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Global trends in scientific and technological development medicine in the world: biomedical technology

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Abstract. Biomedical technologies have made it possible to begin the transition from standardized treatment of individual diseases to personalized medicine, taking into account genetic characteristics, the patient's lifestyle and environmental characteristics, says Elizaveta Rozhdestvenskaya, executive director of the Primer Capital venture fund, "which is especially important in the treatment of rare and complex diseases." One of the most promising areas is the development of products for the treatment of cancer. Not only developed countries, such as the USA, Europe, and Japan, are actively investing in the biopharmaceutical industry. Large-scale programs across the entire spectrum of technologies have begun to be implemented by rapidly developing economies China and India. Almost all states have a program to support biotechnology companies. "This is the most high-tech industry in terms of absolute and relative R&D costs," note the authors of the "Review of Trends in the Global and Russian Pharmaceutical Market." In addition to the biological products market, the segments of diagnostic biochips and biosensors, biocompatible materials, cellular technologies and bioinformatics based on genomic research are also developing.

1 Introduction

The path from scientific research to implementation in healthcare throughout the world and in Russia is long, says German Shipulin, head of the department of molecular diagnostics and epidemiology of the Central Research Institute of Epidemiology of Rospotrebnadzor. "To create a diagnostic kit that can detect one marker (for example, chlamydia), it will take six months of work and another year for registration. In oncology, identifying one marker usually does not give anything; it is necessary to track hundreds of mutations and conduct complex clinical trials," notes German Shipulin. According to him, the development of a complex oncology test will require at least three years and huge financial investments. Only very large companies can undertake such tasks. It takes at least two and a half years for registration preclinical testing of a new drug and the same amount for clinical trials, Alexey Lyundup, head of the department of advanced cell technologies at the Institute of

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Regenerative Medicine of the Scientific and Technological Park of Biomedicine of Sechenov University, told RBC+. Before this, permission to conduct these studies must still be obtained. It is possible to register a product whose production is localized in Russia two to three years faster; legislation allows the use of data from international multicenter clinical trials [2]. The process of importing reagents and equipment necessary for research into Russia is complex and not always predictable, says Elizaveta Rozhdestvenskaya: “The lack of the ability to predict delivery times makes downtime in laboratories inevitable.” In addition, talented scientists lack entrepreneurial spirit, she notes. According to Rozhdestvenskaya, in Russia it became possible to make money from science not so long ago and it will take time to change public consciousness and create entrepreneurial initiative among scientists. Elizaveta Rozhdestvenskaya considers the participation of state institutions to be important for the development of the market: the Skolkovo Foundation, RVC, Rostec, Rusnano. “Public investment programs are evolving into public-private partnership projects, which also contributes to the development of private funds,” she notes [3]. In 2015, Primer Capital became the first completely private venture fund in Russia, ready to invest in biotech startups at the early stages. The main industry strategic documents provide for de-bureaucratization of the process of bringing biomedical technologies to the market, including the introduction of registration regimes based on intermediate evidence, as is done in the USA and the EU. The regulator sees itself as having the task of halving the innovation chain from development to implementation of biomedical drugs so that it takes no more than five years, head of the Ministry of Health Veronika Skvortsova said last year at the III National Congress on Regenerative Medicine. The new “road map” for the development of biotechnologies and genetic engineering for the next two years provides for the launch of two centers for the development and preclinical research of biomedical cell products, and an increase from 5 to 50 in the number of medical organizations accredited by the Ministry of Health to conduct clinical trials of cellular biotechnologies. According to Alexey Lyundup, the adoption of the law on biomedical cell products after many years of regulation of this high-tech area with the help of orders of the Ministry of Health was actually the birth of a new industry in the country: “Regulation of all stages of the development of cell products, preclinical and clinical trials, registration and further production will allow the production of domestic cell products products are no longer objects of scientific interest, but specifically for clinical practice.” “In Russia, developments are underway in the field of preimplantation and perinatal diagnostics, in the field of oncology, we are ahead of Western countries in the field of molecular diagnostics of infectious diseases,” says German Shipulin. Now, he said, explosive growth is possible and it is important to support it.

2 Research Methodology

The development of science in the world is increasingly acquiring cross-border features. Research teams combine their efforts to obtain systematic results. Today, more than ten large-scale scientific programs aimed at understanding people and their health are being implemented in the world. Global research into the human brain to map, monitor and modulate brain activity will lead to many clinical applications, but neuroscanning projects are coming to the fore. Knowledge of how the brain produces complex behavior and how it adapts to external and internal changes is limited. Understanding different senses, emotions, and cognitive functions—thinking, choosing, and even consciousness—promises innovative solutions in areas such as healthcare, education, and the 21st century economy [3]. With the growing burden of major brain diseases worldwide, scientists need to find the most effective means to comprehensively apply modern biotechnology and solve clinical medical problems. Neuroscience and imaging are entering a new era of collaboration in which breakthrough new technologies generated by major scientific projects around the world will have a profound impact not only on medical science, but also on the economy and society.

The following methods were employed in conducting this study:

- Literature Review: A thorough review of scientific and medical literature, including academic articles, reports, and studies, was conducted. This step helped establish the existing knowledge base, identify key trends, and determine research gaps.
- Data Collection: Data related to global trends in biomedical technology and its impact on the field of medicine were collected. This included both quantitative data (e.g., statistical information on research funding, technology adoption rates) and qualitative data (e.g., descriptions of emerging technologies).
- Case Studies: Several case studies from different regions and healthcare sectors were examined. These case studies offered practical examples of how biomedical technology is being applied, its outcomes, and its implications for healthcare systems.
- Data Analysis: Quantitative data collected from various sources were subjected to statistical analysis. This involved examining trends, patterns, and correlations in data related to the adoption of biomedical technologies, research funding, and clinical outcomes.
- Expert Interviews: Interviews were conducted with experts in the fields of biomedical technology, medical research, healthcare delivery, and healthcare policy. These interviews provided valuable insights into the current and potential impact of emerging technologies in medicine.
- Surveys and Questionnaires: Surveys and questionnaires were administered to healthcare professionals, researchers, and policymakers to gather their opinions and assessments of the role of biomedical technology in global medical trends.
- Frameworks and Models: Existing frameworks and models for assessing healthcare technology adoption and impact were utilized to evaluate the effects of biomedical technology on healthcare systems, patient outcomes, and healthcare costs.
- Regulatory and Ethical Assessment: An examination of regulatory frameworks and ethical considerations related to the development and adoption of biomedical technologies was conducted. This step aimed to understand the challenges and ethical implications associated with new medical technologies.
- Comparative Analysis: Comparative analysis was performed to assess the relative importance and effectiveness of various biomedical technologies in driving global trends in medical research, healthcare delivery, and patient care.
- Interdisciplinary Approach: The study adopted an interdisciplinary approach by integrating insights from various disciplines, including medicine, engineering, data science, and health policy. This approach allowed for a comprehensive understanding of the topic.
- Synthesis and Reporting: Findings from the literature review, data analysis, case studies, expert interviews, surveys, and comparative analysis were synthesized to draw conclusions about the global trends in biomedical technology and their impact on medicine. Results were reported in a structured and coherent manner.
- Limitations and Future Research: The study recognized its limitations, such as potential bias in data sources and the dynamic nature of technological developments. It also identified areas for future research and opportunities for further investigation in the field of biomedical technology and its role in global medical trends.

This research methodology aimed to provide an evidence-based exploration of global trends in scientific and technological development in medicine, specifically focusing on the significant role played by biomedical technology in shaping the future of healthcare and medical research worldwide.

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3 Results and Discussions

Scientists have discovered how to produce new neurons. Dormant neural stem cells were resurrected in the brains of adult mice by restarting their metabolism, resulting in the production of new neurons (fig.1). This regenerative potential may have long-term implications for the treatment of neurodegenerative diseases. Neural stem cells are stem cells that have the ability to differentiate into cells of the nervous system, including neurons and glial cells [4]. They are present in various tissues such as the brain, spinal cord and peripheral nervous system. They are necessary for the regeneration and restoration of damaged nerve tissue. These cells allow the brain to grow, but most of them lie dormant (or quiescent) in the adult body. This limits our ability to create new neurons throughout our lives. In the new work, a Swiss team led by Professor Jean-Claude Martinou has found a way to "awaken" these stem cells from their dormant state in mice, allowing them to become active again. To understand this work, it is helpful to consider mitochondria. These cellular organelles, present in most eukaryotic cells (including human cells), are often called the "energy centers" of the cell [5]. Their main task is to produce energy in the form of ATP (adenosine triphosphate) during cellular respiration. It should be remembered that mitochondria have a characteristic double membrane structure: a smooth outer membrane and a highly folded inner membrane that forms ridges.

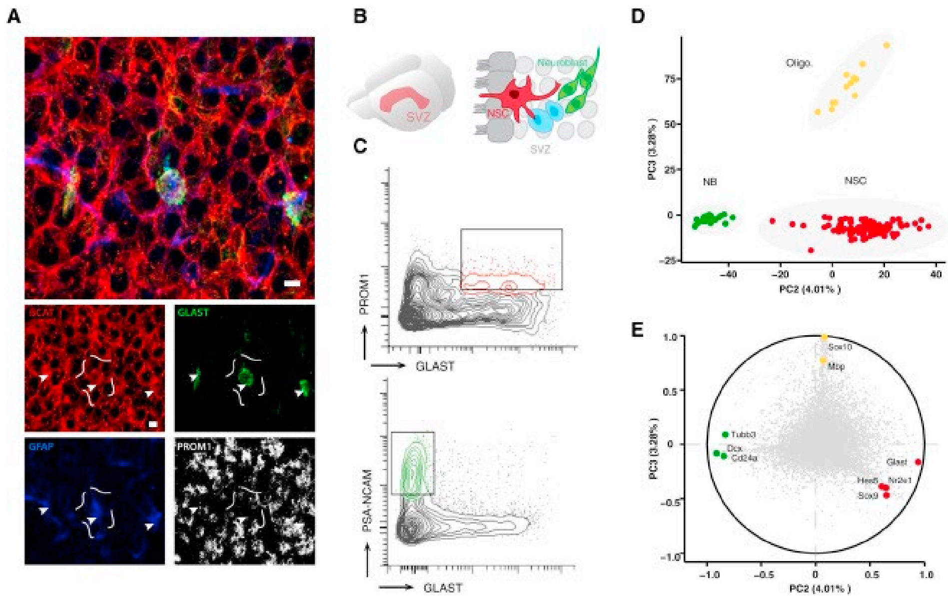

Fig. 1. Single-Cell RNA-Seq Analysis of NSCs and Neuroblasts Defines Cell-Type-Specific Transcriptomes

(A) Confocal images of a wholemount staining of the lateral wall of the lateral ventricle. Cells were immunostained for GLAST (green), GFAP (blue), and Prominin1 (Prom-1) (white). Pinwheel structures are defined by β-catenin (red). Arrowheads mark the cilium of monociliated GLAST- and Prom1-expressing cells. Scale bar, 10 μm.

(B) Schematic representation of the SVZ.

(C) FACS strategy for the isolation of NSCs, which express both GLAST and Prom1, and neuroblasts, which express PSA-NCAM, from the SVZ niche. See also Figures S1 and S2.

(D) PCA of single-cell RNA-seq transcriptomes from 104 GLAST/Prominin1 and 26 PSA-NCAM cells. See also Table S1.

(E) Genes characterizing each population based on the correlations with principal components 2 and 3 from the PCA (each point corresponds to a gene and previously known marker genes are highlighted in color).

This structure promotes efficient ATP production [6]. That said, several years ago the same team identified a key protein complex called the mitochondrial pyruvate transporter (MPC) that may help direct cells down specific metabolic pathways. In this case, scientists were trying to find a way to use this mitochondrial machinery to their advantage to reactivate dormant neuronal stem cells. Newly formed neurons in the dentate gyrus are shown in red. Cell nuclei are shown in blue. Green is a marker for immature neurons. By eliminating MPC activity using chemical inhibitors in genetically modified mice, the researchers were able to suppress its effect on neural stem cells. As a result, these cells began to generate new neurons, even in old mice. “With this work, we show that rerouting metabolic pathways can directly influence the activity state of adult neural stem cells and therefore the number of new neurons generated,” the authors note in a press release. The ability to regenerate parts of the adult brain could have huge implications for treating brain injury or disease if these results are replicated in humans. Ideally, we could use these restored cells to replace lost neurons. This is still a long way off, but it is a promising path that will require further exploration [7].

New laser technology can detect and identify bacteria within minutes. Currently, in order to detect and identify bacteria present in liquid samples, artificial cultivation of bacterial cultures from samples in laboratory conditions is required. Depending on the number and type of bacteria in the samples, the cultivation process can take a long time, from several hours to several days. However, this approach can already be considered obsolete, thanks to the development of new laser technology, which allows you to get results within a few minutes after taking a sample.

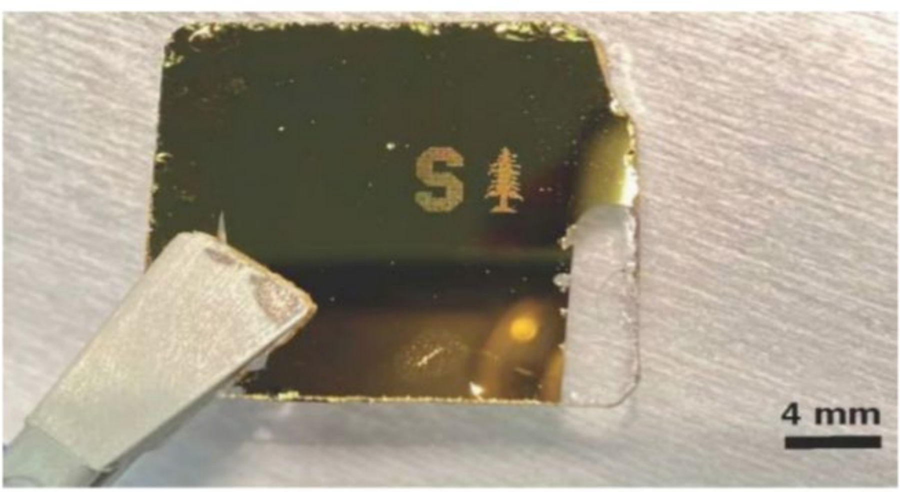

Fig. 2. Modified inkjet printer

The new technology is based on the fact that when bacteria are illuminated with laser light, they reflect light, the spectral parameters of which are unique to each type of bacteria. The problem is that other microscopic objects in the sample, such as blood cells, also reflect light with slightly different spectral characteristics [8]. Thus, the spectral signature of bacteria is simply lost among extraneous interference. A team of researchers from Stanford University circumvented the problem described above using a modified inkjet printer that, using pulses of vibration in the audio range, “prints” tiny droplets of sample liquid onto the surface (fig.2). The volume of each droplet is only two trillionths of a liter, and such a small volume of liquid usually contains at most a few dozen bacteria, cells and other microscopic particles. In addition, gold nanopillars are located on the surface, which serve as a kind of antennas that focus laser light. And as a result of all this, the spectral signature of bacteria appears in reflected light 1.5 thousand times stronger than when simply illuminating a liquid sample with a laser. The spectral data obtained in this way is run through specially trained neural networks, which provide an answer in the form of the types and concentration of bacteria present in the sample. Neural network training was carried out on blood samples of experimental rodents infected with various types of bacteria, and, naturally, the technology demonstrates very good results specifically when analyzing blood samples [9]. However, scientists argue that the same approach will work just as effectively with other types of biological fluids, plus it can be used not only to detect bacteria, but also to detect other types of microorganisms, such as viruses. “This innovative technology could save many lives in some cases, because doctors will know about bacterial contamination within minutes, rather than hours or days,” the researchers write. “We are now preparing this technology for commercialization and it is likely that In the future, it will become the new standard for bacterial detection and single cell characterization.”

Biologists have turned cancer cells into immune cells, and they have joined the fight against the tumor. Scientists at Stanford Medical School have discovered that when cancer cells become immune cells, they begin to teach other immune cells how to effectively fight cancer. The study was published in the journal Cancer Discovery. Some of the most promising cancer treatments use the patient's immune system to attack the cancer. But there are many targets for attack, each of which usually has to be dealt with separately. Doctors sometimes have to guess which ones will be most promising. A better approach would be to train immune cells to recognize cancer naturally. During the learning process, special APC cells “show” T cells what the pathogen that needs to be neutralized looks like. Scientists theorized that if they turned cancer cells into APCs, they could naturally train T cells to attack cancerous tumors [10]. Researchers programmed mouse leukemia (blood cancer) cells so that some of them could transform into APCs. The scientists' approach worked: immune cells recognized the cancer, and the mice were successfully cured. When the scientists reintroduced the cancer into the mice after 100 days, they still had a strong immune response that protected them from the tumor. The nature of blood cancers and tumors with a hard shell is different. When the researchers tested their method on solid tumors, the effect was worse, but the survival rate of the animals was still significantly improved.

4 Conclusions

The relevance of regenerative technologies in cardiological practice is beyond doubt: according to the World Health Organization, in the vast majority of countries in the world, cardiovascular diseases occupy first place among the causes of mortality in the population. The market is witnessing major technological advancements in the areas of biologics, biomaterials, stem cell technologies, and tissue engineering, which is driving the growth of the market. There are also various recent advances in regenerative medicine, including regenerated tracheas for transplantation, 3D bioprinting, stem cell treatments for vision loss, and stem cell treatments for heart repair.

The current market is also witnessing extensive research and development. In addition to the R&D carried out by private players, academic institutions are being actively engaged to conduct various studies. Thus, several new biotech and healthcare companies are expected to emerge in the future as a result of ongoing research and development around the world.

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