

# Digital Production and Biotechnology as a New Techno-Economic Paradigm

Natalia Tikhonyuk<sup>1,\*</sup>, Kometa Paytaeva<sup>2</sup> and Svetlana Ivanova<sup>3</sup>

<sup>1</sup>The Russian Presidential Academy of National Economy and Public Administration (Vladimir branch), Vladimir, Russia

<sup>2</sup>Kadyrov Chechen State University, Grozny, Russia

<sup>3</sup>Plekhanov Russian University of Economics, Moscow, Russia

**Abstract.** Digital technologies continue to actively penetrate into all spheres of human activity. At the same time, there has been a trend in production to move from the use of individual solutions to the introduction of unified knowledge, technology and competency management systems - digital platforms. The use of new materials, computer engineering and virtual modeling technologies, additive technologies, the “industrial Internet”, mechatronics and robotics ensures the growth of the quality of traditional and the emergence of fundamentally new products, reducing the costs of creating and manufacturing products, including by reducing the volume of full-scale tests, terms bringing finished products to market, and generally increasing the predictability of industrial systems. It becomes possible to carry out a quick restructuring of production facilities for various conditions, which ensures the customization of production, as well as quickly respond to market changes.

## 1 Introduction

Combining enterprise elements into a single network based on intelligent control systems allows you to remotely control production processes online. This will lead to the transformation of the main sectors of the economy (industrial production, energy, transport, medicine, agriculture, etc.), the disappearance of a number of traditional markets and the emergence of new sectors that change the very model of interaction between people and machines [1]. An increasing number of devices will not only become intelligent, but will also be included in a single network that provides a synergistic effect of their interaction - the Internet of Things. “Smart” infrastructures will constantly monitor and analyze production processes, timely eliminate problems that have arisen and synchronize the work of individual elements, adapt them to the implementation of a single goal. In general, the transformation of industrial production will lead to the growth of the market for “factories of the future” technologies, the volume of which by 2020 will exceed \$ 700 billion [2]. The consequences of progress in this area will be, in particular, the displacement of low-skilled labor by machines and the emergence of new types of competencies that require high qualifications. Technologies of a New Element Base, Electronic Devices, Quantum

---

\* Corresponding author: [tasha-ti@yandex.ru](mailto:tasha-ti@yandex.ru)

**Technologies** The emergence of materials capable of replacing silicon has become a key impetus for the development of a new element base of modern electronics. The use of graphene in electronics has begun, which makes it possible to significantly reduce the size of the microcircuit and increase the efficiency of the microprocessor. With the use of quantum computers, the most complex operations will be performed in a short time: deciphering the most complex codes, modeling the interaction of molecules at the quantum level, which will greatly simplify the process of creating materials with desired properties, etc. An increase in the volume of transmitted data requires an increase in the throughput of information channels. For this, interconnections on chips can be implemented based on photonics technologies [3-4]. Processors for mobile communication devices will use multi-core architectures and design standards to reduce interface lags, command response times, system error rates, increase application launch speeds, and increase the level of parallelism in operations.

**Mechatronics and Robotics Technologies** Developments in big data technologies, growth in processor performance, and discoveries in alternative computing architectures are driving progress in the field of mechatronics and robotics. Automation of production, including the use of decision-making systems based on artificial intelligence technologies and neural networks, will become the main impetus for global changes in the employment market and the spread of the concept of “unmanned” production. At the same time, new devices will be autonomous, more flexible, and will receive expanded functionality, as a result of which production processes will be accelerated and the quality of products will increase. At the same time, a total replacement of people by robots should not be expected in the foreseeable future: with the use of currently existing technologies, about 5% of all professions and less than half of human activities in various professions can be fully automated [5].

**Computer modeling of materials and processes** Based on the technologies of predictive multi-scale modeling of materials and processes throughout the entire life cycle of products (from conception and design to operation and disposal, including verification of calculations on an array of experimental data), the concept of digital “twins” is being formed, which involves the combination of virtual and real copies [6]. Fully digital environments that simulate reality will allow full use of artificial intelligence to customize the interaction of robotic systems and their training in digital simulators with subsequent application in real environments. As a result, there is a significant reduction in production costs due to the creation of high-tech virtual models instead of expensive full-scale prototype models.

## 2 Research methodology

During the study, statistical analysis and comparative analysis were applied. Computer engineering systems are used in almost all areas of modern production, including mechanical engineering, electronics, design and architecture, and the range of their applications is expanding [7]. At the same time, it becomes possible to reduce the proportion of defects in finished products by reducing unnecessary production operations and eliminating errors in technical documentation, ensuring the creation of customized products in a shorter time.

**Structural, functional and metamaterials** The tightening of requirements for production, associated primarily with the need to improve its efficiency and safety, determines the creation of new materials with a unique combination of properties: electrical and thermal conductivity, strength, durability, etc. Their wide distribution will allow solving such problems, as the protection of components and assemblies from external factors, the creation of coatings to protect structures in extreme conditions, the increase in the throughput of on-chip connections while reducing power consumption, etc. In the production of plastics, medical devices and medicines, environmental cleaning products, waste processing, the replacement of many chemical

processes with biotechnological ones will continue due to technologies for obtaining biomaterials and organic synthesis products from renewable raw materials. Progress in the field of industrial biotechnologies will be aimed at optimizing and greening the production of biologically active compounds, recombinant proteins for industrial and medical purposes, biocatalysts with a high level of specificity, efficiency and stability, and other substances [8]. The production of many active substances (vaccines, enzymes, hormones, vitamins, etc.) will be carried out with the help of plants and animals - biofactories. The accelerated development of biotechnology carries serious risks and highlights biosecurity issues, in particular the detection of new infections and genetic drift, the control of the use of molecular and cellular medical technologies, new forms of environmental pollution associated with high-tech activities and population growth. It is necessary to introduce effective systems to preventively identify and predict the emergence of new biogenic threats. It is especially important to monitor the use of genetic technologies that affect the human genotype, as well as cellular technologies that involve the manipulation of stem cells. It is necessary to establish monitoring of uncontrolled horizontal transfer of engineered genes and interspecies transfer of genes that lead to species change.

### 3 Results and discussions

Intelligent and customizable functional and structural materials with high strength, ductility, lightness, transparency and reflectivity in the future can replace the metals and plastics currently used. Another promising area is metamaterials [9]. These are composites, the characteristics of which are determined not by the properties of the constituent elements, but by the structure created using computer modeling methods. Potential applications of metamaterials cover all sectors in which electromagnetic radiation is used. With their help, it is possible not only to significantly improve the parameters of existing devices, such as phased antenna arrays, but also to create fundamentally new ones, for example, superlenses for optical microscopy in medicine and biology. Additive and hybrid technologies The transition to digital production is impossible without the use of additive technologies (3D printing) [10]. Their combination with computer engineering technologies ensures the creation of products, parts, machines and structures that are optimal in terms of various characteristics (dimensions, shape, weight, strength, rigidity, durability, wear resistance, etc.) with a material utilization factor close to unity. The result is a significant reduction in the volume of consumable materials (by more than 70%), as well as production waste and, accordingly, the cost of production. A promising area of additive technologies is metal printing, which makes it possible to manufacture products of the most complex geometric shapes used in the automotive and aircraft industries, as well as medical prostheses. In addition, the development of hybrid technologies that combine subtractive and additive technologies makes it possible to perform both 3D printing and machining of a printed product on the same machine. Diagnostics of materials Transition to a new level of understanding the structure of nanomaterials is possible on the basis of new diagnostic technologies, including non-destructive research methods aimed at revealing various parameters of nanostructures and the processes occurring in them. This requires the use of complex systems for visualizing the surface of materials with atomic resolution, monitoring their state during physical and chemical processes. The development of new methods of synchrotron-neutron diagnostics of inorganic, organic, hybrid and biosimilar materials and structures is expected [10-11]. The creation of integrated approaches to the practical diagnostics of materials will lead to the development of the next generation of electronic and optical devices based on them.

The development of biotechnologies is aimed at increasing the duration of active human life and improving its quality, reducing the level of human impact on the environment and

combating pollution, the integrated use of renewable resources, ensuring food security, and preserving the natural resource potential. In the coming decades, it will be possible to safely intervene in the genome of the human embryo, due to which in the future the creation of a “perfect person” will be limited only by ethical and social norms. The development of neurotechnologies will make it possible to take a step forward in the formation of an individual personality profile and a personal trajectory of its development. Biotechnologies cover a number of promising areas of scientific research. The progress of genomic and post-genomic technologies, based on the identification of the molecular mechanisms that underlie the life of the body, will ensure the transition to precision medicine, aimed at treating not the disease, but the specific patient, as well as preventing the development of diseases. Transcriptome, proteome and metabolome analysis, providing a deep understanding of the biochemical processes occurring in living organisms, will be increasingly used in the development of new highly effective drugs. By reconfiguring the epigenetic landscape of the genome, it will become possible to treat cancer, diseases associated with aging, and hereditary diseases. The results of deciphering the metagenomes of natural microbial communities and the genetic engineering impact on the genome of organisms will be used to select communities of microorganisms for industrial purposes and to obtain new pro- and prebiotics. Genome editing will make it possible to proceed to a deep correction of the human genotype to significantly extend life and improve its quality. In the field of agriculture, new varieties of plants and animal breeds will be developed with desired characteristics without the introduction of alien genetic material. An active directed impact on microbial communities will make it possible to increase the productivity of animals and the biological protection of plants, effectively clean the environment, intensify various biotechnological processes, including waste processing, biofuel production and mining. Modern achievements in the field of cellular biotechnologies stimulate the development of methods for regenerative and transplantation therapy for a number of diseases. In the coming decades, with the help of somatic cell reprofiling technologies, technologies for growing human tissues and functional organs (including the heart, liver, retina) in vitro with subsequent implantation into the recipient will be created and widely used [12]. The transition to a new level of understanding of the principles of the formation of oncological tumors and the functioning of the body’s defense systems against neoplasms will contribute to the development of radically new methods of diagnosis and therapy, which will significantly increase the effectiveness of early diagnosis and treatment of cancer.

## 4 Conclusions

In agriculture, technologies for cloning individuals with distinctive characteristics will be in demand to create new plant varieties and animal breeds that are resistant to pathogens and adverse environmental conditions. Synthetic biology is a rapidly developing area that provides the creation of strictly specified biological structures, often unparalleled in nature and possessing fundamentally new properties, based on the methodology of gene and protein engineering and the possibility of precise editing of the genome of a living cell. On the basis of gene banks and genomes, it will be possible to construct a synthetic genome for any task in the shortest possible time. With the use of producer strains, practically any synthetic substances previously obtained from oil will be produced, including environmentally friendly biofuels and biotechnological systems for environmental protection. An increase in the accuracy of genetic editing systems is expected, which will be actively used in medicine (for example, editing the lymphocyte genome to obtain an individual cancer vaccine should become a mass technology in the coming years). Technologies for growing human organs in animals for xenotransplantation will be

massively applied, which, in turn, will require the formation of an appropriate regulatory framework. In agriculture, the achievements of synthetic biology will be widely used to develop high-yielding plants and productive animals, including synthesizing active substances, the use of which will have a beneficial medical effect, providing the prevention and treatment of certain diseases. The convergence of bio- and information technologies will become a driver of intensive progress in neurotechnologies, opening up wide opportunities for neurocommunication, integration of human intelligence and artificial intelligence, including into a single network, as well as controlling various devices with the power of thought. Neurocommunication technologies have the potential to be applied in various areas of human life, from medicine and education to the computer games industry and neuromarketing. Neuroimaging and functional mapping systems will significantly increase the efficiency of neurorehabilitation of patients, while neuroprostheses and exoskeletons will radically improve the quality of life of people with spinal cord and musculoskeletal injuries. Thanks to non-invasive brain stimulation, it will be possible to prevent the development of a number of diseases of the human nervous system associated with mental disorders, and significantly enhance human cognitive abilities. In addition to individual application, there will be an integration of a person and devices into an integral network system. Ensuring continuous monitoring of key indicators (including mental and emotional activity) is relevant both for medical purposes and for production, control of machines and mechanisms.

## References

1. A. Yu. Apokin, D. R. Belousov, Scenarios for the development of the world and Russian economy as a basis for scientific and technological forecasting, **3(3)**, 12-29 (2009).
2. S. B. Danilova, Experimental gardening in the Arctic zone of the Russian Federation (AZRF) on the example of the village of Yar-Sale (Yamal-Nenets Autonomous Okrug), 312-325 (2021).
3. S. B. Danilova, *Scenario Approach to Hybrid Public Spaces and the Landscape of Highly Digitalized Medical Institutions*, 152-167 (2021).
4. A. A. Chulok, Forecast of prospects for scientific and technological development of key sectors of the Russian economy: future challenges, **3(3)**, 30-36 (2009).
5. V. P. Emelyanova, G. N. Danilova, T. Kh. Kolesnikova, *Assessment of the quality of land surface waters by hydrochemical indicators*, **115** (2020).
6. A. A. Daukaev, R. Kh. Dadashev, L. S. Gatsaeva, R. A. Gakaev, IOP Conf. Series: Earth and Environmental Science, 378 (2019).
7. R. T. T. Forman, M. Godron, *Landscape Ecology*, 620 (2010).
8. E. Reynard, M. Panizza, *Geomorphosites: definition, assessment, and mapping. Geomorphol Relief*, 177-180 (2018).
9. Bio-Economy Technology Platforms. The European Bioeconomy in 2030: Delivering Sustainable Growth by addressing the Grand Societal Challenges (2021).
10. C. Cagnin, E. Amanatidou, M. Keenan, Orienting European Innovation Systems towards Grand Challenges and the Roles that FTA Can Play, **39(2)**, 140-152 (2020).
11. EU-Russia Energy Dialogue, Energy Forecasts and Scenarios 2009–2010 Research. Final Report. (Moscow: Publishing House “Economica, Stroitelstvo, Transport”, 2021).

12. K. Haegeman, F. Scapolo, A. Ricci, E. Marinelli, A. Sokolov, Quantitative and qualitative approaches in FTA: from combination to integration?, **80**, 386-397 (2021).