities to develop artificial living systems, require a discussion of several complex problems relating to world outlook as well as of ethical issues, and both a scientific community and humanity are supposed to come up with solutions to them.

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ПОСТНЕКЛАСИЧНИЙ СИНТЕЗ ЗНАНЬ У СУЧАСНИХ БІОТЕХНОЛОГІЯХ

Стаття присвячена сучасним біотехнологіям: технологіям генної інженерії, зокрема CRISPR, технологіям PGD, ЕКО та ін. Сучасні біотехнології принципово відрізняються від традиційних технологій. Останні створювалися на основі прикладних наукових знань. Сучасні біотехнології безпосередньо виникають із поля фундаментальних досліджень, заснованих на міждисциплінарних і трансдисциплінарних методах.

Сучасні біотехнології розглядаються в контексті постнекласичного типу наукової раціональності, який був розроблений під час сучасної глобальної наукової революції для дослідження цілісних, складних систем людського виміру, здатних до самоорганізації та саморозвитку. Норми наукового дослідження цього сучасного типу наукової раціональності були встановлені для нелінійної науки, зокрема для теорій самоорганізації, змінна нелінійна динаміка яких описується нелінійними рівняннями з декількома випадково обраними рішеннями. Тому пояснення певного стану системи, що самоорганізується, має враховувати специфічний вибір системою варіанта подальшого руху; отже, це опис за своєю логічною структурою. Навіть у сучасній фізиці нелінійні теорії є описовими, оскільки нелінійні рівняння розв'язуються за допомогою численних методів наближення, що описують конкретні системи в конкретних умовах їх існування. Таким чином, протиставлення фундаментальних теорій прикладним, характерне для лінійної фізики, стає менш актуальним. Отже, давні критичні зауваження на адресу біологічних теорій за їхню невідповідність ідеалізованим гіпотетико-дедуктивним стандартам виявляються неадекватними та вводять в оману з точки зору специфіки біологічних об'єктів. Зрештою, біологія забезпечена нормами наукового дослідження цілісних складних систем, які самоорганізуються і саморозвиваються, відповідно до природи живого. З цього випливає, що біологічні теорії цілком можуть бути і є описовими.

З огляду на те, що стаття присвячена технологіям, центральне місце займає проблема співвідношення штучного і природного. Досліджуючи цю проблему, ми спиралися на класичну працю Герберта Саймона під назвою "Науки про штучне", яка колись була присвячена переважно кібернетиці, хоча має ширше застосування. Штучне створюється на основі людських цілей, тоді як воно діє за природними законами. На відміну від техніки, яка проектує штучні пристрої, критично важливо, щоб технологічні процеси не були "спроектованими", а виникли за певних умов, і вони часто мають справу з аспектами самоорганізації. Крім того, для біотехнології життєво важливо, щоб будь-який дизайн у генній інженерії не порушував процеси самоорганізації живих організмів. Нелінійність цих процесів забезпечує можливість втручання людини, що зумовлено принциповою мінливістю таких процесів, коли втручання створює умови для сприятливого вибору. Однак ризик залишається. Крім того, визначення сприятливості не завжди чітке. Таким чином, ціннісні аспекти є незмінними і вимагають звернення до етики та гуманітарних досліджень загалом.

Ключові слова: філософія науки, біотехнологія, генна інженерія, CRISPR, постнекласичний синтез знань, нелінійне природознавство, міждисциплінарність, трансдисциплінарність, етика науки.