



# SCIENTIFIC RESEARCH OF THE SCO COUNTRIES: SYNERGY AND INTEGRATION

上合组织国家的科学研究：协同和一体化

Proceedings of the  
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这些会议文结合了会议的材料 – 研究论文和科学工作者的论文报告。它考察了职业化人格的技术和社会学问题。一些文章涉及人格职业化研究问题的理论和方法论方法和原则。

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经济衰退和日益严重的全球经济衰退对欧亚和亚洲发展的影响。中国领先企业推动信息通信技术和碳氢化合物市场增长的战略探讨

**THE IMPACT OF DICAPPING AND THE GROWING GLOBAL RECESSION ON EURASIAN AND ASIAN DEVELOPMENT. APPROACHES TO THE STRATEGIES OF LEADING CHINESE COMPANIES AS DRIVERS OF THE GROWTH OF ICT AND HYDROCARBON MARKETS**

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抽象的。 欧亚趋势影响着市场的各个领域，并引发多向运动，从而塑造了中国、中亚和俄罗斯进一步发展的真实状况，作为全球经济数字化转型及其潜在复苏过程中的单一参与者。 新冠疫情后的经济衰退，使其无法完全形成亚洲和中国独立投资流入各自经济各个部门的主要趋势。 这些趋势非常不稳定，并且在企业影响国家经济主权机制的领域中存在政治动荡的因素。

关键词：中国、美国、俄罗斯、脱钩、投资、ICT行业、NBICS、工业4.0、区块链、网络安全、市场、生态系统、元宇宙、支付系统、人工智能、大数据、MRI、IEO。

**Abstract.** *Eurasian trends affect all sectors of the markets and cause multidirectional movements that shape the true state of affairs in the further development of the PRC, Central Asia and Russia, as single actors in the processes of digital transformation of the global economy and its potential recovery from the post-Covid recession, which does not allow it to fully form the main trends of independent Asian and Chinese investment flows into various sectors of*



*their own economies. And these trends are highly volatile and have a factor of political turbulence that arises in sectors of corporate influence on the sovereign mechanisms of national economies.*

**Keywords:** *China, USA, Russia, decoupling, investments, ICT industry, NBICS, Industry 4.0., blockchain, cybersecurity, marketplace, ecosystem, metaverse, payment system, AI, Big Data, MRI, IEO.*

The October 2023 trends on the state of the sovereign economies of the Eurasian region were assessed by experts of the Eurasian Development Bank, who named the main factors influencing the markets and the conditions of de-globalizing sectors of the national economies of the countries of the Central Asian region and Eurasian countries in the post-Covid recovery.

In particular, they pointed to continued persistent price pressure, which was a consequence of lower energy prices, which slowed down both consolidated inflation in the eurozone and in the New World, but at the same time its values remained high. At the same time, core consumer price indices in July increased for the EU by 5.5% y/y, and June growth in the US was 4.8%, which undermines the idea of developed self-sufficiency of the leading economies of the “golden billion”. At the same time, the professed strategy of increasing interest rates, in the logic of this monetary policy of post-Covid recovery countries, should remain at elevated levels for a long time. Even despite the increase in ECB and Fed rates by 0.25 p/p, as a limit to multi-year highs, which thereby make it impossible for these economies to rapidly develop in their countries and actually reduce both their competitiveness and the marginality of innovative projects that reach Industry 4.0. up to 90% growth in the formation of national GDP through the introduction of innovations and NBICS technologies. This means that the applied figures of stable inflation for these actors will go beyond the previously calculated 2% in the pre-Covid period and will be able to reach 3-5% in the future for the entire time of the energy transition in search of the optimum “green agenda” and reindustrialization on the new principles of the “knowledge economy”. This means that the planned growth of the world economy itself will begin to cool down and the influence of the previously achieved overheating will lead the main subjects of the meso- and macro-levels to a low-income concept of slow development, in terms of the introduction of new technological business models, which is already observed in both the EU and the USA, and in China, which continues to reduce export supplies and conserve business activity in priority areas.

This leads to a revision of industrial growth and to cycles of production of goods of creative industries and basic industries, losing orders from outside and switching, to the rescue and to minimize losses, to their domestic markets. This is also facilitated by the trend of overheating of the labor market, when the level of blue collar workers with low competencies is replaced by AI and machine learn-

ing and neural algorithms, while the average set of critical skills and standard characteristics of workers does not have time to cover all existing industries and provide them with digital transformation. At the same time, white-collar workers, as representatives of top management, become less effective than the machine solutions of the strategies they themselves execute, and are subject to the same reduction and transformation of the transition to the lower strata of the “middle class”, dissolving due to the redistribution of the bulk of income between the rich and very wealthy business owners who are not ready to share with business managers the revenue generated by robots and machines in the context of the reduction of traditional professions and the emergence of a whole set of creative specialties and unique competencies from the emotional sphere of “behavioral economics.” This problem is gaining momentum and is becoming a consequence of excessive financial injections of Covid to keep various economic entities afloat during the Covid lockdown period, which does not have time to staff the growing post-Covid demand and triggers inflationary pressure in anticipation of a shortage of real goods and services for the reduced solvent demand. Both these flows and the growing shortage of low- and middle-level workers (blue collar workers) undermine the trends of scientific and technological progress itself, which is not ready to wait for more comfortable strategies for the implementation of highly innovative products that guarantee their monopoly in the markets, until the emergence of substitutes that were previously needed volume was provided by Asian producers. At the same time, the focus on internal sources of growth deglobalizes national industries that depend on cross-border supplies and provide global markets with the required amount of raw materials, which both Russia and Kazakhstan supply uninterruptedly and in the required volume even under conditions of sanctions pressure, ensuring the deindustrializing economy on time and in the required volume. the eurozone and the countries of the East, but due to the failures of the global market and the ongoing recession of the entire world economy, they are beginning to reduce the activity of involving the oil and gas sector in industrial production, in general, and the entire resource and raw materials model, in particular.

And this will lead to the fact that the global race in the ICT industry and the ongoing decoupling between the United States and China will intensify competition and contribute to the development of worsening fragmentation between industries and in TNCs, polarizing the economy and adjusting the priority of the post-Covid recovery of sovereign states trying to maintain their place in GDL (global division of labor) and in IER (international economic relations) of Industry 4.0. and NBICS way of life. That’s why, to maintain their leadership in electronic gadgets and cybersecurity, Chinese companies are increasingly investing in a wide range of sectors, with the trend towards investing in technology accelerating recently, and the banking industry accelerating the pace of going global through participation in personalized digital ecosystems and when creating metaverses of future marketplaces of individual, targeted, orientation.

The outbound investment policies of Chinese companies in relevant fields have been introduced in line with the global trend towards the development of the digital and green economy. In 2021, the Ministry of Commerce of China, together with other departments, issued two policy documents, namely “Working Guidelines for Green Development of Outbound Investment Cooperation” and “Working Guidelines for Outbound Investment Cooperation in the Digital Economy”, which define the main directions of investment in relevant areas and act as recommendations for Chinese companies, guaranteed by the state industrial ideology of accelerated reindustrialization on new principles of leadership and overcoming critical infrastructural vulnerabilities.

The “Working Guide for Green Development of Outbound Investment Cooperation” lists as the main directions of investment activities abroad the promotion of environmentally friendly production and economic activities, the construction of green infrastructure, the promotion of innovation in the field of green technologies, the promotion of green transformation of corporate structures, “smart cities”, prevention of environmental and environmental risks while correcting them and deeper adherence to “green” international rules<sup>1</sup>.

The “Working Guide for Outbound Investment Cooperation in the Digital Economy” lists the following as the main directions of investment activity abroad: active integration into the global industrial supply chain and production based on the digital economy, accelerating the construction of digital infrastructure, promoting the digital transformation of traditional industries, optimizing the exit pattern digital economy to the global level and the creation of digital economy enterprises with international competition<sup>2</sup>.

The digital economy, driven by technologies such as big data, cloud computing, the Internet of things, artificial intelligence and blockchain, has been rapidly developing in recent years, taking priority in scientific investments and in the development of corresponding nanoclusters, which have become a continuation of innovation zones, industrial materials science foundations, and technolabs. and academic campuses. China is the undisputed pioneer in the development of the digital economy and has a well-developed digital infrastructure. The Covid-19 outbreak in 2020 became a catalyst for the digital transformation of the Chinese economy. In 2020, China’s digital economy reached 39.2 trillion yuan, accounting for 38.6% of GDP. The digital economy of Beijing and Shanghai has taken a dominant position in the regional economy, accounting for more than 50% of GDP<sup>3</sup>.

<sup>1</sup> Working guide on green development of outbound investment cooperation [Electronic resource] // Access mode: <http://images.mofcom.gov.cn/hzs/202107/20210716144040753.pdf> (access date: 10/05/2023)

<sup>2</sup> Working guide on outbound investment cooperation in the digital economy [Electronic resource] // Access mode: <http://images.mofcom.gov.cn/hzs/202107/20210723142119100.pdf> (access date: 10/05/2023)

<sup>3</sup> 《中国企业全球化报告（2021-2022）》 [Electronic resource] // Access mode: <http://www.ccg.org.cn/archives/69855>

With the development of the digital economy, Chinese enterprises can take advantage of the market opportunity to build digital infrastructure abroad (which is especially actively implemented by these economic actors in the Middle East, Africa and South America, as well as with the increasing deindustrialization of the EU). Their main components of investment and construction-innovative breakthrough are such elements of the ongoing global digitalization as fiber optic cable, broadband network, satellite communications, 5G network, AI (artificial intelligence), data centers, as well as transformation of traditional infrastructure. Chinese companies are also actively involved in the development of international digital rules, the development of technology standards, protocols and roadmaps for new digital platforms, payment systems and marketplaces.

Typical examples of such activities are the investment strategies of two Chinese companies - Huawei Technologies Co. Ltd. and China National Petroleum Corporation (CNPC). These companies were chosen because they operate in different sectors of the economy, moreover, one of the enterprises is a private company, and the second is controlled by the state.

Founded in 1987, Huawei is a leading global provider of information and communications technology (ICT) infrastructure and smart devices. The company operates in more than 170 countries and regions, serving more than three billion people worldwide. For 2022, the company's total R&D expenditure was 161.5 billion yuan, accounting for 25.1% of total revenue, and the total R&D investment over the past decade exceeded 977.3 billion yuan. As of 2022, Huawei owns a total of 120,000 active patents by the end.

Speaking about the investment strategy of this company, first of all, it is worth emphasizing that it is focused on long-term, strategic investments. In his speech at MWC Barcelona 2022, Huawei Chairman Guo Ping delivered his "Just Look Up, Let's Light Up the Future" speech, outlining the company's top strategic priorities. The two main motivations for his presentation were (1) that existing theoretical frameworks and architectures are unable to support the "explosive growth" of accelerated demand for digitalization and (2) that reducing carbon emissions affects the long-term viability of the digital economy by slowing down its development by being too restrictive certification requirements for "green standards" in the Asia-Pacific region, in particular. Therefore, Huawei continues to steadily increase the volume of strategic investments in fundamental technologies to transform the technological structure, abandoned the basic priority of cloud computing in September 2023 and went completely into the development of AI itself, neural networks and machine computing<sup>4</sup>.

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<sup>4</sup> Speech by Guo Ping, Chairman of the Board of Directors of Huawei 03.03.2022 [Electronic resource] // Access mode: <https://carrier.huawei.com/en/events/mwc2022/videos/keynote-guoping> (access date: 10.05.2023)

Long-term strategic investments can be confirmed both by the company's declared total investment in R&D, according to which it ranks 2nd in the world among private companies after the American Amazon, and by specific projects. For example, Huawei began investing in research and development of sixth generation networks – 6G – back in 2017<sup>5</sup>.

It is clear that simply investing large amounts of money in R&D is not always enough to produce innovations that are easily accessible to customers. Therefore, Huawei uses an “open innovation system” through which it actively introduces technology and knowledge. The idea is that a company that objectively understands its own innovation capabilities and limitations can increase its profits by licensing its technological strengths to others and strategically complementing its weaknesses through joint research or other activities with other parties.

One can also note a shift towards investment diversification strategies in recent years. Although plans to hedge claims/diversify into the area of innovatively developed products were announced long ago, starting with projects such as Huawei Cloud, the transition from the production of devices and equipment to the development of computer programs and software accelerated sharply in 2018, as the company found itself under US sanctions. This has contributed to the company's growing presence in non-communications technologies such as home appliances and wearables; in the field of software and data processing, for example in automobiles and water management systems; as well as in the field of R&D, including outside telecommunications and electronics, for example, in startups, greenfields and in parallel growing according to their own principles of digitalization, similar in tasks, in the Chinese “unicorns” of creative industries.

The third important area of investment is investment in talent, which is always an investment that pays off in the long term, because the “industry of a happy and safe childhood” has made it possible to create a healthy and well-trained generation of post-baby boomers, the “X”, which today is in most businesses. structures of China and in the leadership of post-Soviet republics. Huawei launched its Seeds of the Future initiative back in 2008. This initiative aims to expand opportunities for engineering and science students around the world. To date, the initiative has been implemented in 137 countries and regions of the world, and more than 12,000 students from more than 500 of the world's best universities have benefited from the program.<sup>6</sup>

Every year the company strengthens its interaction with universities, research centers and laboratories, including in Europe. In 2021 alone, Huawei spent

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<sup>5</sup> Eric Xu Chairman of the Board of Directors of Huawei 2021 Joint Visioning and Defining 6G [Electronic resource] // Access mode: <https://www.huawei.com/en/huaweitech/future-technologies/envisioning-and-defining-6g-together> (access date: 10/05/2023)

<sup>6</sup> Program “Seeds for the future” [Electronic resource] // Access mode: <https://www.huawei.com/minisite/seeds-for-the-future/index.html> (access date 10/05/2023)

US\$400 million on research and education activities with more than 300 universities and 900 research institutes. Conceptually, these “industrial-academic collaborations” represent the infrastructure of technological innovation in ICT, which means they are vital for a company like Huawei to be able to penetrate this area, to become its underlying substrate, ecosystem. This model of “open innovation” is based on the use of cooperation with many academic partners in different countries, summarizes knowledge and skills, and sets priorities in the development and use of nature-like NBICS technologies of the 7th robotic-humanoid scientific and technological order. It, as an innovative business process, focuses on the specific and competitive strengths of individual institutions and then creates sustainable, long-term partnerships and cooperation chains that bring innovation and help introduce the company into the industrial and production structures of the partner state. However, if we consider them from the point of view of national security, then they represent “soft power”, a battering ram at the gate, used skillfully and accurately by a given Chinese company in the industry and economy of such a country as a whole.

Huawei is investing more actively in the development of digital infrastructure in developing countries in Africa and Latin America, which can be justified by the announcement of the Digital Silk Road initiative in 2015, as an offshoot of the Belt and Road Initiative in the digital sphere, as well as the need to diversify and searching for new markets under pressure from US sanctions.

The investment strategy of this company in developing countries is as follows. The technology company aims to dominate the ICT equipment manufacturing market by purposefully aligning its growth with the development needs of host countries. Thus, this allows the company to increase market share in the host countries, gain access to resources, adopt the necessary technological regulations and laws of the host country in its support, strengthen the monopoly of its position in it, etc.

Sinopec is one of the world’s largest oil companies. It dominates the oil and gas business in the domestic Chinese market along with PetroChina. In addition to the production of petroleum products and petrochemical products, it is engaged in the development of resource deposits. The company is also China’s largest gasoline retailer, with 30,000 stations nationwide. Sinopec alone accounts for 60-70% of China’s crude oil imports. Sinopec’s net profit for 2022 was 66.3 billion yuan. Ranked 45th in the 2022 Forbes Global 2000 list of the world’s largest companies (4th in revenue, 79th in net income, 146th in assets and 174th in market capitalization)<sup>7</sup>.

The investment strategy of this company is also characterized by a clear focus on the long term, rather than a focus on making profits in the short term.

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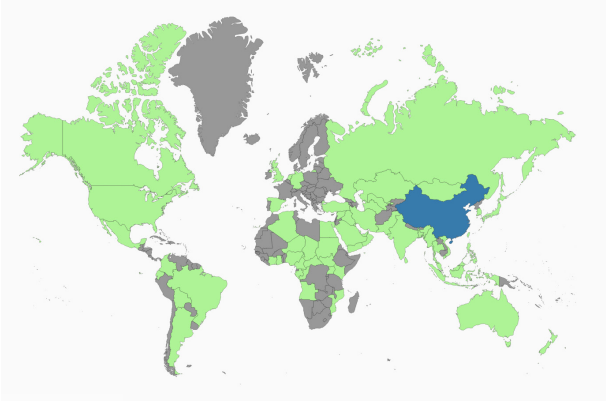
<sup>7</sup> Forbes Global 2000 rating [Electronic resource] // Access mode: <https://www.forbes.com/companies/sinopec/?sh=10a29caf892e> (access date 10/05/2023)

As part of its strategy to expand its presence abroad, Sinopec acquires shares of oil and gas or petrochemical companies operating in the market of the relevant country, obtains concessions and buys out oil and gas fields, even if development work cannot begin immediately<sup>8</sup>.

For example, in 2015, “Sibur” and “Sinopec” entered into an investment agreement on the entry of the Chinese company into the capital of Sibur as a strategic investor<sup>9</sup>. The largest number of the company’s foreign assets is concentrated on the African continent in the field of field development - Sinopec owns shares in oil and gas fields in Nigeria, the Central African Republic and South Sudan.

There is also a trend towards diversification of the company’s assets - more and more similar investment and partnership agreements are being concluded with countries in the Middle East. One of the most recent acquisitions: On April 12, 2023, Sinopec acquired a 1.25% stake in the North Field East expansion project and a 5% stake in the liquefied natural gas (LNG) plant project by signing an agreement with QatarEnergy.

Sinopec strives to diversify its energy supplies as much as possible by opening subsidiaries in foreign countries. In the figure below, the countries where Sinopec’s subsidiaries operate are marked in green.



**Figure 1.** Presence of Sinopec subsidiaries in countries around the world  
 Source: compiled by the authors based on data from the official Sinopec website  
 (<http://www.sinopecgroup.com/group/en/>)

<sup>8</sup> 世界经济与政治。— 2022。— №3。— С. 92-119. URL: <https://d.wanfangdata.com.cn/periodical/sjjjyzz202203004> Access mode: by subscription. (Yang Xiuyan, The Diplomatic Impact of Chinese State-Owned Enterprises’ Overseas Investment in the Context of Great Power Competition) // 世界经济与政治。— 2022。— No. 3。— pp. 92-119. URL: <https://d.wanfangdata.com.cn/periodical/sjjjyzz202203004> Access mode: by subscription.

<sup>9</sup> RBC News Agency Chinese Sinopec bought 10% of Sibur [Electronic resource] // Access mode: <https://www.rbc.ru/business/17/12/2015/5672855f9a79476f7a323916> (access date: 10/05/2023)



In addition, the company actively invests in research and development. In 2022, the company filed 8,687 patent applications at home and abroad, 6,289 of which were granted. Breakthroughs have been made in the field of exploration and production, and the innovations and technologies of Chinese scientific developers have been applied in the theory of exploration and development of deep and ultra-deep oil and gas fields, as well as shale oil and gas. In oil refining, projects were implemented on large-scale test production and on the use of biojet fuel. The chemical industry has increased production of carbon fiber. In addition, the wet oxidation process of sulfur-containing waste alkaline liquid for ethylene meg-cracking was put into commercial operation.

One of the latest trends in the company's investment areas is "green" energy. Aligning its strategy with the goals set by the 14th Five-Year Plan (2021-2025), Sinopec included the concept of "greenness" for the first time. The planned investment volume for the implementation of the "hydrogen strategy" is 30 billion yuan or 4.6 billion US dollars by 2025.

Thus, we can conclude that the investment strategies of large Chinese companies have many similarities. They take a long-term view, focus on diversifying markets and invest heavily in research and development to continue to be leaders in their industries. In addition, there is also a clear correlation between the goals and objectives set by the Chinese government in policy documents and the direct content of investment strategies of Chinese companies, regardless of the form of state participation in the company's capital and the economic sector in which the corresponding company operates.

This means that such a business approach based on the national ideology of breakthroughs and dominance in key sectors of the world economy is actively and successfully displayed through the introduction of modern business models and the ongoing modernization of the entire world economy in its post-Covid recovery, digitalization processes and building critical infrastructure of the future capable continue to support the growing competitiveness of Chinese companies and give them exclusive business rights in the areas where they operate.

Moreover, the global recession and high-stakes era discussed at the beginning of the article brings to the fore questions about the redistribution of businesses within new strategic international alliances and preparations for the 6th wave of post-Covid mergers and acquisitions, leading the world elites to new participants in the recovery of the global economy and to the change of old owners who are unable to provide the required level of profitability and profitability of their business models, as well as who are not ready to accept the trends of the state return to the corporatocratic sphere and the introduction of a planned economy and export support for their leading economic entities as part of the upcoming sovereignization of states recovering from covid consequences.



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医药发展：保守与创新  
**DEVELOPMENT OF MEDICINE: CONSERVATISM AND INNOVATION**

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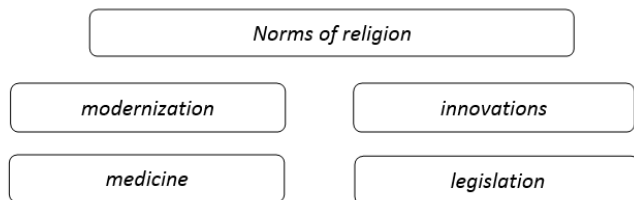
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注解。最新技术的发展对于医疗保健领域的创新是必要的，但当谈到人工智能在医学领域的发展时，我们也不应该忘记其他几点。人性的因素，医生的人性品质，可以帮助病人的康复或延长生命。一个人的一句话就能给病人带来康复的希望。我们是否考虑过正确的词语在一个人的生活中的含义？我们的生活不就是虚荣吗，有品质吗？这个因素取决于人本身。

关键词：普遍公约、立法、统一、战略、数字化、创新。

**Annotation.** *The development of the latest technologies is necessary for the innovation of the medical and healthcare sector, but we should not forget about other points when it comes to artificial intelligence in the field of medicine. The factor of humanity, the human qualities of a doctor, which can contribute to the patient's recovery or prolongation of his life. One human word can give a patient hope for recovery. Do we think about the meaning of the right words in a person's life? Isn't our life just vanity and does it have quality? This factor depends on the person himself.*

**Keywords:** *universal conventions, legislation, unification, strategies, digitalization, innovations.*



*According to the Constitution of the Russian Federation* article 41: «1. Everyone has the right to health care and medical care. Medical care in state and municipal health care institutions is provided to citizens free of charge at the expense of the relevant budget, insurance premiums, and other revenues<sup>1</sup>.

2. In the Russian Federation, federal programs for the protection and promotion of public health are financed, measures are taken to develop state, municipal, and private healthcare systems, and activities that contribute to the strengthening of human health, the development of physical culture and sports, and environmental and sanitary and epidemiological well-being are encouraged.

3. Concealment by officials of facts and circumstances that pose a threat to the life and health of people entails liability in accordance with federal law<sup>2</sup>.

States are paying attention to the development of telemedicine.

In Russia according to the Article 36 The Federal Law «On the basics of protecting the health of citizens in the Russian Federation» 2011 : «Medical care using telemedicine technologies is organized and provided in the manner established by the authorized federal executive body, as well as in accordance with the procedures for providing medical care and taking into account the standards of medical care»<sup>3</sup>. The use of telemedicine technologies in the provision of medical care is carried out in compliance with the requirements established by the legislation of the Russian Federation in the field of personal data and in compliance with medical confidentiality<sup>4</sup>.

The need to comply with ethical standards in the field of medicine is subject to legal regulation.

<sup>1</sup> “Constitution of the Russian Federation” (adopted by popular vote on 12/12/1993 with amendments approved during the nationwide vote on 07/01/2020). // Official publication of legal acts. <http://publication.pravo.gov.ru/Document/View/0001202007040001>(last accessed on 23.04.2022).

<sup>2</sup> “Constitution of the Russian Federation” (adopted by popular vote on 12/12/1993 with amendments approved during the nationwide vote on 07/01/2020). // Official publication of legal acts. <http://publication.pravo.gov.ru/Document/View/0001202007040001>(last accessed on 23.04.2022).

<sup>3</sup> The Federal Law «On the basics of protecting the health of citizens in the Russian Federation» 2011 as amended on June 13, 2022// <http://pravo.gov.ru/proxy/ips/?docbody=&nd=102152259&intelsearch=%D4%E5%E4%E5%F0%E0%EB%FC%ED%FB%E9+%E7%E0%EA%EE%ED+%EE%F2+21+%ED%EE%FF%E1%F0%FF+2011+%E3. +%B9+323-%D4%C7+%22%CE%E1+%EE%F1%ED%EE%E2%E0%F5+%EE%F5%F0%E0%ED%FB+%E7%E4%EE%F0%EE%E2%FC%FF+%E3%F0%E0%E6%E4%E0%ED+%E2+%D0%EE%F1%F1%E8%E9%F1%EA%EE%E9+%D4%E5%E4%E5%F0%E0%F6%E8%E8%22> (last accessed on 3.10.2023).

<sup>4</sup> Ibid. // <http://pravo.gov.ru/proxy/ips/?docbody=&nd=102152259&intelsearch=%D4%E5%E4%E5%F0%E0%EB%FC%ED%FB%E9+%E7%E0%EA%EE%ED+%EE%F2+21+%ED%EE%FF%E1%F0%FF+2011+%E3. +%B9+323-%D4%C7+%22%CE%E1+%EE%F1%ED%EE%E2%E0%F5+%EE%F5%F0%E0%ED%FB+%E7%E4%EE%F0%EE%E2%FC%FF+%E3%F0%E0%E6%E4%E0%ED+%E2+%D0%EE%F1%F1%E8%E9%F1%EA%EE%E9+%D4%E5%E4%E5%F0%E0%F6%E8%E8%22>(last accessed on 3.10.2023).

In article 8 “The Code of Professional Ethics of Doctors of the Russian Federation” (adopted by the First National Congress of Doctors of the Russian Federation on October 5, 2012) states that medical confidentiality refers to everything that became known to the doctor in the performance of his professional duty. Disclosure of information constituting medical confidentiality is not permitted without the permission of the patient or his legal representative, including after the death of a person, except in cases provided for by Russian legislation<sup>5</sup>.

Issues of medicine and healthcare are also subject to legal regulation in Georgia.

In accordance with paragraph 4 of Art. 5 of the Constitution of Georgia: «The state takes care of human health and social protection, providing a living wage and decent housing, protecting the well-being of the family. The state supports the citizen in employment. The conditions for ensuring the subsistence minimum are determined by law»<sup>6</sup>.

Article 28 of the Constitution of Georgia regulates the right to health protection:

«1. The citizen’s right to affordable and quality health care services is guaranteed by law.

2. The state controls all health care institutions and the quality of medical services, regulates pharmaceutical production and circulation of pharmaceuticals<sup>7</sup>. According to the Article 151 Georgian Law about health protection 10.12.1997 : «Medical personnel, as well as any other person, are prohibited from performing or participating in euthanasia»<sup>8</sup>.

The UN Sustainable Development Goal 3 states: «Ensure healthy lives and promote well-being for all at all ages»<sup>9</sup>.

Member states of the European Union are attempting to regionally unify the legal regulation of cross-border medical services.

According to the Directive of the European Parliament and of the Council of 9 March 2011 on the application of patients’ rights in cross-border healthcare: «Health systems in the EU are key to achieving high levels of social protection in the EU and contribute to achieving social cohesion and social justice,

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<sup>5</sup> “The Code of Professional Ethics of Doctors of the Russian Federation” (adopted by the First National Congress of Doctors of the Russian Federation on October 5, 2012). // <https://docs.cntd.ru/document/561281077> (last accessed on 3.10.2023).

<sup>6</sup> Constitution of Georgia. 24.08. 1995 with amendments of June 29, 2020. // <https://matsne.gov.ge/ka/document/view/30346?publication=36> (last accessed on 3.10.2023).

<sup>7</sup> Constitution of Georgia. 24.08. 1995 with amendments of June 29, 2020. // <https://matsne.gov.ge/ka/document/view/30346?publication=36> (last accessed on 3.10.2023).

<sup>8</sup> Georgian Law about health protection 10.12.1997 with alterations from 3.07.2023 // <https://matsne.gov.ge/ka/document/view/29980?publication=50#!>(last accessed on 3.10.2023).

<sup>9</sup> UN Sustainable Development Goals. // <https://www.un.org/sustainabledevelopment/ru/health/> (last accessed on 3.10.2023).

as well as achieving sustainable development»<sup>10</sup>. Although patients may be able to receive cross-border health care in accordance with the provisions of this Directive, Member States within their territories remain responsible for providing citizens with safe, high-quality, effective and sufficient health care. Moreover, the transposition into national law of the provisions of this Directive and their application should not lead to situations in which patients are encouraged to seek medical care outside the Member State of the patient's home country. The concept of cross-border health care should cover the acquisition by a patient of such medical products and medical devices both in the Member State where the prescription was issued and in a non-Member State of its affiliation<sup>11</sup>.

Member States that are the patient's home country shall ensure that patients have the right to receive, in the territory of another Member State, at least the same benefits as provided for by the law of the patient's home country Member State.

The objectives of the electronic medical services system are:

a) achieving sustainable economic and social benefits from European e-health systems, e-health services and other interoperable e-services to achieve high levels of trust and safety, ensure continuity of care and access to safe and high-quality health care;

b) establishing guidelines regarding:

i) an open list of information to be included in patient medical records that can be transferred between health care providers in order to ensure continuity of cross-border health care and patient safety;

ii) effective methods to enable the use of health data for health systems and research;

c) support EU Member States in developing common identification and authentication measures to facilitate data transfers for cross-border health care<sup>12</sup>.

The priority areas for solving the main health problems are:

development of new medical technologies and their introduction into the healthcare system, widespread introduction of a mechanism for targeted innovative development, allowing to shorten the cycle of creating a new product - from its development to launching on the market, and support for the most relevant and in-demand areas of medical science<sup>13</sup>.

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<sup>10</sup> Directive of the European Parliament and of the Council of 9 March 2011 on the application of patients' rights in cross-border healthcare. // <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:088:0045:0065:en:PDF> (last accessed on 3.10.2023).

<sup>11</sup> Ibid.

<sup>12</sup> Directive of the European Parliament and of the Council of 9 March 2011 on the application of patients' rights in cross-border healthcare. // <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:088:0045:0065:en:PDF> (last accessed on 3.10.2023).

<sup>13</sup> Decree President of the Russian Federation «About Strategy Health Development in the Russian Federation for the period until 2025». // <http://www.pravo.gov.ru> (last accessed on 3.10.2023).

Stated in the BRICS Economic Partnership Strategy until 2025: «Development of integration of innovative technologies in all sectors of the economy, including traditional industries, integrating smart technologies into production processes to enable manufacturers become more efficient and adapted to the use of information technology»<sup>14</sup>.

Investments are also interconnected with medicine.

As to the investments according to the BRICS Economic Partnership Strategy until 2025:

«BRICS countries will endeavor to regularly exchange of information and experiences on their policies aimed at investment facilitation and the practical implementation thereof as well as the relevant policies and experiences of BRICS countries' investors encountered in other markets»<sup>15</sup>.

Thus, the development of the latest technologies and artificial intelligence is discussed by scientists and practicing doctors, lawyers, and economists in various fields, be it medicine or various branches of law.

But the world community will be faced with the question: is compliance with the law sufficient for the innovative development of medicine?

We believe that compliance with religious norms and legal norms will lead to the development of innovative medicine.

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<sup>14</sup> BRICS Economic Partnership Strategy until 2025. // <https://brics-russia2020.ru/images/114/81/1148133.pdf> (last accessed on 3.10.2023).

<sup>15</sup> Ibid. // <https://brics-russia2020.ru/images/114/81/1148133.pdf> (last accessed on 3.10.2023).

哈萨克斯坦高校学生反恐意识的培养  
**ON THE DEVELOPMENT OF ANTI-TERRORIST  
CONSCIOUSNESS OF STUDENTS IN UNIVERSITIES OF  
KAZAKHSTAN**

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As we know, terrorist radicalization can occur at any age, but young people are more vulnerable. Youth turn to destructive groups to gain a sense of acceptance, camaraderie and identity. Monty Marshall and Ted Gurr, in 2005, noted that “terrorism, as a political act, lies at the intersection of individual and collective action, emotional and rational, traditional and unconventional. It may be the strongest form of protest, the weakest form of rebellion, or a special tactic in the larger process of tyranny or war” [Marshall, Monty G. and Gurr, Ted Robert, 2005].

In this regard, young people must have the knowledge and skills to understand and reject violent extremism and terrorism. Consequently, educational initiatives should be aimed at the formation and development of anti-terrorist consciousness, by which we mean a focused process of training and educating young people to understand and be aware of the threats of terrorism, as well as the readiness and ability to respond to them. G.B. Romanovsky believes that the process of forming an anti-terrorist consciousness of an individual “is a continuous process, the main directions of which are: 1) instilling anti-terrorist values; 2) the formation of appropriate moral beliefs, qualities and feelings; 3) development of necessary moral needs and habits” [Romanovsky G.B., 2018]. From this point of view, it is necessary to conduct constant monitoring and study of the well-being of young people, their ideas and preferences regarding religions and religious movements.

However, it should also be noted that the process of preventing terrorism itself is a complex concept. We suggest that the best way to study the threat of involvement of the population, including students, in terrorist activities is to use the tools of psychological and sociological sciences, which allow us to methodologically question our assumptions and develop hypotheses that can be tested.

The objects of the study were 1st-2nd year students of a higher educational institution. The survey involved 114 respondents who freely expressed a desire to complete the survey. The method that was used was the technique of unfinished sentences. The methodology was taken as the basis, author-compiler A.N. Brazhnikova. This technique belongs to the class of projective psychological procedures and is traditionally used to study subjective experiences, expectations, and personality states. [Sikevich Z.V., 2019]. This technique allows you to focus on “soft processes” and significantly reduce the concentration of attention of respondents from the phenomenon being studied. The survey was conducted in Kazakh and Russian languages. In terms of composition, 65% of respondents are people aged 17-18 years, 22% are 19-20 years old, and only 13% are young people aged 21-23 years. According to gender specification: males made up 79.8%, females 20.2% of the respondents.

All answers were processed by statistical analysis (word statistics), based on the most repeated words, and the results of this analysis are presented below.

42% of respondents believe that religion is associated with faith, 24% - by religion they mean the process of choosing the right path, 18% of respondents note that religion is Islam, 13% were able to show the connection between religion and knowledge and 3% did not give an answer, because they could not clearly formulate their vision.

The next question, related to the analysis of wording, what is Faith, showed that 31% of respondents believe that faith is faith in a higher power and in God. 26% associate faith with faith in people, in themselves, in their capabilities and strengths, and 25% believe that faith is a feeling that gives support and strength. 18% of respondents associate faith with responsibility, decency, and dedication to business.

In response to the statement, “God is...” - 46% noted that he is the creator, 19% - mercy and faith, 18% - the supreme power, 17% - my Allah.

Overall, the results here show young people’s general understanding of categories such as “religion”, “faith”, “god” and the answers correlate with the values that are accepted in Kazakh society.

The next block of questions, everyday life, is related to the analysis of the feelings and experiences that respondents experience when worshipping God, visiting mosques and churches.

**Table 1**  
*Distribution of responses to the statement “Faith in God gives me...”*

<b>statements</b>	<b>Number of repetitions</b>	<b>% ratio</b>
Calm and strength	17	15%
Faith, hope and happiness	26	23%



Confidence, security, safety	16	14%
Responsibility and Honesty	11	9,6%
Award and gratitude	10	8,9%
Everything gives	16	14%
Shows the way	12	10,5%
Doesn't give anything, I don't believe	6	5%

**Table 2**

*Distribution of responses to the statement "When I first visited a mosque or church, I had such emotions..."*

<b>statements</b>	<b>Number of repetitions</b>	<b>% ratio</b>
Forgot	12	10,5%
No feelings	21	18%
Faith and joy	17	15%
Mercy	11	9,5%
Excitement	18	16%
Astonishment	10	9%
Ease and safety	16	14%
I can't answer because I didn't/don't go	9	8%

At the same time, it should be noted that almost 85% of respondents go to a mosque or church. The purposes of visiting are different, among them: 28% note serving God; 19% go for themselves; 10% go to say namaz; 14% associate this with the duty of a Muslim, 14% go to honor the memory of their ancestors or the deceased.

Most respondents are able to distinguish between religious holidays and traditional national holidays. This is 81% of respondents know such religious holidays that are celebrated in Kazakhstan as Kurban Ait, Oraza Ait, Easter and Christmas. At the same time, only 30% of respondents can name the main religious movements that are known to them. 37% have no idea at all about religious movements, and here we can also add 33% of respondents who confuse religious movements with the main religions in Kazakhstan.

The results indicate that targeted social and pedagogical work is needed among young people to explain the basic essence of religions and religious movements. A set of measures is needed aimed at developing tolerance towards other cultures and religions, skills of independent critical thinking, and counteracting foreign influence.

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非语言类院校学生应用专业外语教学的体会  
**EXPERIENCE OF USING PROFESSION-ORIENTED FOREIGN  
LANGUAGE TEACHING TO STUDENTS OF NON-LINGUISTIC  
UNIVERSITIES**

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抽象的。该研究的目的是确定组织培养外语专业沟通技能的教育过程的具体细节。本文还探讨了向在俄罗斯大学学习的外国学生教授专业俄语作为外语的问题。因此，事实证明，需要采用一种与学生新兴的交际能力密切相关的综合方法来教授外国专业语言。

关键词：专业培训、交际能力、项目工作、外语、术语词汇、外国学生。

**Abstract.** *The purpose of the study is to determine the specifics of organizing the educational process for developing professional communication skills in a foreign language. The article also examines the issues of teaching professionally oriented Russian as a foreign language to students from foreign countries studying at Russian universities. As a result, the need for an integrated approach to teaching a foreign professionally oriented language in close connection with the emerging communicative competence of students has been proven.*

**Keywords:** *professionally oriented training, communicative competence, project work, foreign language, terminological vocabulary, foreign students.*

An analysis of the tradition in the Russian education system allows us to assert that “education in higher education cannot but be of a professionally oriented nature” [Balykhina, 2006, p. 9].

Teaching a professionally oriented foreign language (hereinafter: POFL) at a university has been practiced in the Russian education system for quite a long time. The main goal of this approach is the formation and development of pro-

essional foreign language skills in the field of a specific specialty (economics, law, hospitality business, etc.). For this purpose, the bachelor's degree programs include the disciplines "Foreign language for business communication", "Foreign language in the field of jurisprudence", "Foreign language professional". Students in all areas of training in the master's program study the discipline "Foreign language for academic and professional purposes."

Let us note that the specificity of POFL training is that it "directs the pedagogical process towards the final result of a student's education at a university - a future profession, which will ultimately become the sphere of application of all acquired knowledge, skills, and abilities, testing their effectiveness" [Koreneva, 2009, p. 3].

In addition, teaching POFL contributes to the development of communicative competence in students. As many methodologists note, "the main markers of the new education paradigm are creativity, culture, communication, tolerance, interactivity and autonomy of learning" [Mikheeva, Ermolenko, 2006, p. 84]. Achieving these goals is directly related to the development of the linguistic component of university education, understanding of linguistic and cultural aspects and the foundations of intercultural communication.

The concept of "professionally oriented training" cannot be reduced only to teaching the language of the specialty. This is in a special way "organized training, built on taking into account the professional communicative and linguocultural needs of students in the educational, professional, sociocultural and administrative and business spheres of communication" [Murodov, 2021, p. 264]. Its goal is to develop students' abilities to solve professional problems in any communication situations.

Requirements for the professional training of specialists pose a number of problems for foreign language teachers. The first is the selection of language material related to the sphere of professional knowledge of students, and its distribution among stages of training in accordance with the increasing language difficulty. Teaching specialty vocabulary involves constant contact between a foreign language teacher and colleagues from special departments in order to highlight the core of the necessary terminology and avoid unnecessary duplication of professionally oriented educational material.

In teaching POFL, the main didactic unit is the text. It can be in the form of printed, video or audio material. Methodists draw attention to the fact that "careful selection of texts is a prerequisite for effective teaching. When selecting text material, the following criteria should be taken into account: authenticity, professional orientation, novelty and information content, genre diversity, linguistic accessibility" [Vepreva, 2012, p. 6]. It is the text that is "a phenomenon that combines not only linguistic (lexical, grammatical), but sociolinguistic characteristics that must

be mastered by students for further study of the language and its use in professional activities” [Lopatina, 2005, p. 11].

Studying the language of a specialty involves students mastering a large number of terms and special concepts. When teaching students terminological vocabulary, the teacher must focus on the thematic principle of word selection, as well as take into account their structural and linguistic features. For example, traditionally single-component terms are distinguished that have equivalents in the Russian language - term-words (liquid - “liquid”, pressure - “pressure”). Single-component polysemantic terms are also distinguished (promotion - “promotion”, “advertising”, “promoting” is translated by different parts of speech depending on the context); multi-component terms that are attributive noun groups - terms-phrases (long term contract - “long-term contract”, foreign direct investor - “direct foreign investor”); as well as international terms that do not need translation (provider - “provider, supplier”, consulting - “consulting, consulting”).

In addition, a characteristic feature of professional texts is the presence of non-equivalent vocabulary, i.e. words that have no analogues in the Russian language and reflect the realities of non-Russian reality (a drive in bank - “savings bank”, a down market - “down market”); unique historical and cultural phenomena (Great Depression - “great depression” - the global economic crisis that began in the USA in the late 20s of the last century, Four Freedoms - “four freedoms” - a term meaning the free movement of goods, services, labor and capital within the framework of European economic integration); “false friends of the translator” (a ratio - “ratio, coefficient, share”, a curb - “containment, suppression, curb”). Such words cause natural difficulties in learning and using and require different methodological approaches to their development.

Lexical skills and abilities in professionally oriented teaching of vocabulary should be formed at the initial stages of students’ education at a university, and then updated through systematic work within the framework of a single educational and methodological complex.

The next problem facing a teacher of a foreign professional language is the choice of effective teaching methods. It is possible to instill in students the skill of the need for a continuous process of updating professional knowledge with the help of special teaching technologies.

In our pedagogical practice, traditionally, much attention is paid to project technology (“working with projects”), as one of the forms of teaching a foreign language, which “is capable of providing a high level of formed professional competence of students. The main goal of using project technology in teaching a foreign language is the desire to shift the emphasis from performing various types of exercises to active cognitive activity” [Chireikina, 2017, p. 210]. We practice using several types of projects in foreign language classes. For example, a perform-

ing project, during the implementation of which various types of professionally oriented activities of students are integrated (search, communicative, written and speech, project, presentation).

The second type of project is a constructive project, in which students, having discussed the sequence of actions with the teacher, carry out the work independently.

The next type of project is a creative project. This is the most difficult, but also interesting type of student activity. Students themselves must propose an idea (for example, introducing a real, new product to the market) and then develop an action plan for its implementation. For example, a project for creating a new business is being developed: a business plan is being formed, an electronic presentation of the project is being prepared, and the business idea is being defended during an oral presentation.

Of course, this is very labor-intensive and energy-consuming work for both the teacher and the students. It is necessary to familiarize students with the requirements for the structural parts of the project plan. The final stage of work on the project is its defense during presentation and public discussion.

The use of project technology in the classroom provides a good motivational effect for students, since it “really prepares them for future professional activities. In the process of preparing and performing such types of tasks, there is a synthesis of several professionally oriented actions: organizational, search, analytical, communication, translation, written and speech, presentation” [Chireikina, 2017, p. 212].

As for teaching POFL to students from foreign countries receiving higher education at Russian universities, there are, of course, its own specifics. Firstly, the requirements for levels of proficiency in Russian as a foreign language (hereinafter: RFL) are clearly outlined in the State Educational Standards within the framework of professional modules for levels I and II of language proficiency. They are designed for students of natural sciences, medical-biological and engineering-technical profiles and determine the intentions, as well as the requirements for students to master language knowledge, skills and abilities. Unfortunately, there are no professional modules for humanities students yet.

Being in a language environment, receiving education in Russian, which is foreign for this contingent of students, our students have the opportunity to simultaneously gain general proficiency skills and master the professionally oriented Russian language. The teacher’s task is to determine the amount of language information that will be necessary for the successful inclusion of students in educational and scientific activities, and their successful professional adaptation.

From the very first classes, foreign students are in a situation of immersion in the professionally oriented Russian language. They are immediately faced with

the need to read unadapted texts in their specialty, this creates an urgent need to teach them various types of reading (introductory, viewing, studying). The ability to create a secondary text (plan, theses, outline) based on a primary text is one of the important skills that students must master at the very beginning of the learning process.

Thus, the formation of professional and communicative competence of foreign students begins with the first classes of the first year of study when mastering all types of speech activities (reading, writing, speaking and listening) and should continue in senior years, reaching new, higher levels requirements.

The choice of methods and technologies suitable for teaching professionally oriented Russian is not a big problem for RFL teachers. As in the study of POFL, project technology gives good results. Students with great interest prepare various types of projects related to their future profession.

As for textbooks for teaching professionally oriented Russian, we have a large selection of the necessary literature. Today, textbooks on RFL are actively published for students of medical, technical, economic, and military universities.

To summarize our review, I would like to note that modern students are already aware that a good level of foreign language proficiency gives them access to significant foreign sources of information, increases the academic mobility of young people, develops professional skills necessary for communication and career growth and work in international professional teams.

Having acquired the skill of fluency in professionally oriented language material, as well as having developed communicative competence in a foreign language, future graduates of Russian universities will be able to provide themselves with the opportunity for effective communication in the professional foreign language community.

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宇宙辩证法的共构构造垄断在创造存在集合体的整体拼写矩阵中的协同作用  
**SYNERGY OF SYNARCHIOTECTONIC MONOPOLY OF THE  
DIALECTIC OF THE UNIVERSE IN THE INTEGRAL SPHELLTOR  
MATRIX OF THE CONTINUUM OF BEING ENSEMBLES OF  
CREATION**

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抽象的。存在的协同整体连续体反映在现代哲学和集成创造的科学系统实践中，其中新的解决方案在预定标准的统一不断变得更加复杂，其在实际现实中的实施措施也相应地越来越多。揭示了对辩证法的重要而深刻的补充和澄清，从这个角度来看，一种独特的多元认知和理解宇宙共构构造垄断辩证法的方法论，可能在A.F.洛塞夫的“绝对存在”表中提出（专着“神话”），数，本质），然后按照作者的积分sfelltor-椭圆矩阵（sfelltor）的逻辑进行格式化。

关键词：协同作用、整合、垄断辩证法、共构构造学、宇宙、spelltor（球状椭圆环面）、矩阵、连续体、存在、系综创造。

**Abstract.** *The synergistic-integral continuum of being is reflected in modern philosophy and scientific-systemic practice of ensemble creation, where new solutions are constantly becoming more complex in the unity of predetermined criteria, their measures of implementation in actual reality and, accordingly, more and more important and profound additions and clarifications of dialectics are revealed, and in this perspective, a unique-multiple methodology of cognition and understanding of the synarchiotectonic monopolydialectics of the universe, potentially presented in the table of “absolute being” by A.F. Losev (monograph “Myth, Number, Essence”), and then formatted in the logic of the author’s integral sfelltor-ellipsotic matrix ( sfelltor).*

**Keywords:** *synergy, integration, monopolydialectics, synarchiotectonics, universe, spelltor (spheroidal-ellipsotic torus), matrix, continuum, being, ensemble creation.*

In the history of scientific and systemological searches for synergistic and integral dominants of knowledge, and its understanding in the unity of contradictions, one should recall von Bertalanffy's statement that the foundations of the general theory of systems were laid in "tectology" - the unified organizational science of A. A. Bogdanov (1). Western science is poorly familiar with the discoveries of Russian scientists. This is evidenced by the fact that they also do not notice V. Shmakov's "synarchy" and "law of synarchy" (2). Nevertheless, synarchy and tectology a hundred years ago outlined the possibility of their synergetic-integral effect arising along the paths of the art of fusion, symbiosis, and convergence of a new scientific and philosophical direction - synarchitectonics.

When moving through time, along more reliable and understandable ways for a larger number of people, ways of understanding and constructing a positive change in a single "edifice of knowledge", changing worldviews, confirmed through scientific experience, dialectics turned out to be indispensable. With the corrective complementarities of classical and non-classical dialectics, the requirement appears in their joint, system-activity deployment and clarification. The tendency of increasing systematicity of dialectics was manifested in different synergetic versions of ideological and world-creating pictures of the universe.

Due to its integral-collective integrity, synarchitectonics is concentrated in "sin" (single, whole), "arch" (the highest, powerful manifestation in the material "archi", in the ideal "arch", and historical "archo"), "tectonics" (creative, construction, organizational). Thus, in the syncretism of the synarchitectonics of the universal unity of the world, additional opportunities for considering the integrity of being open up. In the center of attention, with the convergent assemblies of modern science in unity with philosophy, systemology and telematics, the relative integrity of the wisdom of the science of sciences is maturing. Between philosophy and science, a system-wide methodology is increasingly gaining strength in turning to practice. In this approach, in our opinion, all of the above-mentioned monopolydialectical action is reflected and concentrated in the synarchitectonics of the universe.

The model of the enriched path of the new methodology, in the logic of the basic table of five by five blocks of categories, dialectics is especially clearly presented by A.F. Losev "Myth, number, essence" (3, p. 270). Expanding "a very complex dialectical system" (ibid. p. 296) and, based on the dialectical triad, A.F. Losev consistently and logically builds his "absolute dialectics" in tabular form (ibid., pp. 269 – 293). The end-to-end logic of the final tabular model is spelled out with "the most real and the most concrete" scrupulous respect (ibid. p. 297): with five rectangular mesh blocks ( $5 * 3 * 4$ ) and a sixth addition ( $3 * 4$ ). The empty cells in the matrix are reminiscent of the filled voids discovered by other authors in later times, for example, the universal recognition of the periodic system of D.I. Mendeleev.

Table 1 proposed by the authors repeats the horizontal table of A.F. Losev, but in a graphical reading it is presented in a vertical version, since, according to the authors, there is a clear hierarchical logic of the elevation of words and semantic complications of the categorical-conceptual system. For a better reading of the metahierarchical path along the structure of the table, the cells are indicated by numbers and placed in a single column. The relatively freely described additional structured concepts at the bottom of Losev's table also entered into a holistic, but relatively independent block at the top of the entire infographic construct. Perhaps the top fragment should not be at the very top, but next to the fifth block. Structural and volumetric details can be resolved later, taking into account the opinion of specialists in formal logic on the functional and genetic structure of the final formation.

However, due to the difficulties of an in-depth reading of the entire table of A.F. Losev, the authors consider it possible to call the final version a rectangular matrix. In a more complex construction, it could potentially be not planar, but plastically volumetric. In particular, the sixth block could be parallel to the fifth. In three faces of three, with a possible transition to four and five elements, it is possible to set volumetric-spatial, rather than linear, meanings of textual information, just as A. F. Losev did in the texts.

In the life of society, and of each individual person, everything that is symbiotically integral, which includes ensemble creation, always occurs in the aggregate of many real factors, qualities, and properties. All elements of table A.F. Losev are also present in everything and always in the lives of people who form ensembles of creators and harmonized creative works - ensembles. That is why the significance of the topic under consideration is highly relevant in its universal manifestations of ensemble organization in all types of practical and spiritual activity of people: urban planning, architectural and town planning ensembles, collective songs and dances, parades. Moreover, in many business planning models and management design plans, there are similar structural structures, of course with their own specifics. If the periodic system of chemical elements by D. I. Mendeleev is of fundamental importance mainly for chemistry, then the tabular matrix of A. F. Losev is much more universal in relation to the civilized ensemble of creation of Man and Society, the interactions of the first and second Nature.

Continuing the traditions of Marxist-Leninist philosophy, in the final book of many years of reflection, "Leninist dialectics and the metaphysics of positivism" by E.V. Ilyenkov showed: "dialectics as a system of laws of the movement of knowledge, reflecting the universal laws of the objectively developing world, and not a set of only subjective techniques and rules used in knowledge by any scientist." (4, p.172). In the subsequent series of works by Soviet and Russian scientists, materialist objectivist dialectics became established and dominated for a long time

(5,6). It turned into a synergistically unambiguous methodology of the universal philosophical dialectics of integral reality.

As an independent scientific and educational discipline, with an integratively unified theoretical and historical methodology, dialectics was built in Soviet philosophy in the 70-80s. The Institute of Philosophy of the USSR gathered outstanding philosophers from all over the country and actively published joint works with prominent figures in philosophy from the countries of the socialist camp. The main advantage of Soviet dialectics was the formation of its integrity on the basis of synergistically deep historical research, which had not previously been carried out on such a grand scale anywhere in the world (6,7).

Dialectics, in combination with the components of the “synarchiotectonics of the universe” (ideome, philosopheme, cultureme, theory, doctrine, paradigm) may well represent a general systemic scientific and philosophical area of research (8-12). “Mono” manifests itself as a whole and accordingly the monodialectic is revealed, and on the other hand, there is a need to supplement it and unfold it into “poly” - polydialectic. In a single synthesis of these interacting moments, the integral unity of diversity (“monopoly”) content unfolds in the monopolydialectics, which can be conjugated in the core of the final synergetic model of the monopolydialectics of the synarchiotectonics of the universe.

The toolkit of interrelations between categories, developed in philosophical dialectics, allows it to become closer to the realities of existence of subject-personal ensembles and complexes. Globalism on the planet is also a monopoly manifestation of one of the real priority roles of monopolies in the ensemble life of humanity according to the rules of post-postmodernism and archeomodernism. In economic and political life and the development of the architecture of international relations, monopolies have revealed themselves to be selfishly effective with obvious pros and cons. The civilizational multipolarity proclaimed by BRICS is also a planetary ensemble-creating pattern. She is against the rules of the “great game”, in which the “chosen ones” persistently lead humanity to the side of those fighting for political-economic unipolarity and denying the “Decline of Europe”.

As an initial working model that incorporates the achievements of A.F. Losev’s dialectical matrix of being, the structure of not a rectangular model, but a “viviparous” matrix, planetary-circular, sfelltor-torsion type - “sfelltor” (Fig. 2) can be proposed. The authors are aware of the conceptual and typological limitations of the proposed scheme, since it has yet to be supplemented with modern categories, not only in voids, but also in volume. Note that this is a separate topic of ongoing research. Modern dialectics is not “at the end of history,” but at the beginning of a new Great Path, and it is quite likely that the promising synergistic-integral emergence of volumetric-holographic dimensions of a more dynamic and synchronotopically complex matrix of monopolydialectics will occur.

In the final conclusion, which draws a preliminary line over the beaten paths, with milestones in the development of dialectics, we emphasize the following initial postulates:

The necessity of deploying classical, non-classical and post-classical dialectics as a systemic model of monopolydialectics in parallel unity of reflecting the civilizational integrity of the economic and cultural philosophical understanding of the synergy of the synarchitectonics of the universe is revealed.

In the newest, additional name Mono (One - 1) and Poly (many), one sees the need to reflect the first synarchic law of dialectics - the “law of unity” of the whole (Sin) and the struggle (“diverse unity”) of opposites.

To master dialectics means to master the “law of measure” - the transition of quantitative changes into qualitative ones according to the measure of unity (syn), supremacy (“arches”), organization (“architectonics”) of sustainable development, i.e. according to the key hierarchical law of monopolydialectics of the synarchitectonics of the universe.

The universe is reflected in the infinitely complex guides of the actual hierarchical reality and serves as a kind of final integral experience for an objectively logical verification of the reliability of all knowledge obtained from the past, present for the future in accordance with the “law of development”.

Retention of the monistic beginning of the original law of synarchy correlates with the need for interconnection with “Sin” in its highest – “Arch” (archi, arche, archeo) organizational transformations of information-material-energy eco-economics flows of ensemble actual reality.

Monopolydialectics and synarchitectonics of the universe, in their inextricable unity, do not pretend to be a departure from philosophy, with its core - dialectics, but promote their interaction, integration and systematic completeness of information with other fundamental areas of reliable fundamental knowledge, the most important for the integration of civilizations and synergistic cultural and economic assets of mankind.

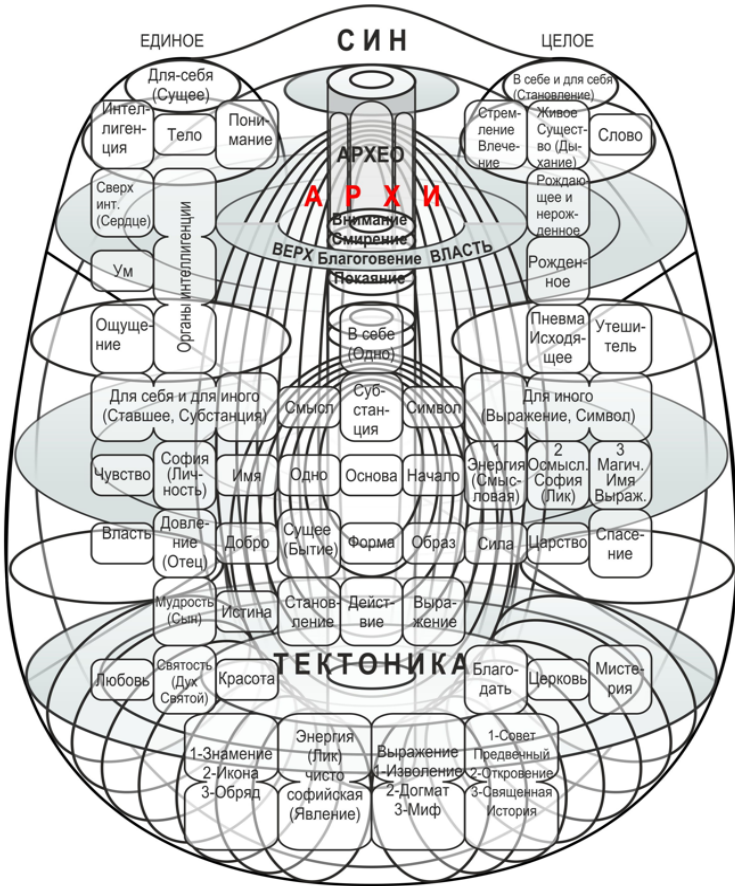
The most important advantage of the absolute dialectical table of A.F. Losev lies in her synarchy of hierarchy and synergetics of the deployment of transitions into structural complications, without losing the main advantages.

The author’s proposed ellipsoidal-torsion (sfelltor) matrix of being is built in the continuum logic of the monopolydialectics of the synarchitectonics of the universe, continuing the traditions laid down in the methodology of “absolute dialectics” by A.F. Losev.

	58	59	60	61	<p>Fig. 1. Table A.F. Loseva (“Myth, number, essence”)                      A – In itself (One); B – For oneself (Existing); B – In itself and for itself (Becoming); G – for oneself and for another (Become, Substance); D – For something else (Expression, Symbol);                      1 – Meaning; 2 – One; 3 – Existing (Being); 4 – Formation;                      5 – Substance; 6 – Base; 7 – Shape; 8 – Action; 9 – Symbol; 10 – Beginning; 11 – Image; 12 – Expression; 13 – Intelligentsia;                      14 – Super-int. (Heart); 15 – Mind; 16 – Feeling; 17 – Body; 18 – Organs of the intelligentsia; 19 – Understanding; 20 – Aspiration (Attraction); 21 – Living being (Breath); 22 – Giving birth and unborn; 23 – Birth; 24 – Pneuma Outgoing; 25 – Word; 26 – Comforter; 27 – Feeling; 28 – Power; 29 – Love; 30 – Sophia (Personality); 31 – Addition (Father); 32 – Wisdom (Son); 33 – Holiness (Holy Spirit); 34 – Name; 35 – Good; 36 – Truth; 37 – Beauty; 38 – Energy (Semantic); 39 – Strength; 40 – Light; 41 – Grace; 42 – Energy (Face) Sophia number (Appearance); 43 – Sign; 44 – Icon; 45 – Rite; 46 – Comprehension, Sophia (Face); 47 – Kingdom; 48 – Glory; 49 – Church; 50 – Expression to energy; 51 – Will; 52 – Dogma; 53 – Myth; 54 – Expression to energy (Lik) purely Sophia; 55 – Eternal Council; 56 – Revelation; 57 – Sacred history; 58 – Magic. Name Express; 59 – Salvation; 60 – Euchology; 61 – Mystery.</p>
	54	55	56	57	
	50	51	52	53	
E	46	47	48	49	
	42	43	44	45	
	38	39	40	41	
D	34	35	36	37	
	30	31	32	33	
	27	28		29	
C	25			26	
	21	22	23	24	
	20				
B	19				
	17	18			
	13	14	15	16	
A	9	10	11	12	
	5	6	7	8	
	1	2	3	4	

Figure 1. Table A.F. Losev (“Myth, number, essence”)

MONOPOLYDIALECTICS



SYNARCHIOTECTONICS OF THE UNIVERSUM

*Figure 1. Monopolydialectics of the universe of synarchiotectonics in a spheroidal-ellipsotic-torsion matrix (sfelltor), built on the basis of the model of multi-element and multi-hierarchical universal philosophy of “absolute dialectics” by A.F. Losev*



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公元三至四年间叛乱分子对罗马帝国身份的影响程度  
**THE DEGREE OF INSURGENTS' INFLUENCE ON THE IDENTITY  
OF THE ROMAN EMPIRE IN THE III-IV A.D.**

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概括。三世纪是罗马帝国历史上的一个艰难的转折点。因此，本文的目的是试图确定叛乱分子作为影响罗马国家身份改变的政治力量的作用。这项研究的相关性在于，任何国家都需要开发工具来维护其身份，而转型的领导人必须找到一种方法，使这些变化成为国家身份不可分割的一部分。作者的结论是，叛乱分子有意识地、更多地是在某些原因、情况、个人动机的影响下，改变政治领导人，从而试图在不改变国家形式的情况下改变国内和外交政策的方向。或影响其意识形态。

关键词：叛乱者、罗马帝国、三世纪、危机、身份、皇帝、军队、政治领袖。

**Summary.** *The third century is a difficult turning point in the history of the Roman Empire. Therefore, the purpose of this article is an attempt to identify the role of insurgents as a political force influencing the modification of the identity of the Roman state. The relevance of the study is justified by the need for any state to develop tools to preserve its identity, and leaders through transformations must find a way to make these changes an integral part of the state's identity. The author concludes that Insurgents exerted a conscious, and more often under the influence of some reasons, circumstances, personal motives, on the change of political leader, thereby trying to change the direction of domestic and foreign policy, without changing the form of the state or influencing its ideology.*

**Keywords:** *insurgent, Roman Empire, III century, crisis, identity, emperor, army, political leader.*

Insurgents were bound to appear on the political scene of ancient Rome after the military reforms of Gaius Marius. Augustus, Septimius Severus, because of which they successively became actors in political life, increasingly coming to the fore and seizing a leading role, thanks to the support of the emperors, their desire to make the military the support and protection of their power. The peak of

the activity and influence of the insurgents falls on the difficult III A.D., when the processes launched in the era of the Early Empire finally and irreversibly changed the state in the IV A.D. Under these conditions, the insurgents became the driving force for the determinants influencing the identity of the Roman state<sup>1</sup>.

The intensification of hostilities contributed to the rapid militarization of society, at the same time, the need to maintain the numerical composition of the army led to its barbarization. This period also saw the peak of the struggle between the political forces of the empire – the army and the senate – and, as a result, almost none of the so-called “soldier” emperors died a natural death, moreover, their families were also in the centre of the struggle for power. The insurgents of one side sought to prevent the gradual hereditary transfer of power by the other side. Under these conditions, any relative who had a chance of finding support from the group of the assassinated emperor’s entourage, found themselves in the zone of attention of the insurgents, who sought to nominate a new leader from among themselves.

The term “soldier emperor” came into use in the 19th century thanks to the German antiquarian F. Altheim [1] and began to be actively used to systematize research on the history of Ancient Rome. The name of the period is based not only on the fact that the emperors were legions, but also on the fact of their low origin, which the ancient authors often define by the words “obscurissimo genere”, “obscurissime natus” (Eutr. IX, 2, 6, 9, 19). At the present stage, more and more researchers express a quite fair and well-grounded opinion [2, p. 47] that such a division does not actually take into account many aspects, for example, the legitimization of the power of the emperors of this period through the approval of the Senate as the expression of the will of the people, but by the third quarter of the III century the Senate no longer had political initiative and lost its influence, which was quite clearly demonstrated after the assassination of emperor Aurelianus, when the army had placed the right of electing a new emperor in the hands of the senate, but the senators were in no hurry to settle on a candidate for a long time (Anonym., fr. 10; Epitom., XXXV. 9). And the second aspect is the policy of the emperors, who had to maneuver between the army and the senate, i.e., between military and financial power.

During the period of the 3rd century, more than 70 emperors were replaced, and it should be noted that the change of ruler took place by a group of military men, but at the same time did not lead to a change in the existing system. It should also be borne in mind that for the Romanized barbarians, who dressed in purple, there was no ideal of a republic, the nostalgia of which had slipped into the writings of Roman writers earlier. The image of the state was transformed, becoming

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<sup>1</sup> The identity of the Roman state must be perceived, on the one hand, as the relations that are being formed and changed, and on the other hand, as the main nucleus underlying all spheres of life of Roman society, since identity is determined not only by the form and system of government, but also by the citizens of the state.

more in line with the realities of the time, although ancient historians used the term “*res publica*”.

For the Romans, *res publica* was the conjuncture of society and the state, in which the interests of the entire civic collective were the basis, which made it possible to reach a compromise between all political groups and social strata. The collapse of the *res publica* was perceived as the degradation of morals and the oblivion of *mores maiorum*, the loss of the core of identity, which was contained in the very meaning of the phrase “public cause”, which prevailed over other categories. Therefore, the idea of the restoration of the republic - *restituta res publica* - was supported by all emperors, but by the 3rd century this idea was also transformed, reflected in the coin legends of the emperors Restitutor, Restitutor Orbis and their variations Restitutor Galliarum, Restitutor Orientis (Witte, Postum., 38–42, 113–116, 212–221, 256–261; RIC, Sept. Sever., 167, 288; Valer. I, 117, 287; Claud. II Goth., 189; Aurel., 284, 288, 289–290) and even Restitutor Generi Humani (RIC, Valer. I, 220). Having assumed the functions of maintaining and preserving the foundations of the state and its traditions, the emperor also acts as the Guardian of both the state itself and its values, which are enshrined in the *mores maiorum* – Conservator (RIC, Valer. I, 83; Postum, 308; Tetr. Sen., 14; Claud. II Goth., 201; Aurel., 258; Prob., 348–352; Diocletian., 206, 263). Therefore, despite the changes that took place in the state system, the form of government, even in the terminology of ancient authors, changed very slowly, remaining in its form *res publica* (SHA. Duo Valer., IV, 2; Duo Gall., I, 1, 3; Tyr., trig., XXX, 1; Prob., VI, 1; Car., I, 1; Amm., XIV, 10, 8; XIV, 6, 9, 8; XV, 3, 9). But it is important to take into account that for the Romans the *res publica* was the opposite of the absence of the state as such, and in conditions of political instability, the desire to preserve identity by referring to the times of prosperity only intensified, but the changes were already taking place, albeit slowly, but becoming noticeable and had a significant impact on the worldview of the Romans, especially since the Roman citizens were natives of the provinces. The Romanized Germans, for whom the republic had only those characteristic features that they saw around them in the realities of life, and the “glorious past” remained in the writings of historians and the propaganda of the Roman emperors. In this regard, it is interesting to use legends on the coins of some emperors who were close to the Senate or sought to agree with the Senate ROMA AETERNA (RIC, Sept. Sever., 291, 350G; Gord. I, 4, 10; Valer. I, 120; Claud. II Goth., 241) и RESTITVTOR VRBIS (RIC, Sept. Sever., 168, 288; Prob., 926d).

It is important to note that any emperor proclaimed during this period can be recognized as legitimate, since the law acted post factum, however, as well as any order of the commander during the conduct of hostilities. This complicates the recognition of the actions of one leader against another as political terrorism,

because for the Romans themselves there was nothing strange in the fact that the emperor, after the assassination, could be recognized as a tyrant, an enemy of the Romans, subjected to “damnatio memoriae”, and his murder - “a necessary action for the salvation of the Fatherland”, as was the case with Maximinus “Thrax”, Trebonianus Gallus, Carinus and Numerianus, etc. that his murder was committed in the name of the common good (Aur. Vict., XXXIII, 22).

If at the end of the 2nd and the beginning of the 3rd centuries the senate was an expression of the will of the Roman people, which is why its recognition of the proclaimed emperor was so important, then during the period of the third century the pole of influence shifted. To strengthen its position in this political struggle, in the conditions of constant military operations, the establishment of a successive blood dynasty was one of the most important aspects. The political influence of the army became so great that in the third century the appointment of the Caesars took place thanks to the will of the emperor and the support of the insurgents, and if in the first years the legitimization of their power through the senate, although it was very conditional, turned into a rudiment, and by the end of the third century it had completely disappeared. During this period, due to the militarization of society, the voice and will of the people was the army. Thus, after the capture of the emperor Valerianus, Macrianus and Ballista were proclaimed emperors. However, as the sources indicate, due to his disability, inability to ride a horse, and therefore to fully command the army<sup>2</sup>, Macrianus relinquished power and, thanks to the convictions of the praetorian prefect Ballista and considerable monetary payments, contributed to the proclamation of his sons Macrianus as emperors Macrianus Minor (Fulvius Junius Macrianus Augustus) and Quietus (Titus Fulvius Junius Quietus Augustus).

Those who embarked on the path of political confrontation and formed groups of insurgents believed that they were restoring the social justice that had been violated by the previous emperor. Therefore, the reasons could lie in a variety of areas: morality, finances, traditions, etc. It should be borne in mind that the restoration of justice due to the militarization of society was in the hands of the military, who, like the cults of the gods they revered – Mithras, Hercules, were protectors and intermediaries. That is, they fulfilled the divine will. Thus, the legitimization of power took place, as it were, through the election of the people in the person of the army, which, in the conditions of increasing militarization of society, gradually became the voice of the entire people.

The lack of agreement between the Senate and the army left no chance for a common decision on the choice of an emperor whose personality and policies would suit both political groups. The appointment of sons as co-rulers to some

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<sup>2</sup> However, Macrianus had no authority in the army, being a financial official, and in fact bought the consent of the troops to proclaim his son's emperors.

extent gave confidence in the stabilization of political power, but thus political terror found a new target in the form of the emperor's family. Thus, his son was slain together with Maximinus. At the same time, the age of the heir often did not matter for such an act – most often they were 13-15 years old<sup>3</sup>. Ancient authors do not report on the fate of the wives of emperors, who during this period most often followed their husbands in military campaigns and gradually gained authority and influence in the army, as evidenced by the special title of "first ladies" - *mater castrorum*<sup>4</sup>. It was worn by the women of the Severus's dynasty, Zenobia, who considered herself a relative of Julia Domna, Magnia Urbica, and other representatives of the imperial house (RIC, Julia Domna, 568. 880; CIL VIII, 02384; CIL, XI, 05168). Nevertheless, the insurgents who stood behind the new leader also saw the empresses as a threat to power<sup>5</sup> – for example, the wife of Regalian was killed, as well as the wife of the emperor Gallienus, his youngest son, along with a close relative, was overtaken on the road, and the wife Carina Magnia Urbica, like her husband, was subjected to "damnatio memoriae" after her death under the pressure of a group of the new emperor's entourage.

Political forces, among which an important place was occupied by insurgents – united groups of military men, very often close in place of residence or ethnic origin (a striking example is the Illyrian emperors – former military commanders who came from the same province), sought, on the one hand, to promote strong leaders, but they were also feared, since they were able to conduct a completely independent policy. In this respect, the sole leader was more advantageous to the army, while the conservative Senate dreamed of the times of the Republic, during which the two consuls shared powers, so the desire of the large, landed nobility, who did not want to lose power and political and financial influence, was aimed at countering attempts to strengthen individual power. An example of this is the proclamation by the senate of Pupienus and Balbinus as co-emperors in 238. (Herodian., VIII, 7), whose rule represented the ideal in the form of a division of powers between two princeps in the full tradition of republican Rome [3, p. 263].

By the third century, two opposing forces were gradually consolidating, striving to change not only the internal course of the state but also to carry out a few socio-economic reforms, sometimes interfering in foreign policy. Now only the army (a group of insurgents) or the Senate decided on the candidacy of the emperor, and this decision was not always thought through, very often it happened

<sup>3</sup> Macrinus' son Diadumenus was executed when he was only 10 years old (Epitom., XXII; XXVIII).

<sup>4</sup> This title was first bestowed by Marcus Aurelius on his wife Faustina Minor, mother of the emperor's 13 children – the "mother of military camps", and became especially popular in the era of the "soldier emperors": RIC, Marc. Aurel. (Faust. Jr.), 753, 1711v. Abolished by Emperor Diocletianus.

<sup>5</sup> Diocletian's wife Prisca and his daughter fell victim to political terror and were murdered on the orders of Licinius (Lact., I, XV).

under the influence of certain factors and moods, on a wave of rebellious moods. Deviations from the intended goals, policies and financial support of the army become the reasons for the removal of one leader and his replacement by another.

Thanks to the political and economic measures taken by the emperors, as well as the ideological propaganda carried out by them, the connection between the army and the emperor and his government was strengthened. Different groups of society wanted to see an emperor in power who would implement their own program, so in the third century there was an extremely rapid change of emperors, all of whom died violent deaths, in most cases at the hands of soldiers.

After the central authority was significantly weakened, and the soldiers realized that they themselves could elect someone who would fulfil their hopes, the confrontation of the army as a political force against the Senate began. The emperor himself was only an expression of the will of the power that had placed him on the throne. And it was very rare that the candidacy suited the opposing parties, since the interests of the large, landed aristocracy and the small and medium-sized landowners were sharply opposed. It is also necessary to consider the fact that sometimes one group was involved in the assassination of the emperor, and another proclaimed it, and very often in a completely different region. The group that supported the former emperor could pay with their lives not only as supporters of the previous leader, or resisting and unwilling to swear allegiance to the new one, but also as a “necessary victim” of changing the political regime, because in order to be recognized by the Senate or the population, it was necessary, first of all, to discredit the murdered leader, so various accusations, unflattering descriptions and epithets were used («*appareat ignobilem, sordidum, spurcum fuisse*» - SHA, Macrin., XV, 1; «*simul quod successoris asperitas atque rusticitas Maximini*» - SHA, XVIII, 63, 2), For example, the murderer of the emperor Caracalla, Marcus Oppelius Macrinus, who was enthroned by a small group, had no support either in the army or in the senate and was killed after holding power for about a year. However, his reign is unique. For the first time, a man of Moorish origin, the son of a freedman, occupied the throne of the Roman Empire (Aur. Vict., 22; Eutr., VIII. 22; SHA, Macrin., XV). Or, for example, Aurelian, who, according to ancient authors, did everything for the greatness of the Roman state, returned the former territories to the jurisdiction of Rome, established discipline in the army, carried out reforms, but was still very demanding, cruel, and intemperate<sup>6</sup> (Aur. Vict., XXXV). Therefore, the justification for the removal of a political leader in the works of ancient authors depends not only on the political views of the author himself, but also on the influence of certain political forces. The action of the

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<sup>6</sup> Eutropius accuses him not only of a tendency to cruelty, but also of intemperance “*animi tamen inmodici et ad crudelitatem propensioris*” (Eutr., IX, 13). Aurelian’s intemperance is also mentioned by Lactantius, “*esset natura vesanus et praeceps*” (Lact., VI, 1).

insurgents can be seen most clearly in the assassination of the emperor Gallienus, when a group of warlords conspired and carried out a conspiracy, assigning roles in advance. At the same time, the agreement was not only for direct actions, but also for further roles, locations and even destinies [4]. Thus Claudius II "Gothicus", who clearly participated in the murder of Gallienus, thanks to the affection of ancient writers, and perhaps to the fact that it was he who was proclaimed the new emperor, strangely far from the scene of the assassination, was actually acquitted (Eutr., IX, 11; Aur.Vict., XXXIV).

However, in the murder of the emperor Aurelianus, all the blame was shifted exclusively to the army, which brought almost public repentance for what it had done, so that the readers have no doubts about the guilt of the party. It was after this event that it became clear that the Senate ceased to be a political force, and the insurgents began to lose influence and the ability to interfere in the political life of the Roman Empire, with the reforms of Emperor Diocletianus and Constantinus Great, this possibility was eliminated by law.

Based on ancient sources, the investigation of the assassinations of emperors during this period was not even conducted. The new emperor could be proclaimed by another political group, so either through the senate he issued an edict that put a curse on the very name and deeds of the murdered person, or discredited him, up to his alleged participation in secret conspiracies, treachery, etc., and the survivors who swore allegiance to the new leader also did not need such an investigation, the emperor himself understood that any attempt to investigate could cause a mutiny in the army. which also threatened the safety of the emperor. In addition, it was also a matter of the special legal status of the emperor who was at war, all his decisions were recognized as legal *post factum*, which ensured a kind of right of the victor.

However, it should not be thought that the insurgents did not try to regain their influence, moreover, to find allies among other categories of the population or courtiers. Thus, in 337, the heirs of Emperor Constantinus I the Great were virtually wiped out, an act that put the empire in a difficult position and possibly hastened the collapse of the Western Roman Empire.

Thus, during this period, the war determined politics, creating a favourable basis for the emergence of new leaders, contributing to the militarization of society, at the head of which the most important civilian positions were held exclusively by the military. Therefore, the overthrow of the emperor in the difficult and turbulent third century was a response to the social demands of the same active military and veterans, on the one hand, and a way to preserve the identity of the Roman state within the framework and with the rules determined by a militarized society. A change of political leader often led to a change in the administrative apparatus (usually it was the emperor's inner circle, i.e., the military, or veterans, and often the change also took place in ethnic terms, so Septimius Severus surrounded him-



self for the most part with immigrants from Syria, and the so-called Illyrian emperors with immigrants from the Danubian provinces. But for ancient authors, the overthrow of most of the emperors was the result of a general decline in morals, which manifested itself in the positioning of each new emperor as a tyrannicide (“for often he who seized power with arms in his hands, who rose to prominence by crime,....declares that he has eliminated tyranny”) - Aur. Vict., XXXIII 33-34).

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“隐藏的力量！”……穆索尔斯基先生生活和工作中的宗教  
“HIDDEN POWERS!”... RELIGION IN  
THE LIFE AND WORK OF M. MUSSORGSKY

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抽象的。本文专门介绍俄罗斯艺术古典时期最伟大的俄罗斯作曲家之一穆索尔斯基 (M. Mussorgsky, 1839 - 1881 年) 的作品, 他以其艺术地位的鲜明民族历史基础而闻名。在无神论时代 (尤其是苏联时期), 穆索尔斯基艺术的宗教根源问题几乎没有被提出。同时, 他的音乐的东正教基础过去和现在仍然很重要, 而且是作曲家美学和风格的重要支持。本文探讨的宗教与艺术之间的关系使我们能够以新的方式理解和欣赏穆索尔斯基的音乐遗产。

关键词: 无神论、音乐文化、东正教音乐、歌剧、现实主义派、俄罗斯民间传说。

**Abstract.** *The article is devoted to the work of one of the largest Russian composers of the classical period of Russian art - M. Mussorgsky (1839 - 1881), known for the bright national-historical basis of his artistic position. In the era of atheism (especially during the Soviet Union), the question of the religious roots of Mussorgsky's art was practically not raised. Meanwhile, the Orthodox basis of his music was and remains important, moreover, the essential support of the aesthetics and style of the composer. The relationship between religion and art, explored in this article, allows us to understand and appreciate the musical heritage of M. Mussorgsky in a new way.*

**Keywords:** *atheism, musical culture, Orthodox music, opera, realistic school, Russian folklore.*

“Someone said: Mussorgsky must be so lucky, whether he does something in music, fierce disputes immediately arise. So much the better...” (From the letters of M. Mussorgsky).<sup>1</sup> Just as in the past, and perhaps even more so, in our age prone to spiritual themes and genres, there are discussions about whether the most original of geniuses was an atheist or a believer The Golden Age, a nugget of the Russian land, not understood by contemporaries and not recognized by immediate descendants. The spirit of Orthodoxy in operas and the Satanism of symphonic

music. Interest in mysticism as a dominant personality trait and a truly realistic operatic style. The circle of the atheistic “Mighty Handful”, which raised the composer, and friendly ties with representatives of the church class. For him, “the religious element occupies a paramount place,” one of them said about Mussorgsky.<sup>2</sup> Let’s try to “cross out” the sacred principle from the composer’s music, it will become very dull and will largely lose its meaning. In his short earthly creative life, which stretches into eternity, Mussorgsky knew how to be both in the world of deep, true faith and in the aura of unbelief. The milestones of his path, put together cursorily, almost at random, point more accurately than all discussions “about music and not only ...” to a certain pendulum of constant oscillations from one abyss to another:<sup>3</sup>

- while still a cadet at the School of Guards Ensigns, Mussorgsky sang in the church choir, was interested in sacred music and was friends with the regimental priest Father Kirill, who gladly introduced Modest to the choral concerts of Dmitry Bortnyansky and other masters;

- later, after graduating from school, by his own admission, for about two years “he was under the yoke of a terrible illness, which began very strongly ... - mysticism mixed with a cynical thought about the deity. This disease developed terribly... I suffered greatly, became terribly impressionable (even painful)”; the illness had to be hidden from others, including Balakirev, whom he met in 1857 and trusted him immensely;<sup>4</sup>

- having overcome an illness, in the early 60s he plunged into the atmosphere of the “Mighty Handful”, far from religiosity, mentored by the great intellectual and open atheist V. Stasov - “the stupid crowd of people still continues to believe in something and in someone, to raise eyes to the wonderful sky, our real “fatherland”, and to the highest father, all-good, all-knowing, all-merciful, almighty and organizer of everything. Ugh, damned herd of fools and ignoramuses!” - this was his constant credo;<sup>5</sup>

- similar views reigned in the youth commune, where from 1865 (together with several comrades - Lobkovsky, Levashev, the three Loginov brothers, and eventually Rimsky-Korsakov) Mussorgsky lived until 1872;

- in 1867, the symphonic fantasy “Night on Bald Mountain” was written - a composition of rare power and brightness, a demonic bacchanalia, rampant evil spirits; “As you can see, it’s a baptized thing,” the author notes in a letter to V. Nikolsky, and this is already mockery;<sup>6</sup>

- on the advice of the same Nikolsky, historian of Russian literature, professor Theological Academy, in the fall of 1868, the composer turned to Pushkin’s “Boris Godunov” as the primary source of the future opera;

-1870: censorship banned the song “Seminarian”, the hero of which, according to the text of Mussorgsky himself, “was tempted by a demon in the temple

of God,” not to mention a purely musical parody of liturgical singing. “What is reprehensible here?...I feel a very great ardor from the prohibitions,” the author triumphed;<sup>7</sup>

- by the beginning of the 70s, with the completion of the first (1869) and second (1872) editions of “Boris”, truly religious scenes imbued with the spirit of Orthodoxy were created: Prologue, Pimen and Gregory in the cell of the Chudov Monastery, the episode with the chimes and the hallucinations of the criminal king, the scene at St. Basil’s Cathedral, the death of Boris and others;

- portraits of schismatics in “Khovanshchina” were painted with deep compassion and admiration for the Christian feat; only they are positive heroes - Dositheus and Martha; schismatic chants, stern and earnest, are full of genuine faith;

- for the collective opus of the Kuchkists, the opera-ballet “Mlada” (the same seventies), Mussorgsky writes the episode “Serving the Black Goat” - according to legend, the devil appeared in the guise of a black goat at the witches’ Sabbath - no more, no less;

- in the last of the operas, “Sorochintsy Fair”, the intermezzo of the third act includes characters, one more beautiful than the other - Kashchei, Worm, Plague, Death, Chernobog; the unclean ones were added by Mussorgsky - even Gogol, who is prone to such images, does not have this scene (just like the episode with the ghost of the murdered baby prince in Boris, added to Pushkin);

- the best among late vocal works, “Song of Mephistopheles in Auerbach’s Cellar”, is accompanied, as you know, by rolling demonic laughter; The plans for the operas “The Leshy” and “Viy” have been nurtured for years, “modulating” from the 60s to the 70s, but remain unrealized.

And here is the final chord: the tombstone of the composer, who did not want to see the priest before his death, is decorated with the names of four works - two on the left side, “Boris Godunov” and “Joshua”, two on the right, “Saul” and “The Defeat of Sennacherib”. Apart from “Boris,” all the opuses are not among Mussorgsky’s peak achievements, but they are united in their appeal to biblical subjects.

Every artist, willingly or unconsciously, directly or allegorically captures himself in his works - in paintings and films, romances and sculptural compositions. Auguste Montferrand placed his image in the corner of the pediment of St. Isaac’s Cathedral, the masters of Renaissance art included his portrait in multi-figure groups of contemporaries singing and playing musical instruments, Hitchcock and Ryazanov loved to act in episodes of their own films. Mussorgsky found his spiritual double in the Holy Fool - an episodic character, but essentially important in the concept of “Boris Godunov”. Orphaned and sick, not of this world, urged on by everyone, he is the only one who can throw the truth in the face of Tsar Herod: the boys offended Nikolka the Fool - “they ordered them to be slaughtered, just

as you stabbed the little prince.” Mussorgsky’s music, sometimes “non-architectonic” in form, deliberately dissonant, not pretending to be externally glossy or complete, always and invariably leaves a strong sense of truth, non-verbal, but revealed to everyone, not requiring proof, like true faith.

“You know, I personally idolize and hate this work at the same time... I idolize it for its originality, strength, courage, originality and beauty, but I hate it for its unfinished work, harmonic roughness, and in some places - complete musical absurdity,” wrote N., who edited the opera, about “Boris.” Rimsky-Korsakov, composer, theorist and teacher rolled into one.<sup>8</sup>

Living in an unreal, closed world, the Holy Fool is not alone in the gallery of similar portraits created by Mussorgsky. There are three of them, close to each other, giving new touches to the same image - the Dwarf from the piano “Pictures at an Exhibition”, a lame freak, wounded in soul and body, and the village Vanka the madman, declaring his love right on the street to the woman he liked, worrying and confused in her name (song “Svetik Savvishna” based on her own text) - both sketches are small in form, but deep in their tragic essence, and the key theme in them is the same: the drama of misunderstanding, the eternal cross of loneliness - the same one that put Mussorgsky on his shoulders fate and his art. Fools, God’s people, and the Orthodox Church are the same concepts, the world is inseparable. Foolishness, and this is known, is precisely an Orthodox phenomenon, and its meaning is in the feat of self-denial for the glory of faith: be foolish in order to gain wisdom and help those devoted to God for their salvation. Dirty rags and spiritual purity, insecurity and mystical power, obsession and prophetic gift - everything came together in the opera’s Fool, bizarrely, as in the musical style of Mussorgsky, his asceticism and attitude towards faith. Not in the Christian sense, but in everyday life, even the purely materialist Vladimir Stasov, the brain and core of the “Mighty Handful,” immensely respected by its members, emphasized in his own way Mussorgsky’s spiritual otherness. The critic mentions Mussorgsky’s “natural thoughtlessness” quite often and with complete inner conviction. “What do I need in Mussorgsky?... Well, yes, he seems to think the same thing as me, but I haven’t heard a single thought from him, a single word from the real depths of a captured, agitated soul. Everything about him is dull and colorless. It seems to me that he is a complete idiot.”<sup>9</sup> Without a doubt, Stasov appreciated the musical genius of his ward, but he never considered him an intelligent person.

Over time, the negative judgment intensified: now, in the mid-70s, Stasov denied Mussorgsky even his potential as a composer. “Under the influence of weakening health and a shocked body, his talent began to weaken and change. His writings began to become vague, pretentious, sometimes even incoherent and tasteless... he no longer wants and cannot work as before. What use is he to me?!”<sup>10</sup> Even his former Kuchka friends gave up on Mussorgsky, considering him dead,

and critics, analyzing rare editions of his works, noted “such unnatural harmonic combinations and sequences that in some cases doubt arises: Are there any typos in the music.”<sup>11</sup> By the end of the composer’s life, everyone left the composer: Rimsky-Korsakov, who went to teach (and study) at the conservatory, gave up the position of the “Mighty Handful,” which rejected pro-Western academic education; authoritarian, tough in Stasov’s assessments; Cui, who was unfairly harsh about Boris in his review of the premiere in 1874; Balakirev, aged and changed under the yoke of mental illness. The only thing that did not betray Mussorgsky was his own visionary gift, which strengthened in his hand the always sharpened pen and the strength to dare, following the motto he found in his youth: “Forward, to new shores!” These shores turned out to be very distant. Only the present time has highlighted the indisputable fact that all innovations in harmony of the 20th - early 21st centuries can easily be illustrated by the music of Mussorgsky, and his “illogical” forms were successfully developed in the works of avant-garde and post-avant-garde artists. The newest sacred wave of the turn of the millennium, in its quest, as well as the composers of the neo-folklore school, students and followers of Georgy Sviridov, see Mussorgsky as their predecessor and main idol. “The pen of a genius is always higher than himself,” this axiom of Goethe has been equally proven in both the eighteenth and twenty-first centuries.

As is obvious in relation to Mussorgsky, this pen is not only great, but also more truthful, especially in music, without external conceptuality, able to penetrate the deep layers of meaning - an art to which Mussorgsky from his youth treated with almost religious fanaticism. The frequent references in his letters to the “religion of the artist” are connected precisely with his attitude towards creativity and its purpose. Mystical realism - such a paradoxical term is in tune with the composer’s style most of all. As a man of an era far from fearing God - in the circles where Mussorgsky moved - he was not a church member, did not observe rituals, rushed in the themes and images of his works, “white and black”, from devilry to schema, from the feat of self-immolation in the name of faith to the satanic procession and games on Bald Mountain. The paradoxes of thinking that prompted the combination of the incongruous are one of the essential aspects of his personality, confirmed both by genres - a tragic lullaby (“Kalistrat”), a lullaby-march (“Forgotten”) or a rollicking mortal dance (“Trepak”), and by plans - the cycle “Children’s”, not addressed to children either from the performing or listening side. Religiosity and morality are by no means synonymous, according to Mussorgsky. In the gallery of characters in “Boris Godunov” and “Khovanshchina” there are many servants of the faith: the schismatic mother Susanna, infallible, but stony at heart; the chatterbox and drunkard Varlaam with his colorless shadow - Misail; ambitious novice Grishka Otrepiev; the tough and cynical Jesuit Rangoni... Among them, and this is symbolic, only Martha is a sorceress who knows how to

summon “secret powers”, a fortune teller, and together, a devoutly religious and at the same time passionately in love and deceived by her beloved woman is the only positive heroine, sublime and pure soul. And she is probably the only one in the female gallery of the composer’s opera images. Faith, but not ritualism. Spirituality, and not the orthodox understanding of religiosity - perhaps even without differences of religion. On this basis, sufficient for Mussorgsky, stands his art with an unchanging credo: “To create a living person in living music.”<sup>12</sup> His musical world, especially opera, has branched, far-reaching roots, and the main one among many, the stem one, is Orthodoxy, and not bright in appearance, bell-shaped and festive, but dark, tragic, gloomy. In the opera, which is secular in essence and plot, the mournful face of Orthodoxy is captured by the composer with such powerful force that it is capable of eclipsing the sacred works written for church services by the leading masters of the genre, from Berezovsky and Bortnyansky to Tchaikovsky, Rachmaninov, Grechaninov. Not the luminous Holy Trinity of Andrei Rublev, shining with the joy of piety, not the cherubic creators of the partes style of the turn of the 18th - 18th centuries soaring in heavenly purity, but the sternly ascetic Znamenny chant, the funeral ringing of bells, the emaciated faces of the sick and the poor, captured by A. Ivanov in the painting “The appearance of Christ to the people” - this is the circle of images that is close to the dramatic element of Orthodoxy, prevailing in Mussorgsky. The tragedy and greatness of the Stoic are characteristic of the modest monk-chronicler Pimen and the head of the schismatics Dosifei, the only undefeated of the “three princes” of the “Khovanshchina”. Boundless despair in turning to the Lord and faith as the last source of strength - in Boris’s dying prayer and Shchelkalov’s monologue, Dosifei’s appeals “Do not let your enemies be offended!” and choral chants of schismatics preparing to ascend to the fire. The coloring of the funeral singing in the scene of the death of Tsar Boris is gloomy, but also in the solemn coronation ceremony, in the Prologue, the major colors of the praises fade, darkened by the prophetic monologue “The soul grieves...”. The tragic tones of Orthodoxy noticeably intensified in the last decade of Mussorgsky’s life, forming a kind of rapidly growing crescendo, revealing the black abysses of art and life, exaggerating the main theme now for the composer - the inevitability of death and the desire to look beyond the fatal line: what is there, beyond the limits of existence, in the world, from where no one returned?

In musicological and other literature it has been mentioned more than once how the atheist Stasov was almost pathologically afraid of death; the Kuchkists believed in him as a spiritual father. Mussorgsky was worried and worried about Balakirev’s unexpected and inexplicable appeal to the church (which happened after a miraculous turn from the latter’s obsessive thoughts of suicide). Responding to Stasov, in one of his letters Mussorgsky writes to the “Generalissimo”: “Your lines seemed to me like a funeral service for the artistic fervor of Milius - terri-

ble if this is true and if, on his part, there was no disguise.”<sup>13</sup> But in these words one can also hear doubts, a clear attempt to understand the incomprehensible turn of a personality, bold, courageous, indomitable. And here is one more thing, to the same addressee in connection with the death of Victor Hartmann: “If nature only flirts with man, I have the honor to get to know her as a coquette, that is, to trust her less...”<sup>14</sup> But also in the music itself, at the same time, the vocal cycle “Without the Sun” and the ballad “Forgotten,” the piano “Catacombs” and “With the Dead in a Dead Language”; crowning the “black crescendo” of “Songs and Dances of Death”, perhaps the most original and powerful interpretation of this theme in Russian art, and the firm idea of making the finale of the five-act opera an extremely small, but terrible in spiritual fervor, scene of the self-immolation of fellow believers - all about the same thing, with the despair of a blind man who cannot find his way... knocking on the same tightly closed door...

The further, the more questions of religion, the meaning of Christian teaching and its commandments interested and worried Mussorgsky. Even in the middle of the journey, he read and re-read the works of the Zurich pastor of the times of the Baroque, quite strong in religious terms, Johann Caspar Lavater, and later retold his ideas to his comrades: “Now in my spare time I translate Lavater’s letters (from German - O.G.) - about the state of the soul after death is a very interesting thing, and besides, I have always been drawn to a dreamy world”; inclined to judge the parapsychological abilities of a person by his appearance and the shape of the skull, the Swiss philosopher amazed Mussorgsky with the confidence that “the soul of a deceased person possessing clairvoyance communicates his thoughts, which, being transmitted by clairvoyants to the friend left by him (soul) on earth, give the latter has the concept of its presence after death.”<sup>15</sup>

Consonant with these searches, which are downright religious, is Mussorgsky’s desire to join the ranks of clergymen among the heroes of his own operas and even to compose Christian or similar texts for their performances. So, for example, the Jesuit Rangoni, a real historical figure, but a character absent from Pushkin’s poem, is added to the list of characters in “Boris Godunov”, and with words written for this monologue by Mussorgsky himself. How is their meaning combined with Balakirev’s statement on a similar occasion in one of the documents created by him during his service in the Court Singing Chapel: “Church singing in Russia, gradually becoming distorted and deviating from the strict style consistent with its sacred purpose, has in our time reached complete disorder, which, depriving the majestic and splendid worship of the Orthodox Church of its best decoration, at the same time deprives the pious people of high spiritual consolations, destroying their prayerful mood.”<sup>16</sup> Mussorgsky also composed texts for the choral scenes of a cantata on the biblical story “The Defeat of Sennacherib,” retelling Byron’s original source in rhythmic “blank verse” (despite the fact that he had at his disposal a rhymed poetic translation by A.K. Tolstoy).



It was Mussorgsky who introduced into the opera “Boris Godunov” the chorus of pedestrians “Angel of the Lord” with its own text (and the scene itself, which is absent in Pushkin’s poem); The cantata “Joshua” for mixed choir, soloists and piano contains sacred stanzas written by the composer. Unexpectedly positive religious tones acquired neutral and even negative images in Mussorgsky’s operas: the informer boyar Shaklovity is sincere in prayerful ecstasy (monologue of the third act of Khovanshchina); Mussorgsky depicts Shchelkalov, who is not noticeable in Pushkin, as devoted to the faith, adding new colors to the character. As for Dosifei, the head of the schismatics, his operatic appearance is certainly related to the personality of Archpriest Avvakum, the founder of the Old Believers, who suffered martyrdom in fire. The churching of opera and other scores is emphasized by the citation, which is not uncommon in the composer’s music, of sacred chants of different times and origins - from the Catholic sequence Dies irae and imitations of the Old Russian kondakar chant (Dosifei’s solo and the schismatic choir) to the theme “Rest with the Saints” (in “Commander” “). Mussorgsky’s interest in a special kind of national epic is known - spiritual verse and its adaptation.

Prayer as a musical genre becomes on par with the monologues and scenes characteristic of the composer, replacing the traditional arias, duets, couplets, and so on in the opera house; interpreted as a choral or solo number, the prayer penetrates into cantatas and even vocal lyrics - “song” and “scene” crowd out the usual “romance”. Shchelkalov’s prayer and the choir of walkers in “Boris” - “Glory to Thee, the Heavenly Creator on earth”; a general prayer service for schismatics going to the fire and a vocal miniature “Prayer” to a text by Lermontov; male choir (offstage) “Holy is the Lord in his saints!” from “Sorochintsy Fair” and a general prayer service in the episode of sacrifice in “Salambo”; the last solo of the main character in the same opera and the appeal to the Almighty in the scene of Boris’s death... the series of musical prayers in Mussorgsky’s works is easy to continue - it is extensive and diverse.

The prayer is sublime, but often prosaic in wording. And prose replaces rhyme in Mussorgsky’s opuses, and with it the nature of the melody and its structure changes. Sacred numbers absorb the vocabulary and figurative structure of folklore tunes; The entire structure of the musical narrative becomes “prayed,” acquiring a distinct conciliarity. “He put a certain “code” into the music, which, at a distance of a century, if correctly deciphered, can serve as a reliable guide for the director and performers,” it is said about Mussorgsky.<sup>17</sup> Deciphering the code, already after half a century, reveals in his service to his ideas and art the level of not just a human, but a cathedral order. He was always faithful to them - even in his youth, when, not wanting to burden the peasants with extra taxes, he renounced his share of his father’s inheritance in favor of his brother Philaret and remained poor; and later, neglecting bureaucratic service for the sake of ascetic composing



work; and further - not wanting to sacrifice his principles for the sake of success and recognition - among the public and professionals. “An artist believes in the future because he lives in it,” Mussorgsky liked to repeat. In the past, he can see the future; while depicting history and his people, he always remained extremely truthful, which means he captured them - “whole, large, unpainted and without leaf” - sincerely devoted to the faith, no matter how and when he himself related to religion.<sup>18</sup> “What a terrible thing new (truly) wealth of folk speech... What an inexhaustible... ore for grasping the real life of the Russian people! Just pick and dance - if you are a true artist.”<sup>19</sup> ... The church choristers who served at Mussorgsky’s funeral refused, as one, to take the required payment, and this is a well-known, although differently explained, fact. As a musician at that time, few people appreciated him; Perhaps what was more important for the singers was the understandable reluctance to approach a person who rejected the last confession and repentance. Unlike the officially atheistic twentieth century, today’s composers write a lot of sacred music, and it is heard both in the philharmonic society and within the walls of the church. Even today no one can equal the “atheist”, and together with the sincerely devoted Mussorgsky, in powerful sacred power.

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3.1~7岁儿童急性肾功能衰竭无尿时心肌需氧量昼夜节律  
**CIRCADIAN RHYTHM OF MYOCARDIAL OXYGEN DEMAND  
DURING ANURIA OF ACUTE RENAL FAILURE IN CHILDREN  
AGED 3.1-7 YEARS**

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抽象的。第一天，MOD昼夜节律的每日波动幅度在第1组中最大，达40%，在第2组中为20%，在第3组中为30%。在随后的日子里，MOD日波动幅度反复增加，第3组在第19天后达到最大，达到30%，这表明由于心肌需氧量显著增加，心肌营养显著不稳定，氧债是主导因素在急性心力衰竭的发展中。第一天，MOD昼夜节律每日波动幅度最大，第1组达40%，第2组为20%，第3组为30%。随后几天，MOD日波动幅度反复增加，第3组在第19天后增幅最大，达到30%，其特点是心肌氧含量显著增加，导致心肌营养明显不稳定。需求、氧债是急性心力衰竭发展的主导因素。第1组儿童在循环功能亢进的情况下，冠状动脉功能不全的风险增加。

关键词：昼夜节律，心肌需氧量，儿童，急性肾功能衰竭。

**Abstract.** *On the first day, the amplitude of daily fluctuations in the circadian rhythm of MOD was the greatest in group 1, amounting to 40%, in group 2 - 20%, in group 3 - 30%. On subsequent days, the repeated increase in the amplitude of daily fluctuations of MOD was greatest in group 3 after the 19th day amounting*

to 30% characterized pronounced instability of myocardial trophism due to a significant increase in myocardial oxygen demand, oxygen debt is a leading factor in the development of acute heart failure. On the first day, the amplitude of daily fluctuations in the circadian rhythm of MOD was the largest in group 1, amounting to 40%, in group 2 - 20%, in group 3 - 30%. In the following days, the repeated increase in the amplitude of daily fluctuations in MOD turned out to be the largest in group 3 after the 19th day, amounting to 30%, characterized by pronounced instability of myocardial trophism due to a significant increase in myocardial oxygen demand, oxygen debt is a leading factor in the development of acute heart failure. An increased risk of coronary insufficiency was revealed under conditions of hyperdynamic circulatory function in children of group 1.

**Keywords:** circadian rhythm, myocardial oxygen demand, children, acute renal failure.

Relevance. In the first stages of acute renal failure, hypervolemia may be observed, which, as the disease progresses, turns into hypovolemia, since the vascular bed, depleted of proteins (total protein in plasma can decrease to 30 g/l) cannot retain water. In addition, vascular permeability is always sharply impaired, and the liquid part of the plasma passes into the interstitium and tissues. Particularly dangerous complications of acute renal failure are cerebral edema, pulmonary edema, and interstitial myocardial edema. In 85% of patients, a “wet lung” is observed, which has a certain x-ray picture (increased pulmonary pattern, cloud-like infiltrates in the root zones). Overhydration, impaired vascular permeability, myocardial weakness, and endogenous intoxication play a role in the pathogenesis of this condition in acute renal failure. In 80% of patients, hemodynamic disturbances are expressed with the formation of a hypodynamic state of blood circulation with a decrease in stroke and cardiac index by 30% or more, an increase in total peripheral resistance by 80% or more. The overwhelming majority of patients develop persistent hypertension, which is formed as a result of impaired renal blood flow, hypoxia of the kidney parenchyma, dystrophy and necrosis of the tubular epithelium, impaired sodium reabsorption with hyperproduction of renin and angiotensin, and decreased production of depressor substances by the affected kidneys. Currently, the genesis of the development of heart failure is explained not only by myocardial damage, but also by damage to the endothelium of the vascular wall. The reasons for the development of endothelial dysfunction are hemodynamic overload of the conducting arteries, hyperactivation of the RAAS and SAS, disruption of the endothelial receptor apparatus, disruption of the formation or blockade of the action of bradykinin, nitric oxide and endothelial relaxation factor systems. Markers of endothelial dysfunction include a decrease in endothelium-dependent vasodilation, an increase in desquamated endotheliocytes, an increase in the level of endothelin-1, an increase in endothelial angiotensin-converting enzyme, a weakening

of the effect of bradykinin, and suppression of the expression/inactivation of NO synthetase. Hemodynamic overload, venous congestion, activation of neurohumoral systems, natriuretic peptides, inflammation, endothelial dysfunction, oxidative stress and its effect on cardiac and vascular remodeling, as well as mechanisms of cellular maladaptation are currently considered the main causes of the pathogenesis of AHF. Excessive afterload is critical to begin with. hypertensive AHF, causing an episode of acute vasoconstriction. The key provoking factors for the development of vasospasm include: sharp sympathetic activation caused by various stimulants, including smooth muscle activation from tension on the arterial wall, unresponsiveness of arterial baroreceptors, and abuse of sympathomimetic substances. Sympathetic stimulation leads to an increase in contractility through activation of cardiac beta-adrenergic receptors and an increase in peripheral vascular resistance through activation of vascular alpha-adrenergic receptors. Additional effects of vasoconstriction may also be mediated by neurohormonal activation of the renin-angiotensin-aldosterone system, where angiotensin II and vasopressin cause direct constriction of blood vessels. Direct endothelial dysfunction can also dramatically alter vascular responsiveness by activating endothelial oxidative stress, with the release of cytokines generating reactive oxygen species that directly promote nitric oxide (NO) removal, thereby limiting the potential for vasodilation. These effects are systemic in nature, including both arterial and venous vessels, and contribute to increased mobilization of the central blood volume. This mechanism is combined with modern pathophysiological understanding of hemodynamic disturbances, where an increase in pulmonary artery pressure can be observed several days to weeks before an episode of AHF [1-3].

One of the many indicators of the pathogenetic mechanism of myocardial ischemia is the myocardial oxygen demand (MOD). Due to the lack of information about changes in MOD during the anuric phase of acute renal failure in children, we made an attempt to study and evaluate the features of the circadian rhythm of MOD in acute renal failure in children aged 3.1-7 years.

Goal of the work. To study and evaluate the features of the circadian rhythm of MOD in acute renal failure in children aged 3.1-7 years.

Materials and research methods. The data of hourly monitoring of MOD in 17 children with acute renal failure who were admitted to the ICU of the Russian Scientific Center for Emergency Medicine in the anuric phase at the age of 3.1 to 7 years from the ICU of regional children's hospitals and branches of the Russian Scientific Center for Medical Emergency were studied. Before admission to the clinic, all patients received anti-inflammatory therapy aimed at treating pneumonia, acute glomerulonephritis, acute intestinal infections, and acute respiratory infections. Due to severe progressive respiratory failure, patients received invasive mechanical respiratory support as indicated on the first day. All patients underwent hemodialysis, under the control of hemodynamics, acid-base balance,

respiratory system, supportive, antibacterial, anti-inflammatory, syndromic corrective intensive therapy in accordance with existing recommendations in the literature. A favorable outcome with restoration of full functional activity of the kidneys and discharge from the hospital was observed in 13 children (groups 1 and 2), an unfavorable outcome – in 4 children (group 3). The first group consisted of patients who received intensive therapy in the ICU for up to 10 days (5 patients), the second - children with a favorable outcome after intensive therapy for 12 - 45 days (8 patients), the third - 4 patients with an unfavorable outcome. Hourly data are presented. monitoring the parameters of the circadian rhythm of MOD. The assessment of changes in the components of the circadian rhythm was carried out by obtaining mesor indicators - the average daily level of the studied indicator, the amplitude of circadian fluctuations, the range of daily fluctuations, indicators of acrophase and bathyphase of the circadian rhythm, the duration of the inversion of the circadian rhythm of the MOD. The research data were processed by the method of variation statistics using the Excel program by calculating arithmetic means (M) and errors of means (m).

To assess the significance of differences between two values, the parametric Student's test (t) was used. The relationship between the dynamics of the studied indicators was determined by the method of paired correlations. The critical significance level was taken equal to 0.05.

Results and its discussion. On the first day, an increase in the mesor of the circadian rhythm of MOD was detected in group 1 by 41%, in group 2 by 14%, in group 3 by 25% (Table 1). That is, on day 1, the level of average daily oxygen demand turned out to be the highest in group 1. But already on the second day there was a decrease in the indicator almost to normal. In the 2nd group, an increase of 17% in the mesor of the circadian rhythm of MOD was detected on days 10-27, 28 by 17%, 22%, 22%, respectively. In group 3 children, progressive growth of MOD was noted from the second day of intensive therapy. With a significant increase in the indicator on days 5–30 by 30-36% relative to the indicator on day 1. Moreover, throughout the entire observation, the circadian rhythm mesor of MOD was significantly greater than the indicator in group 2 (Table 1). The wave-like change in the mesor of the circadian rhythm of MOD in all examined patients is noteworthy (Fig. 1). Analysis of the average circadian rhythm of MOD revealed a significant increase in MOD in children of group 3 than in groups 1 and 2 throughout both daytime and night time (Table 2). The identified feature of changes in the myocardium characterizes one of the mechanisms for the development of heart failure in children with an unfavorable outcome of the disease (Fig. 2). Based on the results obtained by monitoring, it is possible to assert with a certain degree of confidence the feasibility of supplementing intensive therapy with metabolite agents to improve myocardial trophism, coronary blood flow, and contractile function of the heart.

**Table 1.**

*Dynamics of the mesor of the circadian rhythm of the MOD*

<b>Days</b>	<b>1 group</b>	<b>2 group</b>	<b>3 group</b>
1	141±16	114±12*	125±10
2	117±7	110±5	131±8 <sup>0</sup>
3	114±5 <sup>m</sup>	116±4	140±8* <sup>0</sup>
4	116±5 <sup>m</sup>	122±5	143±9* <sup>0</sup>
5	130±6	120±5	155±4* <sup>m0</sup>
6	115±7 <sup>m</sup>	113±4	162±8* <sup>m0</sup>
7		124±6	169±10 <sup>m0</sup>
8		127±5	185±9 <sup>m0</sup>
9		125±3	177±6 <sup>m0</sup>
10		134±5 <sup>m</sup>	156±12 <sup>m0</sup>
11		135±6	145±7 <sup>m</sup>
12		128±5	159±7 <sup>m0</sup>
13		128±7	160±9 <sup>m0</sup>
14		132±8	168±8 <sup>m0</sup>
15		130±9	155±10 <sup>m0</sup>
16		139±7	167±7 <sup>m0</sup>
17		125±5	161±10 <sup>m0</sup>
18		123±6	148±10 <sup>m0</sup>
19		113±8	163±13 <sup>m0</sup>
20		124±8	165±11 <sup>m0</sup>
21		124±5	162±13 <sup>m0</sup>
22		116±7	172±9 <sup>m0</sup>
23		121±6	166±14 <sup>m0</sup>
24		137±5	162±12 <sup>m0</sup>
25		128±13	161±9 <sup>m0</sup>
26		118±13	149±20 <sup>0</sup>
27		149±12 <sup>m</sup>	143±9
28		149±11 <sup>m</sup>	143±8
29			140±12
30			156±8 <sup>m</sup>

**Table 2**

*Dynamics of the MOD in the average circadian rhythm*

<b>Hours</b>	<b>1 group</b>	<b>2 group</b>	<b>3 group</b>
8	120±4	124±10	157±15* <sup>0</sup>
9	123±11	125±11	157±15* <sup>0</sup>
10	124±7	125±10	156±12* <sup>0</sup>

11	121±8	123±11	160±14* <sup>o</sup>
12	126±12	126±10	162±16* <sup>o</sup>
13	125±7	124±10	165±15* <sup>o</sup>
14	125±7	124±10	161±14* <sup>o</sup>
15	127±9	128±9	158±13* <sup>o</sup>
16	129±10	127±9	161±15* <sup>o</sup>
17	126±15	129±10	161±17 <sup>o</sup>
18	130±17	126±11	158±15 <sup>o</sup>
19	130±11	132±10	158±15
20	131±13	131±11	154±14*
21	129±13	132±11	154±13
22	127±12	131±9	156±11 <sup>o</sup>
23	117±8	125±8	154±13* <sup>o</sup>
24	116±10	125±9	154±12*
1	111±6	122±10	149±15*
2	114±12	125±11	149±13*
3	111±6	120±10	153±16* <sup>o</sup>
4	113±6	123±10	154±14* <sup>o</sup>
5	112±10	123±11	155±16* <sup>o</sup>
6	116±5	124±10	155±12* <sup>o</sup>
7	117±6	125±11	156±14* <sup>o</sup>

\*-difference is significant relative to group 1

" - reliable relative to the indicator on 1 day

<sup>o</sup> = significant relative to group 2 indicator

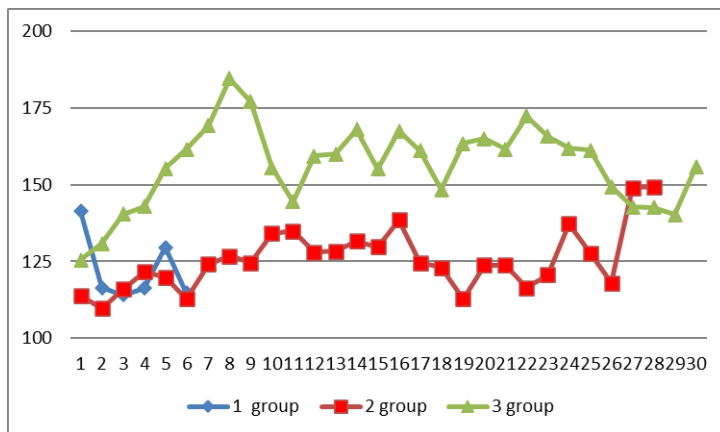
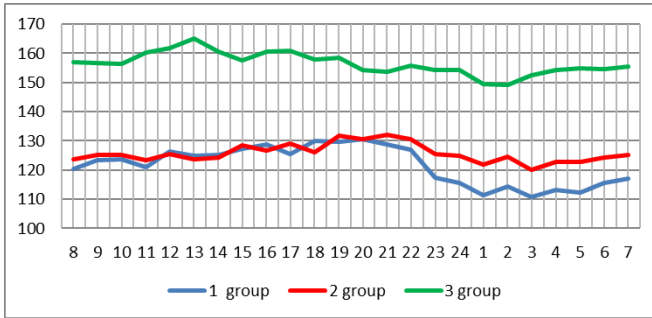


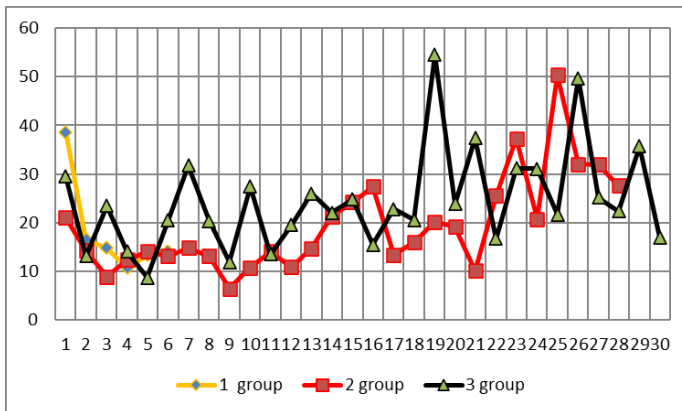
Figure 1. Dynamics of the mesor of the circadian rhythm MOD 3.1-7 l





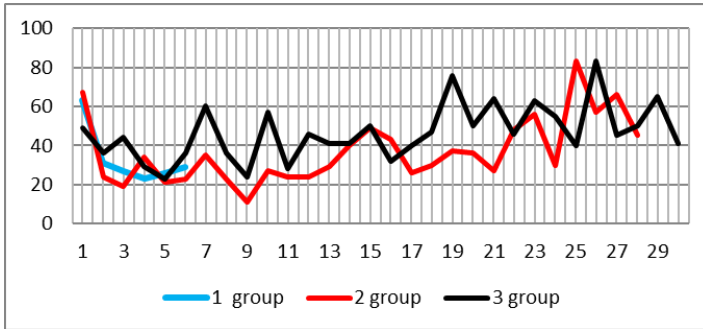
**Figure 2.** Dynamics of MOD in the average circadian rhythm, %

On the first day, the amplitude of daily oscillations of the circadian rhythm of MOD was greatest in group 1, amounting to 40%, in group 2 - 20%, in group 3 - 30%. In subsequent days, the repeated increase in the amplitude of daily oscillations of MOD appeared to be greatest in group 3 after the 19th day, amounting to 30% characterized pronounced instability of myocardial trophism due to a significant increase in myocardial oxygen demand; oxygen debt is a leading factor in the development of acute heart failure (Fig. 3). A high risk of coronary insufficiency with subsequent myocardial ischemia was also observed in patients of group 2 on days 23–28.

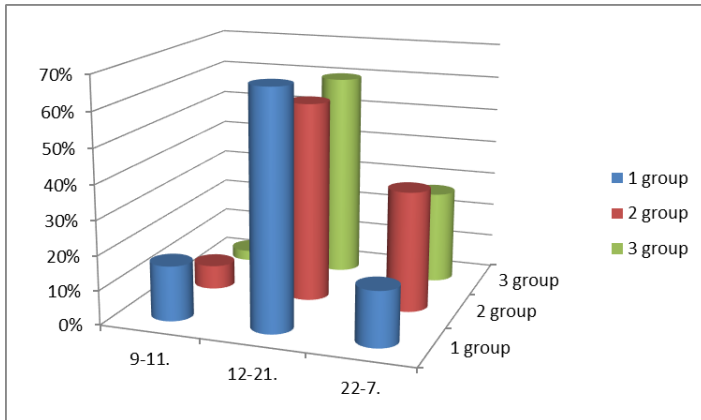


**Figure 3.** Changes in the amplitude of the circadian rhythm of MOD, in%.

The range of daily fluctuations in MOD seemed to be greatest on days 25–27 in children of groups 2 and 3, revealing pronounced instability of myocardial trophism (Fig. 4).

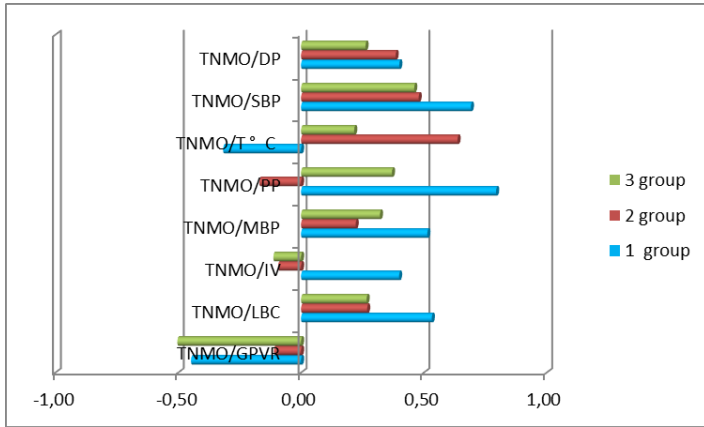


*Figure 4. Dynamics of daily fluctuations in MOD, %.*



*Figure 5. Duration of inversion according to severity of condition*

The longest shift in the acrophase peak of the circadian rhythm of MOD was revealed in group 2, amounting to 10 days and in group 3, amounting to 9 days (Fig. 5).



**Figure 6.** Correlation connections of MOD

A strong direct correlation between the MOD and SBP, MOD and PAP, and a moderate (non-significant) direct correlation between the MOD indicator and MBV and MAP were revealed. The discovered connections characterize an increased risk of coronary insufficiency in conditions of hyperdynamic circulatory function in children of group 1. While these connections weakened significantly in conditions of a more severe condition of children with anuria at the age of 3.1-7 years (Fig. 6).

**Conclusion.** On the first day, an increase in the mesor of the circadian rhythm of MOD was detected in group 1 by 41%, in group 2 by 14%, in group 3 by 25%. On the first day, the amplitude of daily fluctuations in the circadian rhythm of MOD was the greatest in group 1, amounting to 40%, in group 2 - 20%, in group 3 - 30%. On subsequent days, the repeated increase in the amplitude of daily fluctuations of MOD was greatest in group 3 after the 19th day amounting to 30%, characterized by pronounced instability of myocardial trophism due to a significant increase in myocardial oxygen demand, oxygen debt is a leading factor in the development of acute heart failure. On the first day, the amplitude of daily fluctuations in the circadian rhythm of MOD was the largest in group 1, amounting to 40%, in group 2 - 20%, in group 3 - 30%. In the following days, the repeated increase in the amplitude of daily fluctuations in MOD was the largest in group 3 after the 19th day, amounting to 30%, characterized by pronounced instability of myocardial trophism due to a significant increase in myocardial oxygen demand, oxygen debt is a leading factor in the development of acute heart failure. A significant increase in MOD was found in children 3 groups than in groups 1 and 2 throughout both daytime and nighttime. An increased risk of coronary insufficiency was revealed under conditions of hyperdynamic circulatory function in children of group 1.

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3.1~7岁儿童急性肾功能衰竭无尿期总外周血管阻力昼夜节律变化特征  
**FEATURES OF CHANGES IN THE CIRCADIAN RHYTHM OF  
TOTAL PERIPHERAL VASCULAR RESISTANCE DURING THE  
ANURIC PHASE OF ACUTE RENAL FAILURE IN CHILDREN  
AGED 3.1-7 YEARS**

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抽象的。第1天,第3组儿童的昼夜节律TPVR中值最高,在IOC值正常的情况下超出正常值3倍,表明循环系统功能存在低动力型倾向。第1组血管张力昼夜节律的适应性反应表现为平均血管张力昼夜节律的倒转。1天内血管张力变化 $2400 \text{ dyn.s.cm}^5\text{m}$ 应被认为在预后意义上是不利的。外周血管阻力昼夜节律倒置时间最长的是第2组(11天),第3组为9天,第1组为4天,分别为41%、30%、68%。百分比术语。

关键词: 昼夜节律, 总外周血管阻力, 无尿, 儿童。

**Abstract.** *On day 1, the mesor of the circadian rhythm TPVR turned out to be the highest in children of group 3, exceeding the norm by 3 times with a normal IOC value, indicating a tendency towards a hypodynamic type of function of the circulatory system. The adaptive response of the circadian rhythm of vascular tone in group 1 was expressed in the inversion of the average circadian rhythm of vascular tone. A change in vascular tone within 1 day by  $2400 \text{ dyn.s.cm}^5\text{m}$  should be considered unfavorable in a prognostic sense. The inversion of the circadian rhythm of the peripheral vascular resistance turned out to be the longest (11 days)*

*in group 2, for 9 days in group 3 and 4 days in group 1, which amounted to 41%, 30%, 68% in percentage terms.*

**Keywords:** *circadian rhythm, total peripheral vascular resistance, anuria, children.*

**Relevance.** During the active phase of glomerulonephritis (GN), significant disturbances in renal blood flow are observed, which can determine prolonged hypoxia of the renal tissue and contribute to the formation and progression of changes in the interstitial tissue of the kidneys. Elevated blood pressure is either directly transmitted to the glomerular capillaries, and intraglomerular hypertension develops, or it contributes to the narrowing of preglomerular arterioles, and glomerular ischemia develops. The glomerulosclerosis that develops as a result of these mechanisms contributes to a more rapid progression of the renal process.

The main pathogenetic mechanism for the development of acute renal failure (ARF) is renal ischemia. Shock restructuring of the renal blood flow - intrarenal shunting of blood through the juxtaglomerular system with a decrease in pressure in the glomerular afferent arterioles below 60-70 mm Hg – is the cause of cortical ischemia, induces the release of catecholamines, activates the renin-aldosterone system with the production of renin, an antidiuretic hormone, and thereby causes renal afferent vasoconstriction with a further decrease in glomerular filtration rate (GFR), ischemic damage to the convoluted tubule epithelium with an increase in the concentration of calcium and free radicals in tubular epithelial cells. Ischemic damage to the renal tubules in acute renal failure is often aggravated by their simultaneous direct toxic damage caused by endotoxins. Following necrosis (ischemic, toxic) of the convoluted tubule epithelium, leakage of the glomerular filtrate into the interstitium develops through damaged tubules, which are blocked by cellular detritus, as well as as a result of interstitial edema of the renal tissue. Interstitial edema increases renal ischemia and further reduces glomerular filtration rate. The degree of increase in the interstitial volume of the kidney, as well as the degree of decrease in the height of the brush border and the area of the basement membrane of the convoluted tubule epithelium, correlate with the severity of AHF. Currently, more and more experimental and clinical data are accumulating, indicating that the effect of constrictive stimuli on blood vessels in acute renal failure is realized through changes in the intracellular calcium concentration. Calcium initially enters the cytoplasm, and then, with the help of a special carrier, into the mitochondria. The energy used by the transporter is also necessary for the initial synthesis of ATP. Energy deficiency leads to cell necrosis, and the resulting cellular debris obstructs the tubules, aggravating anuria. Administration of the calcium channel blocker veropamil simultaneously with ischemia or immediately after it prevents the entry of calcium into the cells, which prevents acute renal failure or facilitates its course. However, in the literature there is insufficient information

on the characteristics of the reaction of the circadian rhythm of the peripheral vascular system during the anuric phase of acute renal failure, which developed in children aged 3.1 to 7 years [1-4].

**Goal of the work.** To study and evaluate the features of changes in the circadian rhythm of general vascular resistance during the anuric phase of acute renal failure in children aged 3.1-7 years.

**Material and research methods.** We studied the data of hourly monitoring of peripheral vascular resistance in 17 children with acute renal failure who were admitted to the ICU of the Russian Scientific Center for Emergency Medicine in the anuric phase at the age of 3.1 to 7 years from the ICU of regional children's hospitals and branches of the Russian Scientific Center for Medical Emergency. Before admission to the clinic, all patients received anti-inflammatory therapy aimed at treating pneumonia, acute glomerulonephritis, acute intestinal infections, and acute respiratory infections. All patients underwent hemodialysis, under the control of hemodynamics, acid-base balance, respiratory system, supportive, antibacterial, anti-inflammatory, syndromic corrective intensive therapy in accordance with existing recommendations in the literature. A favorable outcome with restoration of full functional activity of the kidneys and discharge from the hospital was observed in 13 children (groups 1 and 2), an unfavorable outcome – in 4 children (group 3). The first group consisted of patients who received intensive therapy in an ICU for up to 10 days (5 patients), the second group included children with a favorable outcome after intensive therapy for 12–45 days (8 patients), the third group included 4 patients with an unfavorable outcome. Data from hourly monitoring of the parameters of the circadian rhythm of the peripheral nervous system are presented. The assessment of changes in the components of the circadian rhythm was carried out by obtaining mesor indicators - the average daily level of the studied indicator, the amplitude of circadian fluctuations, the range of daily fluctuations, indicators of acrophase and bathyphase of the circadian rhythm, the duration of the inversion of the circadian rhythm of the studied hemodynamic parameters. The research data were processed by the method of variation statistics using the Excel program by calculating arithmetic means (M) and errors of means (m). To assess the significance of differences between two values, the parametric Student's test (t) was used. The relationship between the dynamics of the studied indicators was determined by the method of paired correlations. The critical significance level was taken equal to 0.05.

**Results and its discussion.** On day 1, the mesor of the circadian rhythm of TPVR turned out to be the highest in children of group 3, exceeding the norm by 3 times with a normal value of IOC, indicating a tendency towards a hypodynamic type of function of the circulatory system. In the dynamics of patients of group 1, an increase in the mesor of the circadian rhythm of the peripheral vascular resistance was detected on days 4.5 against the background of restoration of urinary

function. In group 2, in dynamics, a decrease in the mesor of TPVR was revealed on days 4, 5, 6 by 28%, 13%, 14%, with a tendency towards an increase in the indicator on days 26, 27 persisting in subsequent days (Fig. 1). In the most severe 3rd group of children, the initially significantly increased OPSS significantly decreased on days 2,3,5,6-14,18 by 35% (2 days), by 53% (10 days) with a tendency to increase in subsequent days of observation ( table 1). The average circadian rhythm of the peripheral vascular resistance in group 1 is marked by higher rates at 10, 12, 13 hours of the day and 24 - 2 hours of the night (Table 2), exceeding the norm by 2.5 times. That is, the adaptive response of the circadian rhythm of vascular tone was expressed in the inversion of the average circadian rhythm of the peripheral vascular resistance in the anuria phase in acute renal failure at the age of 3.1-7 years (Fig. 2).

**Table 1.**

*Dynamics of mesor circus rhythm TPVR, dyn.s.cm<sup>-5</sup>m*

Days	1 group	2 group	3 group
1	1849±443	1864±428	3036±664*
2	1914±232	1555±164	1963±154 "
3	2475±289	1308±116	2196±198 "
4	2713±159"	1320±60*	2289±259
5	2672±206"	1624±171*	1657±160* "
6	2577±444	1581±119*	1820±208 "
7		1625±159	1628±256 "
8		1481±139	1748±150 "
9		1573±87	1637±146 "
10		1459±142	1405±94 "
11		1349±158	1618±168 "
12		1632±187	1611±183 "
13		1396±126	1690±202 "
14		1522±174	1808±210 "
15		1677±173	1964±200
16		1245±119	1899±149
17		1438±190	1823±237
18		1229±97	1710±252 "
19		1943±266	2207±310
20		1822±274	2255±218
21		1797±340	2437±433
22		1890±256	2154±274
23		1765±255	2092±269
24		1603±278	2091±192



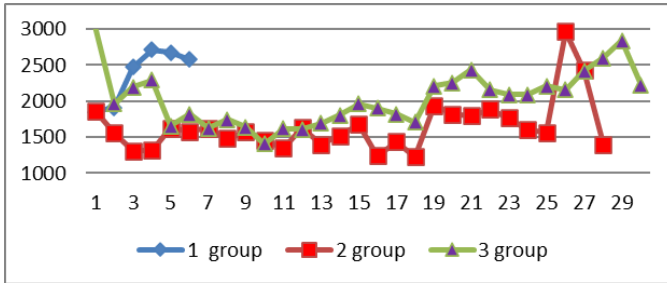
25		1566±297	2213±310
26		2967±756	2159±266
27		2428±404	2418±427
28		1400±628	2600±582
29			2838±628
30			2229±227
Ave. value	2367±323	1645±239	2040±308

**Table 2.**  
*Average level of TPVR in the circadian rhythm, dyn.s.cm<sup>-3</sup>m*

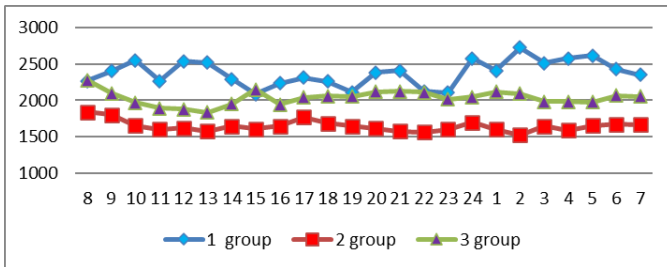
Hours	1 group	2 group	3 group
8	2269±624	1842±383	2278±481
9	2403±437	1800±348	2102±358
10	2552±463	1654±264	1967±351
11	2266±437	1602±341	1892±338
12	2541±241	1621±381	1878±277
13	2520±338	1573±345	1831±250
14	2294±365	1645±370	1951±353
15	2086±332	1606±225	2150±461
16	2236±341	1646±311	1947±300
17	2311±354	1770±434	2040±459
18	2261±329	1681±405	2059±506
19	2110±284	1645±381	2056±439
20	2386±486	1616±276	2115±500
21	2408±395	1577±281	2122±466
22	2127±582	1562±292	2110±379
23	2108±429	1603±319	2012±367
24	2576±436	1695±412	2045±326
1	2410±257	1603±308	2115±354
2	2726±641	1522±225	2095±354
3	2515±376	1644±400	1983±368
4	2577±342	1590±290	1981±310
5	2619±569	1649±303	1976±325
6	2428±466	1670±350	2066±376
7	2354±486	1662±359	2055±374
average daily	2367±323	1645±239	2040±308

\*-significant relative to group 1

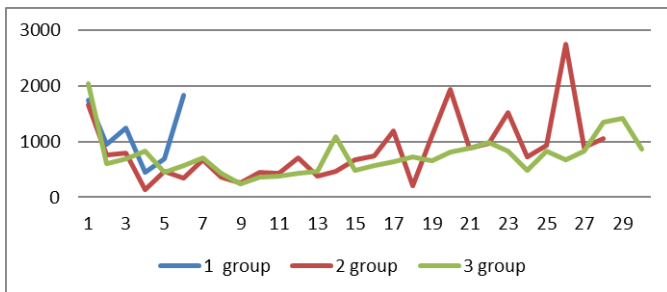
''' - reliable relative to the indicator on 1 day



**Figure 1.** Dynamics of the mesor circus rhythm of TPVR in acute respiratory failure at the age of 3.1-7 l,  $\text{dyn.s.cm}^{-3}\text{m}$

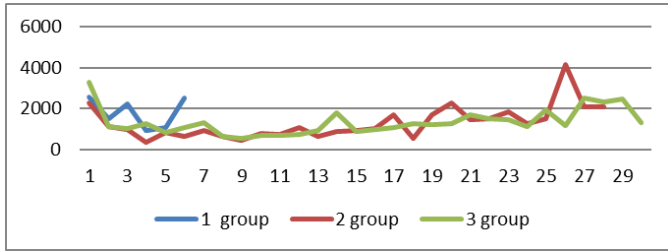


**Figure 2.** Average level of TPVR in the circadian rhythm at 3.1-7 years,  $\text{dyn.s.cm}^{-3}\text{m}$



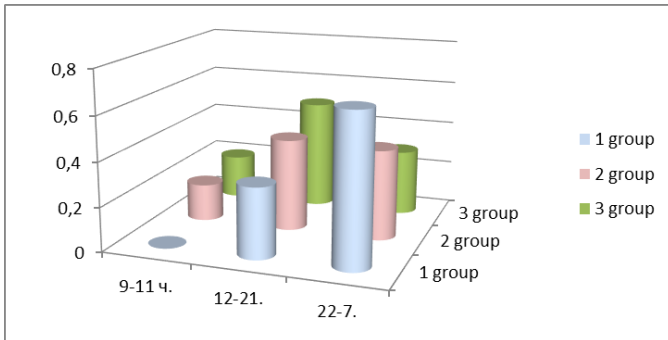
**Figure 3.** Dynamics of amplitude of opss,  $\text{dyn.s.cm}^{-3}\text{m}$

Changes in the amplitude of daily fluctuations in peripheral vascular tone occurred in waves in a deformed weekly rhythm with a decrease in the period of fluctuations to 4.5 days. In group 2, there was a remarkable increase in the amplitude of periweekly rhythms to 1300  $\text{dyn.s.cm}^{-5}\text{m}$  after the 17th day.



**Figure 4.** Change in daily range of TPVR fluctuations,  $\text{dyn.s.cm}^{-5}\text{m}$

The difference between the maximum and minimum values of TPVR (range of daily fluctuations) reached 1300  $\text{dyn.s.cm}^{-5}\text{m}$  in group 1 on the 6th day, in group 2 - 2500  $\text{dyn.s.cm}^{-5}\text{m}$  - on the 26th day, in group 3 - 2400  $\text{dyn.s.cm}^{-5}\text{m}$  per 1 day. Apparently, changes in vascular tone within 1 day by 2400  $\text{dyn.s.cm}^{-5}\text{m}$  should be considered unfavorable in a prognostic sense, since it characterizes a deep disruption of the regulation of peripheral vascular tone, caused by peripheral organic changes not only in the vascular wall, but also by disorders regulation of a central nature.



**Figure 5.** Shift in acrophase of the circadian rhythm of TPVR at 3.1-7 years

The inversion of the circadian rhythm of the peripheral vascular resistance turned out to be the longest (11 days) in group 2, for 9 days in group 3 and 4 days in group 1, which amounted to 41%, 30%, 68% in percentage terms.

**Table 3.**  
Correlation connections of the dynamics of TPVR.

Options	1 group	2 group	3 group
OPSS/MBV	-0,96	-0,90	-0,76

OPSS/UOK	-0,95	-0,83	-0,63
OPSS/MAP	0,39	0,58	0,54
OPSS/SV	-0,36	-0,78	-0,19
OPSS/T°C	0,20	-0,02	-0,12
OPSS/SAD	-0,31	0,65	0,33
OPSS/DAD	0,02	0,83	0,42

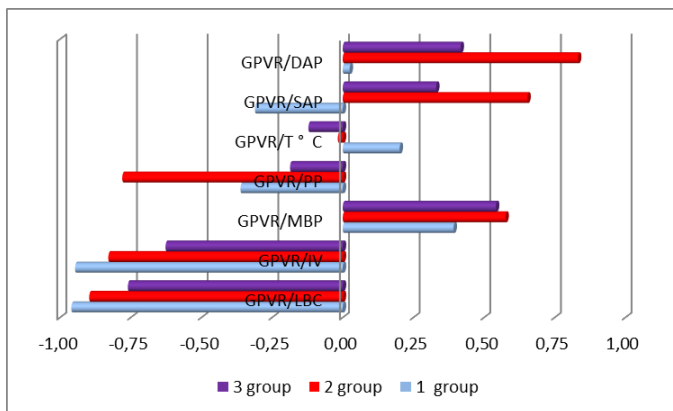


Figure 6. Correlation connections of TPVR.

The discovered significantly significant correlations between the dynamics of the TPVR and the MBV, SV indicated the hyperdynamic nature of the hemodynamic function (-0.9; -0.9; -0.76, respectively) in all patients aged 3.1-7 years (Fig. 6) . A direct relationship between TPVR and DAD (0.83) was revealed in patients of group 2. That is, the increase in DAD in these patients corresponds to an increase in total peripheral vascular resistance (Table 3).

**Conclusion.** On day 1, the mesor of the circadian rhythm OPSS turned out to be the highest in children of group 3, exceeding the norm by 3 times with a normal MBV value, indicating a tendency towards a hypodynamic type of function of the circulatory system. The adaptive response of the circadian rhythm of vascular tone in group 1 was expressed in the inversion of the average circadian rhythm of vascular tone. A change in vascular tone within 1 day by 2400 dyn.s.cm<sup>-5</sup>m should be considered unfavorable in a prognostic sense. The inversion of the circadian rhythm of the peripheral vascular resistance turned out to be the longest (11 days) in group 2, for 9 days in group 3 and 4 days in group 1, which amounted to 41%, 30%, 68% in percentage terms.

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学龄前儿童急性肾功能衰竭无尿期自主神经调节的昼夜节律  
**CIRCADIAN RHYTHM OF AUTONOMIC REGULATION IN THE  
ANURIC PHASE OF ACUTE RENAL FAILURE IN PRESCHOOL  
CHILDREN**

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抽象的。通过对俄罗斯急诊医学研究中心ICU收治的17名3.1~7岁无尿期急性肾功能衰竭患儿的AAT每小时监测数据研究发现：第1天的反应表现为AAT昼夜节律中位数增加，第1组增加了70%，第2组增加了40%，第3组增加了20%，这被认为是来自交感神经反应的反馈。3.1-7岁儿童无尿期初期病情严重程度。在第3组患者中，发现持续存在交感神经紧张反应的倾向，AAT昼夜节律中段在12天内显著增加40-70%，这是交感神经调节活动最显著的每日变化。在所有3组中，交感神经反应在高动力型血流动力学形成中的主导作用均被揭示。

关键词：自主神经调节昼夜节律，急性肾功能衰竭，儿童。

**Abstract.** *Based on the study of hourly monitoring data of AAT in 17 children with acute renal failure who were admitted to the ICU of the Russian Research Center for Emergency Medicine in the anuric phase at the age of 3.1 to 7 years, it was revealed: the sympathotonic reaction on day 1 was expressed in an increase in the mesor of the circadian rhythm of AAT in group 1 by 70%, in group 2 - by 40%, in group 3 by 20%, which was regarded as feedback from the sympathotonic reaction of the initial severity of the condition in the anuria stage in children aged 3.1-7 years. In patients of group 3, a constant tendency towards a hypersympathotonic reaction was found with a significantly significant*

*increase in the mesor of the circadian rhythm of AAT over 12 days by 40-70%, the most pronounced daily changes in the activity of sympathetic regulation. The leading role of the sympathetic reaction in the formation of the hyperdynamic type of hemodynamics in all 3 groups was revealed.*

**Keywords:** *circadian rhythm of autonomic regulation, acute renal failure, children.*

**Relevance.** It has been established that the restructuring of the mechanisms of regulation of functional systems in kidney diseases depends on the individual typological characteristics of the child and the least adaptive is the sympathicotonic type of autonomic regulation, which also determines a less favorable prognosis for the restoration of kidney function. Provided that renal homeostasis is maintained at the physiological level, the individual typological characteristics of the relationships functional systems that determine the disorganization of kidney function are maximally expressed in glomerulonephritis and tubulointerstitial nephritis. In patients with pyelonephritis, the mechanisms of interaction between the functional systems of the body are close to those in healthy children, which allows us to consider this form of nephritis prognostically more favorable. The authors come to the conclusion that determining the type of autonomic regulation and systemic blood flow makes it possible to clarify the hierarchy of interactions of functional systems in acquired nephritis. Researchers It was found that the autonomic nervous system (ANS) directly influences their performance of glomerular filtration, tubular reabsorption and secretion in the body of a new host. The transplant independently selects the optimal mode to maintain, first of all, its vital functions and often exhibits comprehensive autonomous properties of protecting itself from the aggressive humoral influence of the metabolites of its new host. Glomerulotubular imbalance in children indicates an excess of filtration capacity over the reabsorption capabilities of the tubules, which, under certain conditions, will invariably lead to changes in urine analysis. The juxtaglomerular apparatus in young children is also not yet formed, while vasoactive systems (renin-angiotensin-aldosterone system - RAAS, intrarenal adenosine) are active and easily stimulated by hypoxia. Despite the fact that the morphological maturation of the kidney generally ends by school age (3–6 years), children of any age are at risk of kidney damage due to one or another exposure to the body. Based on a systematic approach, the typological features of the interaction of the parameters of the homeostatic mechanisms of the urinary system, blood flow systems, hematopoiesis, immunity, and hemocoagulation in school-age children with nephritis were studied. New data have been obtained on the patterns of reorganization of relationships between functional systems in various nosological forms of diseases. New possibilities have been established for predicting the outcome of nephritis based on the nature of interactions between

mechanisms for optimizing renal function and the functional systems of the body integrated into them. However, due to the lack of information on the peculiarities of autonomic regulation during the anuric phase of acute renal failure in preschool children, we made an attempt to study and evaluate AAT in order to optimize the management of specialized patients [1-6].

**Goal of the work.** To study and evaluate changes in the circadian rhythm of autonomic regulation during the anuric phase of acute renal failure in preschool children.

**Material and research methods.** We studied the data of hourly monitoring of AAT in 17 children with acute renal failure who were admitted to the ICU of the Russian Research Center for Emergency Medicine in the anuric phase at the age of 3.1 to 7 years from the ICU of regional children's hospitals and branches of the Russian Research Center for Emergency Medicine. Before admission to the clinic, all patients received anti-inflammatory therapy aimed at treating pneumonia, acute glomerulonephritis, acute intestinal infections, and acute respiratory infections. All patients underwent hemodialysis, under the control of hemodynamics, acid-base balance, respiratory system, supportive, antibacterial, anti-inflammatory, syndromic corrective intensive therapy in accordance with existing recommendations in the literature. A favorable outcome with restoration of full functional activity of the kidneys and discharge from the hospital was observed in 13 children (groups 1 and 2), an unfavorable outcome – in 4 children (group 3). The first group consisted of patients who received intensive therapy in an ICU for up to 10 days (5 patients), the second group included children with a favorable outcome after intensive therapy for 12–45 days (8 patients), the third group included 4 patients with an unfavorable outcome. Data from hourly monitoring of circadian rhythm parameters of AAT (assessment of autonomic tone) are presented. The results of the identified changes in the components of the circadian rhythm were carried out by deducing mesor indicators - the average daily level of the studied indicator, the amplitude of circadian fluctuations, the range of daily fluctuations, indicators of acrophase and bathyphase of the circadian rhythm, the duration of the inversion of the circadian rhythm of the studied hemodynamic parameters. The research data were processed by the method of variation statistics using the Excel program by calculating arithmetic means (M) and errors of means (m). To assess the significance of differences between two values, the parametric Student's test (t) was used. The relationship between the dynamics of the studied indicators was determined by the method of paired correlations. The critical significance level was taken equal to 0.05.

Results and its discussion. The sympathotonic reaction on day 1 was expressed in an increase in the mesor of the circadian rhythm AAT in group 1 by 70%, in group 2 by 40%, in group 3 by 20%, which was regarded as an inverse dependence



of the sympathotonic reaction of the initial severity of the condition at the stage of anuria in children aged 3.1-7 years (Table 1).

**Table 1.**  
*Dynamics of the mesor of the circadian rhythm AAT, Units.*

Days	1 group	2 group	3 group
1	1,7±0,3	1,4±0,2	1,2±0,2
2	1,4±0,1	1,3±0,1	1,4±0,2
3	1,2±0,1*	1,4±0,04 <sup>m</sup>	1,3±0,1
4	1,2±0,1*	1,5±0,1 <sup>m</sup>	1,3±0,1
5	1,4±0,1	1,4±0,1	1,6±0,1*
6	1,2±0,2	1,3±0,1	1,5±0,1
7		1,4±0,1	1,8±0,2*●
8		1,5±0,2	1,9±0,1*●
9		1,4±0,1	1,9±0,1*●
10		1,5±0,1	1,9±0,2*●
11		1,7±0,1	1,6±0,2
12		1,4±0,1	1,7±0,2*
13		1,5±0,1	1,7±0,2*
14		1,4±0,1	1,7±0,1*●
15		1,3±0,2	1,5±0,2
16		1,7±0,1	1,7±0,2*
17		1,5±0,1	1,6±0,2
18		1,5±0,2	1,6±0,1*
19		1,2±0,1	1,5±0,2
20		1,3±0,1	1,6±0,2
21		1,4±0,2	1,5±0,3
22		1,3±0,2	1,6±0,2
23		1,3±0,1	1,7±0,2*●
24		1,7±0,3	1,5±0,1
25		1,5±0,2	1,6±0,1*
26		0,8±0,2*	1,5±0,3●
27		1,1±0,2	1,5±0,1●
28		1,4±0,4	1,5±0,2
29			1,4±0,2
30			1,6±0,2

**Table 2.**

*Average circadian rhythm of autonomic regulation, units.*

Hours	1 group	2 group	3 group
8	1,3±0,2	1,3±0,2	1,5±0,2
9	1,3±0,1	1,3±0,2	1,6±0,3
10	1,3±0,1	1,4±0,2	1,6±0,2
11	1,3±0,2	1,4±0,2	1,7±0,2
12	1,3±0,1	1,4±0,2	1,7±0,2 <sup>'''</sup>
13	1,3±0,1	1,4±0,2	1,8±0,2 <sup>'''</sup>
14	1,4±0,2	1,4±0,2	1,7±0,2
15	1,5±0,2	1,4±0,2	1,6±0,2
16	1,5±0,2	1,4±0,2	1,6±0,2
17	1,4±0,1	1,4±0,2	1,7±0,2
18	1,4±0,2	1,4±0,2	1,6±0,3
19	1,5±0,2	1,4±0,2	1,6±0,2
20	1,4±0,3	1,4±0,2	1,6±0,2
21	1,4±0,2	1,4±0,2	1,6±0,2
22	1,5±0,3	1,5±0,2	1,5±0,2
23	1,4±0,1	1,4±0,2	1,6±0,2
24	1,2±0,1	1,4±0,2	1,6±0,2 <sup>'''</sup>
1	1,3±0,1	1,4±0,2	1,5±0,2
2	1,2±0,2	1,5±0,2	1,5±0,2
3	1,2±0,02	1,4±0,2	1,6±0,2 <sup>'''</sup>
4	1,3±0,2	1,4±0,2	1,6±0,2
5	1,3±0,2	1,4±0,2	1,6±0,2
6	1,3±0,2	1,4±0,2	1,6±0,2
7	1,3±0,2	1,4±0,2	1,5±0,2

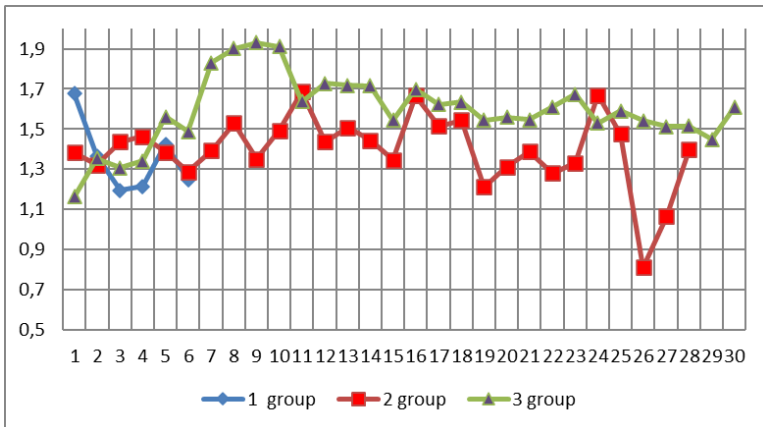
\*-reliable relative to data from 1 day

'''-reliable relative to the indicator in group 1

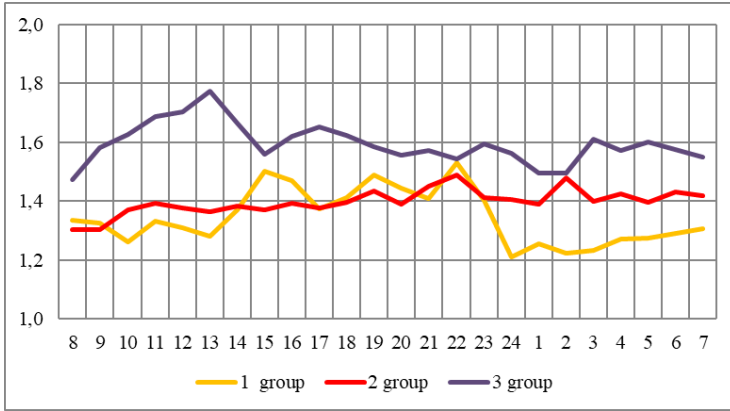
●-reliable relative to the indicator in group 2

The identified feature of the mesor of the circadian rhythm of AAT on day 1 in children of groups 2 and 3 may be associated, along with other reasons, related to the necessary more active stress-limiting intensive therapy up to transfer to mechanical ventilation using drugs with a sympatholytic effect (anticonvulsants, hypnotics, tranquilizers , vasodilators). In dynamics, a significantly significant decrease in stress mobilization of the ANS in group 1 was detected on days 3 and 4 by 50%. While an unstable decrease in the mesor of the circadian rhythm of OBT in group 2 was noted only on day 26 by 60% (Fig. 1). In contrast to the first two groups of children with a favorable outcome, patients in group 3 showed

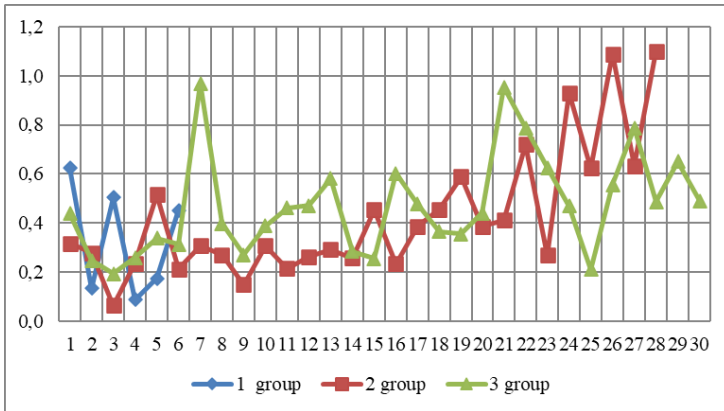
a constant tendency towards a hypersympathotonic reaction with a significantly significant increase over 12 days by 40-70%. Thus, one of the pathogenetic mechanisms in thanatogenesis of children with acute renal failure is the almost constant hyperfunction of the sympathetic structure of the ANS, which indicates the ineffectiveness of the fight against the etiological factor, the insufficient correction of pathogenetic mechanisms that led to the depletion of energy resources with a fatal outcome. At the same time, maintaining viability at the cellular level by effectively combating the energy deficiency state could possibly make it possible to prolong and maintain protective compensatory mechanisms in conditions of severe disorders caused by extensive destructive processes not only in the urinary system. The most pronounced sympathotonic reaction in children of group 3 was confirmed by the average circadian rhythm of AAT (Table 2). A reliably significant excess of the AAT indicator relative to the data of group 1 was found at 12 hours by 40%, at 13 hours by 50%, at 24 hours - by 40%, at 3 hours - by 40%. Thus, excessive hypersympathotonic mobilization was expressed in children of group 3 both during the daytime and at night (Fig. 2).



**Figure 1.** Mesor of the circadian rhythm of AAT in acute renal failure at the age of 3.1-7 years, units.



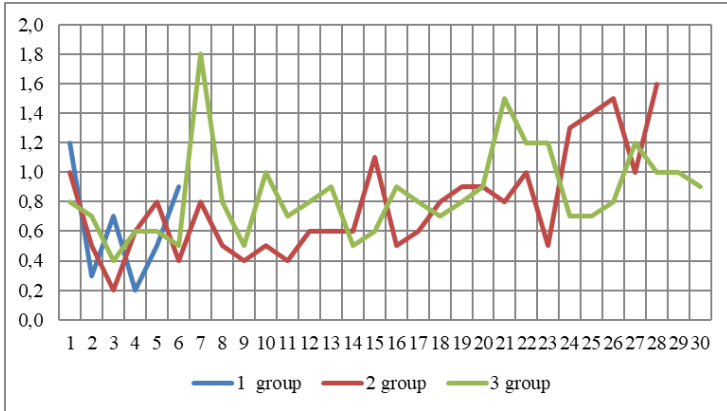
**Figure 2.** Average circadian rhythm of autonomic regulation in acute renal failure at the age of 3.1-7 years, units.



**Figure 3.** Dynamics of the amplitude of the circadian rhythm of AAT, units.

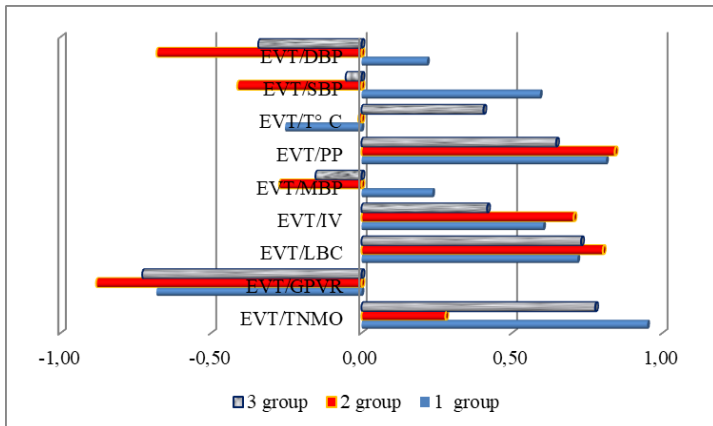
In group 1, the amplitude of the circadian rhythm of AAT in dynamics changed in waves from 0.1 units. up to 0.5 units with an oscillation period of 3–4 days (Fig. 3). In group 2, with the same period of fluctuation, the amplitude of the circadian rhythm of AAT on days 6-20 became more stable, but in the next 22-28 days it increased to 0.6-0.4 units, indicating an increase in the sympathotonic reaction at a later date. The discovered feature of group 2 was due to a secondary inflammatory reaction against the background of restoration of the excretory activity of the kidneys. The most pronounced hypersympathotonic reaction in group 3 was noted on day 7 by an increase in the amplitude of the circadian rhythm of the AAT to 1

unit. A repeated increase in amplitude against the background of relatively more pronounced hypersympathotonia compared to the first two groups occurred on the 21st day, giving way to a sympatholytic effect on the 25th day, indicating severe vegetative-vascular dystonia in conditions of prolonged anuria.



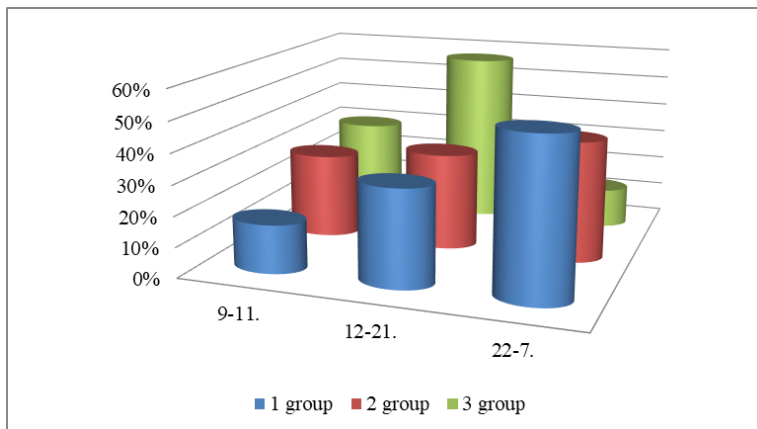
**Figure 4.** Change in daily fluctuations of AAT, units.

Daily changes in the activity of sympathetic regulation were most pronounced in children of group 3 on the 7th day (Fig. 4). Despite the restoration of urinary activity in group 2 after 23 days, the tendency to a hypersympathotonic reaction remained.



**Figure 5.** Correlation connections of AAT

A direct strong correlation between MVP and AAT was revealed (0.95) in group 1, somewhat less pronounced in group 3 (0.78) (Fig. 5). The inverse correlation between AAT and PR (-0.88), with a direct correlation between AAT and IOC (0.8), characterized the leading role of the sympathetic reaction in the formation of the hyperdynamic type of hemodynamics in all 3 groups.



**Figure 6.** Duration of the AAT acrophase shift

The longest inversion of the circadian rhythm of AAT - 11 days - was detected in children of group 2, while in groups 1 and 3, a shift of acrophase to the night hours was observed, respectively, for 3 and 4 days (Fig. 6). In percentage terms, the shift in the acrophase peak of the circadian rhythm of AAT in group 1 was 52%, in group 2 – 40%, in group 3 – 13%. The longest hypersympathotonic reaction at night can be explained by the failure of vagotonic influences, often characteristic of patients with hypertension. Most likely, the identified feature of hemodynamics in group 2 - a tendency to arterial hypertension at night - makes sense to take into account in the process of long-term vasoactive chronotherapy for children who have suffered acute renal failure.

**Conclusion.** The sympathotonic reaction on day 1 was expressed in an increase in the mesor of the circadian rhythm AAT in group 1 by 70%, in group 2 by 40%, in group 3 by 20%, which was regarded as an inverse dependence of the sympathotonic reaction of the initial severity of the condition at the stage of anuria in children aged 3.1-7 years. In patients of group 3, a constant tendency towards a hypersympathotonic reaction was found with a significantly significant increase in the mesor of the circadian rhythm of OBT over 12 days by 40-70%, the most pronounced daily changes in the activity of sympathetic regulation. The leading

role of the sympathetic reaction in the formation of the hyperdynamic type of hemodynamics in all 3 groups was revealed.

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学龄前儿童急性肾功能衰竭无尿期昼夜节律指数特征  
**FEATURES OF THE CIRCADIAN INDEX IN THE ANURIC PHASE  
OF ACUTE RENAL FAILURE IN PRESCHOOL CHILDREN**

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抽象的。研究了17例无尿期急性肾功能衰竭患儿的每小时心率和昼夜节律指数 (CI) 监测数据。第3组儿童白天和夜间心率持续增加25%，且心率昼夜节律相对于第1组和第2组指标的倒转时间最长，对应于相对最严重的情况。随着时间的推移，所有患者在第1天检测到的最初交感神经紧张性强直心律随着时间的推移仅在第1组患者中在治疗第8天显示出趋于正常化的趋势。CI指标正常化的趋势伴随着第1组儿童的心率增加。第1组儿童中发现CI指标数量最多的直接强相关性，表征了功能系统的显着代偿活动。

关键词：昼夜节律、心率、无尿、儿童。

**Abstract.** *The data of hourly monitoring of heart rate and the circadian index (CI) in 17 children with acute renal failure in the anuric phase were studied. A persistent increase in heart rate both during the day and at night by 25% with the longest inversion of the circadian rhythm of heart rate relative to the indicators of groups 1 and 2 in children of group 3 corresponded to the comparatively most severe condition. The initially hypersympathotonic rigid heart rhythm detected*



*on day 1 in all patients over time showed a tendency towards normalization only in patients of group 1 on day 8 of treatment. The trend towards normalization of the CI indicator was accompanied by an increase in heart rate in children of group 1. The largest number of direct strong correlations of the CI indicator, characterizing the pronounced compensatory activity of functional systems, was found in children of group 1.*

**Keywords:** *circadian rhythm, heart rate, anuria, children.*

**Relevance.** One of the leading pathogenetic mechanisms for the development of acute renal failure is a hypersympathotonic reaction, which causes spasm of peripheral, including renal, vessels, ensuring the adequacy of compensatory centralization of blood circulation in conditions of dehydration (hypovolemia) and other stress reactions of the body. In healthy people, a certain cyclicity is observed in the functioning of the circulatory system: during the day the heart beats more often than at night. One of the objective indicators of physiological cyclicity is the circadian index (CI). The calculation is made using the formula:  $CI = \text{Average heart rate during the day (from 7.00 to 22.00)} / \text{Average heart rate at night (from 23.00 to 7.00)}$  The indicator is not affected by the age or gender of the subject. An exception is children under 1 year of age: due to the physiological characteristics of an infant, the CI may be slightly lower and averages 1.15. In practical medicine, deviations of this index are observed both upward and downward. The CI value is within the range of 1.24 -1.44 USD. (M 1.32 + 0.06) is an indicator of the stable autonomic organization of the circadian rhythm of the heart. If the indicator persistently deviates downward, we can say that myocardial contractility has decreased, and the patient has developed irreversible changes in the myocardium and chronic heart failure. A decrease in CI less than 1.2 is observed in diseases associated with autonomic “denervation” of the heart and is associated with a poor prognosis and a high risk of sudden death in patients at risk. However, in the literature there is not enough information on the dynamics of CI in the anuric phase of acute renal failure in children aged 3.1-7 years, which served as the basis for this study [1-6].

**Goal of the work.** To study the features of the circadian index in children with acute renal failure during the period of anuria at the age of 3.1-7 years.

**Material and research methods.** We studied hourly heart rate monitoring data in 17 children with acute renal failure who were admitted to the ICU of the Russian Scientific Center for Emergency Medicine in the anuric phase at the age of 3.1 to 7 years from the ICU of regional children’s hospitals and branches of the Russian Scientific Center for Medical Emergency. Before admission to the clinic, all patients received anti-inflammatory therapy aimed at treating pneumonia, acute glomerulonephritis, acute intestinal infections, and acute respiratory infections. Due to severe progressive respiratory failure, patients received invasive

mechanical respiratory support as indicated on the first day. All patients underwent hemodialysis, under the control of hemodynamics, acid-base balance, respiratory system, supportive, antibacterial, anti-inflammatory, syndromic corrective intensive therapy in accordance with existing recommendations in the literature. A favorable outcome with restoration of full functional activity of the kidneys and discharge from the hospital was observed in 13 children (groups 1 and 2), an unfavorable outcome – in 4 children (group 3). The first group consisted of patients who received intensive therapy in an ICU for up to 10 days (5 patients), the second group included children with a favorable outcome after intensive therapy for 12–45 days (8 patients), the third group included 4 patients with an unfavorable outcome. The data of the circadian index are presented, the correlation between the circadian rhythm of heart rate and other hemodynamic parameters is studied. The normal circadian index for adult men and women should be in the range of 1.24-1.44. The assessment of changes in the components of the circadian rhythm was carried out by obtaining mesor indicators - the average daily level of the studied indicator, the amplitude of circadian fluctuations, the range of daily fluctuations, indicators of acrophase and bathyphase of the circadian rhythm, the duration of the inversion of the circadian rhythm of the studied hemodynamic parameters. The research data were processed by the method of variation statistics using the Excel program by calculating arithmetic means (M) and errors of means (m). To assess the significance of differences between two values, the parametric Student’s test (t) was used. The relationship between the dynamics of the studied indicators was determined by the method of paired correlations. The critical significance level was taken equal to 0.05.

**Results and its discussion.** There were no significant differences in the average heart rate values during the anuria phase of acute renal failure in groups 1 (104±5 per minute) and 2 (106±6 beats per minute) depending on the severity of the condition in preschool children. A significantly significant difference – a 25% increase in the average heart rate (130±7 per minute) in children of group 3 corresponded to the comparatively most severe condition.

*Table 1.  
Dynamics of the mesor of the circadian HR rhythm*

Days	1 group	2 group	3 group
1	117±10	95±6*	107±9
2	104±4	98±2	127±16 <sup>***</sup>
3	100±4	106±3	116±4* <sup>***</sup>
4	98±4	108±3*	117±6*
5	101±3	105±4	131±3* <sup>***</sup> ”
6	102±6	100±2	142±11* <sup>***</sup> ”

7		106±3	141±7 <sup>***</sup>
8		108±3 <sup>**</sup>	146±5 <sup>***</sup>
9		108±2 <sup>**</sup>	148±3 <sup>***</sup>
10		115±3 <sup>**</sup>	140±5 <sup>***</sup>
11		113±4 <sup>**</sup>	125±6 <sup>***</sup>
12		107±4	134±4 <sup>***</sup>
13		109±5 <sup>**</sup>	134±6 <sup>***</sup>
14		107±6	139±5 <sup>***</sup>
15		111±6 <sup>**</sup>	125±5 <sup>***</sup>
16		117±5 <sup>**</sup>	130±4 <sup>***</sup>
17		108±5	132±6 <sup>***</sup>
18		104±2	133±6 <sup>***</sup>
19		92±3	132±7 <sup>***</sup>
20		99±3	130±6 <sup>***</sup>
21		101±4	126±7 <sup>***</sup>
22		99±4	138±5 <sup>***</sup>
23		100±4	133±7 <sup>***</sup>
24		111±3	133±6 <sup>***</sup>
25		114±8	130±6 <sup>***</sup>
26		92±4	126±11 <sup>***</sup>
27		110±6	126±7 <sup>***</sup>
28		131±9 <sup>**</sup>	119±5
29			116±8
30			128±6 <sup>**</sup>

**Table 2.**  
*HR average circadian rhythm*

Hours	1 group	2 group	3 group
8	104±3	104±7	129±10 <sup>* **</sup>
9	104±4	106±7	129±10 <sup>* **</sup>
10	104±4	106±7	130±9 <sup>* **</sup>
11	102±3	107±7	134±9 <sup>* **</sup>
12	105±6	107±10	134±9 <sup>* **</sup>
13	107±7	108±9	133±10 <sup>* **</sup>
14	106±5	107±8	131±9 <sup>* **</sup>
15	107±7	108±7	130±9 <sup>* **</sup>
16	107±8	106±7	133±8 <sup>* **</sup>
17	107±9	107±6	133±11 <sup>* **</sup>
18	109±12	106±8	131±9 <sup>* **</sup>
19	110±7	108±7	131±10 <sup>* **</sup>

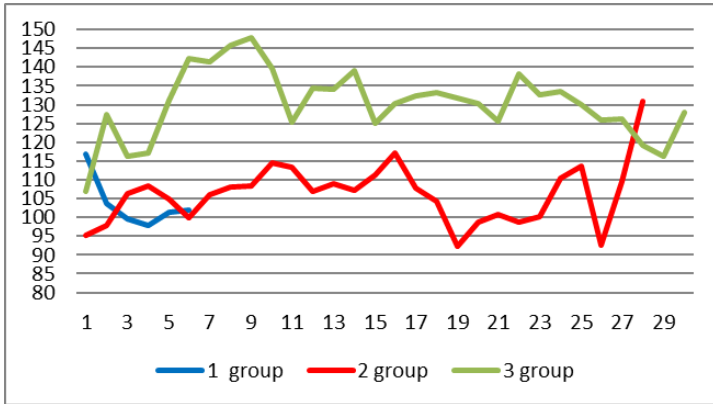
20	107±7	110±8	129±10*
21	107±6	110±8	129±11 *
22	109±7	108±7	130±9* <sup>m</sup>
23	101±4	106±6	129±8* <sup>m</sup>
24	100±4	106±6	130±8* <sup>m</sup>
1	96±2	105±7	130±9* <sup>m</sup>
2	98±5	105±7	127±9* <sup>m</sup>
3	97±4	103±7	129±11* <sup>m</sup>
4	96±5	103±7	130±11* <sup>m</sup>
5	97±7	103±7	130±10* <sup>m</sup>
6	99±5	105±7	130±9* <sup>m</sup>
7	101±3	105±7	130±9* <sup>m</sup>

\*-significant relative to the indicator in group 1

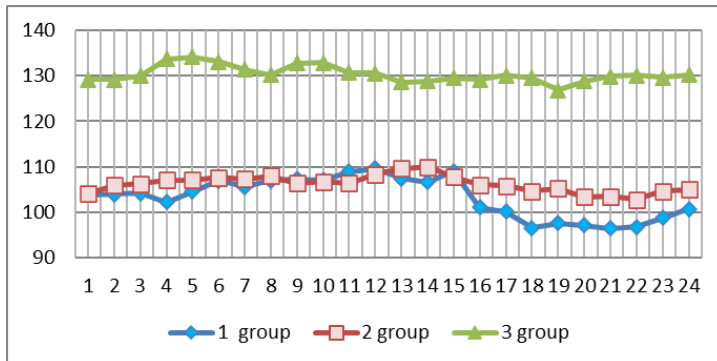
<sup>m</sup>-reliable relative to group 2 indicator

”-reliable relative to the indicator on 1 day

On the 1st day of intensive therapy, a more noticeable tendency to increase heart rate was in group 1. In group 2, the circadian heart rate mesor indicator was closest to normal (18% less than in group 1). During observation, a moderate tendency towards tachycardia remained in group 1. In patients of group 2, a statistically significant increase in the mesor of the circadian rhythm of heart rate was noted on days 8,9,10,11,13,15,28 by 14% (day 8) to 37% on day 28, which indicates instability of cardiac function even with favorable outcome in children (Table 1). A distinctive feature in group 3 was a persistent increase in heart rate relative to the indicator on day 1 by 20%, and also more than the indicator in group 2 throughout the entire observation, starting from the second day by 28%, increasing and exceeding the indicator in group 2 on day 9 by 37 %, with a slight decrease in the difference in subsequent days (Fig. 1). The average circadian heart rate rhythm also indicated persistent tachycardia, characteristic of children of group 3 both during the day and at night, when the difference in the heart rate of children with an unfavorable outcome relative to group 1 averaged 20% during the day, more than 30% at night (Table 2). A significantly significant increase in heart rate in group 3 was revealed relative to group 2, also during both the light and dark periods of the day (Fig. 2).

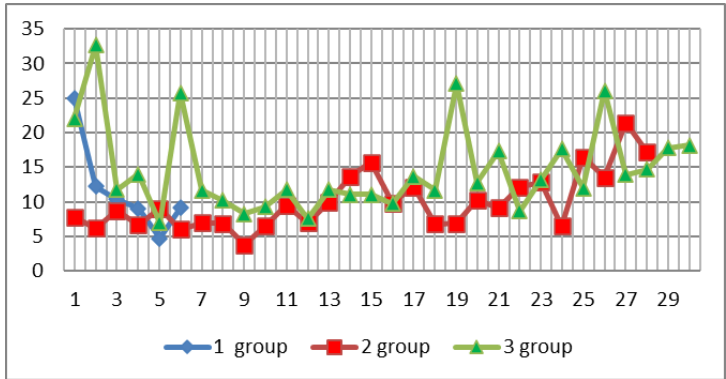


**Figure 1.** Dynamics of the mesor of the circadian heart rate rhythm in the anuric phase of acute renal failure in children 3.1-7 years old, per minute.



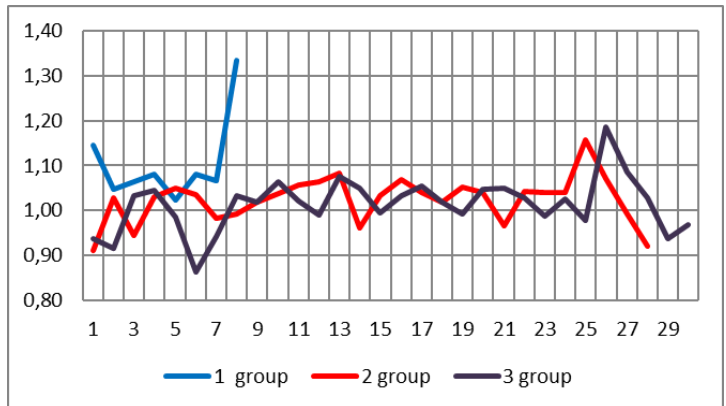
**Figure 2.** Average circadian rhythm of heart rate at the age of 3.1-7 years, beats per minute.

The most pronounced instability of sinus node function was detected in children with an unfavorable outcome (Fig. 3). Thus, an increase in the amplitude of the circadian rhythm of heart rate was observed on days 2, 6, 19, 26, being one of the leading signs of developing acute heart failure. While the maximum value of the amplitude of the circadian rhythm of heart rate in group 2 was observed on days 15, 25, 27 within the range of 15, 22 beats per minute. In group 1, the highest amplitude of the circadian heart rate rhythm on day 1 was 25 beats per minute; in subsequent days it decreased to 5–9 beats per minute, indicating stabilization of the heart rate under conditions of effective stress-limiting therapy and restoration of the excretory activity of the urinary system.

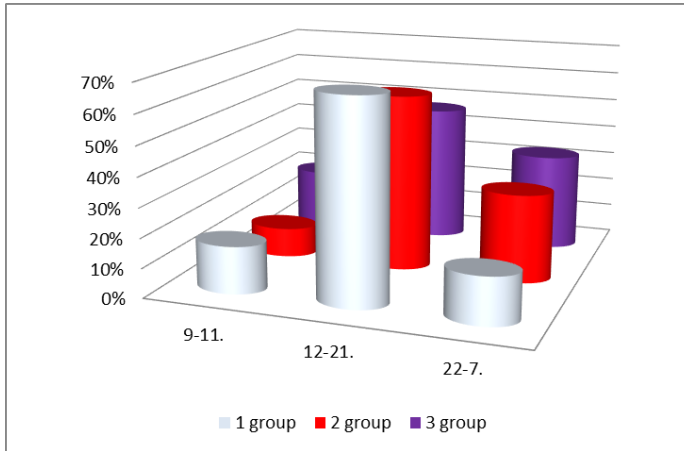


**Figure 3.** Dynamics of the amplitude of the circadian rhythm of heart rate, beats. in a minute.

The diagnostic and prognostic significance of CI deviations is known. The initially hypersympathotonic rigid heart rhythm detected on day 1 showed a tendency towards normalization only in patients of group 1 on day 8 of treatment. While in groups 2 and 3 throughout the observation, the CI index fluctuated from 0.87 (on day 6) to 1.16 on day 26) in group 3. Thus, in patients of groups 2 and 3, almost constant autonomic “denervation” of the heart was found, associated with a poor prognosis and a high risk of sudden death in patients of group 3 (Fig. 4).

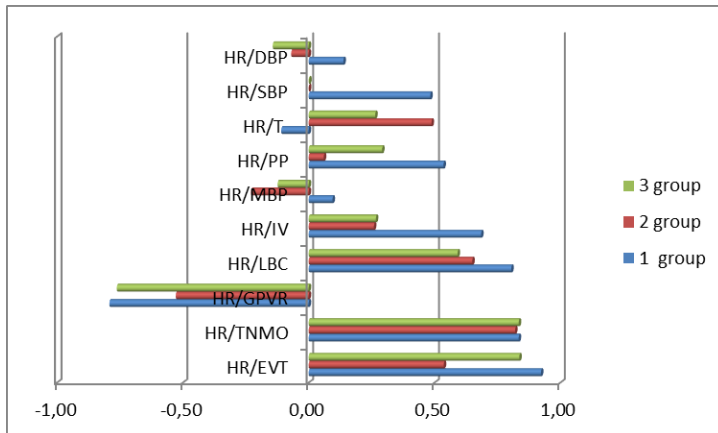


**Figure 4.** Dynamics of the circadian index at 3.1-7 years, units.



**Figure 5.** Duration of acrophase shift in circadian heart rate rhythm

The duration of heart rate circadian rhythm inversion was 10, 9, 1 days, which amounted to 33% in group 3, 30% in group 2 and 16% of the total treatment duration in group 1. Thus, the severity of the shift in the acrophase peak of heart rate corresponded to the severity of the condition of patients in the anuric stage of acute renal failure at the age of 3.1-7 years (Fig. 5).



**Figure 6.** Correlations of heart rate 3.1-7 years

The largest number of direct strong correlations was found in children of group 1, characterizing the pronounced compensatory activity of functional systems. In

groups 2 and 3, a slight decrease in the severity of heart rate correlations was noted (Fig. 6). The identified features corresponded to the active participation of heart rate in the formation of a hyperdynamic type of hemodynamics in acute renal failure. Noteworthy is the direct dependence of MVP on heart rate in all patients under conditions of a hypersympathotonic reaction. The latter suggests the advisability not only of heart rate correction, but also the need to prevent the development of an energy-deficient state of the myocardium, one of the leading factors in the pathogenesis of acute heart failure in conditions of anuria, extracorporeal detoxification in children.

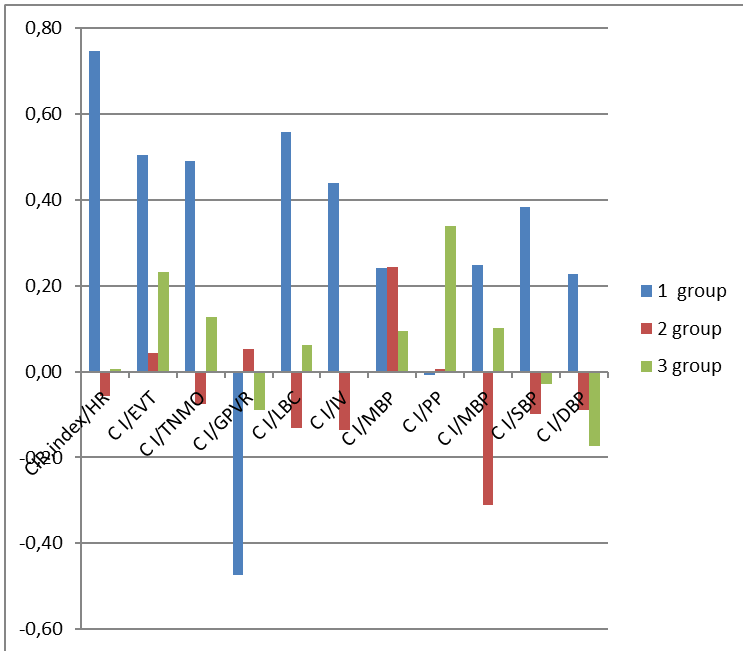


Figure 7. Correlations of the circadian index

A direct strong correlation was found between the CI indicator and heart rate (0.75), that is, an increase in the CI indicator was accompanied by an increase in heart rate in children of group 1.

**Conclusion.** A persistent increase in heart rate both during the day and at night by 25% with the longest inversion of the circadian rhythm of heart rate relative to the indicators of groups 1 and 2 in children of group 3 corresponded to the comparatively most severe condition. The initially hypersympathotonic rigid heart rhythm detected on day 1 in all patients over time showed a tendency towards



normalization only in patients of group 1 on day 8 of treatment. The trend towards normalization of the CI indicator was accompanied by an increase in heart rate in children of group 1. The largest number of direct strong correlations characterizing the pronounced compensatory activity of functional systems was found in children of group 1.

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牙龈退缩期间牙齿硬组织的感觉过敏 – 预防和治疗  
**HYPERESTHESIA OF HARD TISSUE OF TEETH DURING GUM  
RECESSION - PREVENTION AND TREATMENT**

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概括。硬组织感觉过敏是最常见的口腔疾病之一，其表现为对温度、触觉和化学刺激产生的急性疼痛，并且随着牙龈萎缩，该过程会加剧。文献数据分析显示，世界上约40%的人口牙齿敏感性增加。据世界卫生组织称，感觉过敏的患病率正在稳步上升。最常见的是，大约 45–50% 的病例发生在青春期，在 19–25 岁时达到最大值。研究人员表示，19 至 50 岁的患者感觉过敏最为明显。研究还证明，女性（60%）更容易出现感觉过敏，这可能是由于最密集的口腔护理所致。

关键词：牙齿硬组织感觉过敏，敏感性增加，牙龈萎缩。

**Summary.** *Hyperesthesia of hard tissues is one of the most common diseases of the oral cavity, which manifests itself in the form of acute pain in response to temperature, tactile and chemical stimuli, and with gum recession the process is aggravated. Analysis of literature data showed that about 40% of the world's population have increased tooth sensitivity. According to WHO, the prevalence of hyperesthesia is steadily increasing. Most often, in approximately 45-50% of cases, it occurs in adolescence, reaching its maximum value by 19-25 years. Researchers say that hyperesthesia is most pronounced in patients aged 19 to 50 years. It has also been proven that hyperesthesia is more often observed in women (60%), which may be due to the most intensive oral care.*

**Keywords:** *hyperesthesia of hard dental tissues, increased sensitivity, gum recession.*

The increased sensitivity of hard dental tissues during gum recession complicates the process of oral hygiene in patients, which leads to unsatisfactory hygiene and, as a consequence, inflammatory periodontal diseases. Currently, there are two main approaches to the treatment of hyperesthesia of hard dental tissues: desensitization of nerve fibers to reduce the response to various stimuli; blockade of exposed dentin tubules to restore osmotic pressure in them. Potassium salts are used to desensitize nerve fibers. Potassium ions diffuse through the dentinal tubules, depolarize nerve endings, block the occurrence and transmission of pain impulses, and create a depot around the nerve, protecting it from the action of the irritant. The action of fluoride ions is based on partial sealing of dentinal tubules, reducing their diameter. In this case, there is a decrease in fluid flow and a decrease in the reaction to irritants, which cause increased sensitivity and strengthens the enamel. Based on the studies conducted, it was found that the use of preventive agents that contain 0.1% sodium fluoride or 3% potassium oxalate after the procedure for whitening the hard tissues of teeth reduces their sensitivity. Currently, scientists have obtained results from a study of deep fluoridation of enamel and dentin with a liquid containing fluoride and copper ions, followed by the application of a suspension containing calcium hydroxide in distilled water. As a result of this procedure, enamel cracks, dentin tubules and cement are sealed. The resulting suspension, according to scientists, promotes the formation of calcium fluoride crystals less than 1 micron in size in the dentinal tubules, providing effective protection of damaged hard tooth tissues. There is data that confirms the absence of a negative effect of the deep fluoridation procedure on the adhesion of filling and restoration materials.

Data have been obtained on the positive effect of the combined method of sealing dentinal tubules. This method is based on the use of a protective coating for teeth (resin), which contains fluoride and calcium phosphate. It has been proven to reduce tooth sensitivity 2 weeks, 2 and 6 months after its application. There is evidence of a positive effect when using the new Pro-Argin technology. It has been proven that arginine, which is part of the drug used, combines with the protein matrix and ensures adhesion to the walls of dentin, as well as the retention of calcium carbonate and phosphates on the surface of the dentinal tubules and inside. The data obtained as a result of the studies showed a fairly high effectiveness of the drug, based on reducing the sensitivity of teeth to tactile and temperature stimuli, while maintaining the resulting effect for a long time.

There is evidence of the positive effect of a dental preparation, which contains hydroxyapatite and L-arginine in the form of an aqueous paste, which has a high remineralizing effect. The principle of action of the drug is based on sealing the dentinal tubules, L-arginine, which is the main amino acid, forms multiple hydrogen bonds at pH 10. Arginine, due to its ability to selectively ionize, does not

change the pH when adding an acid or base, maintaining the balance of the environment. At the same time, penetrating into the dentin tubules and microdefects, arginine forms compounds that contribute to the analgesic effect, which occurs by blocking the entry of irritating substances. It has also been proven that the use of toothpaste with L-arginine helps restore damaged tooth tissue, reduce pain and prevent dehydration.

It is known that chemicals, such as gels, varnishes and solutions, are also used to prevent and treat dental hypersensitivity. Physical methods are also used: electro-anesthesia and laser, as well as a physico-chemical method - electrophoresis with various drugs. Quite often, electrophoresis with a sodium fluoride solution is used to reduce dental hypersensitivity.

According to the literature studied, reduction of dental hypersensitivity can be achieved by using a vaseline-based drug, which contains potassium fluoride, ecdysterone, ethyl alcohol, and water. During this study, scientists noted that potassium fluoride provided optimal osmotic pressure in the dentin tubules, which occurred by reducing the excitability of nerve fibers. Ecdysterone had a reparative, analgesic, and anti-inflammatory effect. This drug was applied to specially made individual trays, which were introduced into the patient's oral cavity. The authors claim that after 9-10 days of use this drug had a positive effect aimed at reducing dental hypersensitivity. There is evidence indicating the positive effect of an adhesive biopolymer film containing sodium fluoride, chlorhexidine bigluconate and benzalkonium chloride. The authors recommend the use of this film to eliminate dental hyperesthesia. Researchers have proposed a method for treating dental hypersensitivity using a gel that contains finely dispersed calcium hydroxyapatite, Tizol (an aqua complex of titanium glycerosolvate) and chlorhexidine bigluconate (an antiseptic component). The authors of this development recommended using this drug for 10 sessions, every 1-3 days, rubbing it in with a brush for three minutes. According to scientists, the use of this method of treatment makes it possible to obtain a lasting effect of reducing dental hypersensitivity due to the restoration of hard dental tissues. Data have been obtained on the use in the practice of dentists of fine-crystalline porous calcium-containing preparations, which, according to scientists, can be the basis for restoring the structure of teeth. It is known that highly dispersed hydroxyapatite is added to toothpastes, which, according to manufacturers' recommendations, must be used for quite a long time, at least 5-6 months. The mechanism of obstruction of dentinal tubules is also implemented on the market of toothpastes that contain such finely abrasive substances as precipitates of poorly soluble salts. These are components such as strontium, tin, and fluoride salts. Their main task is to create a physical barrier on the surface of the exposed dentin of the tooth. It has been proven that calcium fluoride precipitates are deposited in dentinal tubules, and their diameter decreases. As a result of this,

there is a decrease in fluid flow in the dentinal tubules, a decrease in increased sensitivity in the form of a pain reaction to various types of stimuli.

A number of studies were conducted that made it possible to recommend INNOVA SENSITIVE toothpaste (SPLAT LLC, Russia) for use. It contains nano-hydroxyapatite, which promotes remineralization and reduces tooth sensitivity.

The effect of SENSODYNE toothpaste - Restoration and Protection (Great Britain), which contains the active components of sodium monophosphate and can reduce the increased sensitivity of teeth to the action of such irritants as tactile by 90-96% and temperature by 90-93%, has been studied. The results of clinical observations using the remineralizing varnish "Stomysens" led to the conclusion that it has a desensitizing and protective effect. There is information about the remineralizing effect of green tea on tooth enamel. Based on the research, scientists concluded that the greater the concentration of fluoride ions in green tea, the more effective its effect.

Thus, an analysis of the literature data indicates that information about the occurrence of dental hyperesthesia against the background of gum recession is quite ambiguous, and data on the treatment and prevention of hard tissue hyperesthesia after it are contradictory. Therefore, studying the effect of means of prevention and treatment of hypersensitivity of teeth in patients with gingival recession requires further study.

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牙齿再矿化凝胶“ASEPTA – Parodontal”对硬牙组织效果的临床评估  
**CLINICAL EVALUATION OF THE EFFECT OF DENTAL  
REMINERALIZING GEL FOR TEETH «ASEPTA - PARODONTAL»  
ON HARD DENTAL TISSUES**

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抽象的。对高等学校学生牙齿健康的研究具有针对性和及时性。学习地点因素对学生的一些牙齿健康指标起着显著的作用。根据宗旨和目标,研究和获取科学数据的基础是VSMU的学生队伍。N.N. Burdenko 患有牙龈炎以及代偿期和失代偿性龋齿。所有参与者的维生素 D 水平均不足。该研究使我们得出结论,对照组患者的龋齿过程强度有所增加。然而,该研究最显著的结果是在研究组中观察到的,我们对他们的患者应用了一项开发的计划来预防年轻患者的主要牙科疾病。

关键词: 龋齿强度、CFE 指数、再矿化凝胶“ASEPTA – PARODONTAL”。

**Abstract.** *The study of dental health of students of higher educational institutions is relevant and timely. The factor of the place of study plays a significant role on some dental health indicators of students. According to the purpose and objectives, the basis for studying and obtaining scientific data was the contingent of students of VSMU named after. N.N. Burdenko with the presence of gingivitis and compensated and decompensated caries. All participants had insufficient levels of vitamin D. The study allowed us to conclude that patients in the control group experienced an increase in the intensity of the carious process. However, the most significant results of the study were observed in the study group, to whose patients we applied a developed program for the prevention of major dental diseases in young patients.*

**Keywords:** *intensity of caries, CFE index, remineralizing gel “ASEPTA - PARODONTAL”.*

**Relevance.**

Today, according to numerous studies, dental pathology remains one of the leading in the world. It is known that the incidence of dental caries in the world population is about 95%. In Russia, according to various scientists, there is a deterioration in the “dental health” of the population, which leads to medical and economic damage to society. Unfortunately, the development of new dental technologies in dentistry has not led to a reduction in dental morbidity in Russia.

Research in recent years indicates the prevalence of major dental diseases, which reaches 94-100%. This is especially true for dental pathologies such as caries and periodontal disease, which is a medical problem and has social and economic significance. Currently, a high prevalence and intensity of dental diseases - caries and periodontal diseases - is observed among students. There is information that over the past 10 years, the incidence of caries has increased from 90% to 98%, and gingivitis has increased from 65% to 86%. Premature tooth loss was detected in 30% of those examined.

There is evidence that the upward trend in dental diseases appeared after the liquidation of a number of dental offices that previously operated in children’s institutions and schools, and a decrease in the availability of dental care for socially and economically disadvantaged groups of the population. One of the special social segments of the population, united by a certain age and educational conditions, are students of higher educational institutions. Adaptation to new social conditions, lifestyle, and climatic and geographical conditions causes active mobilization of the body’s reserves, especially in the first years of education. Therefore, the study of dental health of students of higher educational institutions is relevant and timely. The condition of the oral cavity is influenced by factors such as somatic pathologies (mainly diseases of the gastrointestinal tract) and tobacco smoking. In this category of students, carious lesions of hard dental tissues and periodontal tissues were more often found. One of the main reasons is poor oral hygiene among smoking students. In such students, soft dental plaque and supra- and subgingival hard dental plaque are most common.

One of the main factors influencing the development of the carious process is oral hygiene, the presence of anomalies of the dentofacial system and diseases of the body that affect the metabolic processes of hard dental tissues. The importance of understanding this problem among structural students is due to the fact that it is necessary to develop a comprehensive approach to the prevention of major dental diseases, which approach can provide the opportunity for a more accurate choice of treatment and preventive measures.

**Materials and research methods:**

From the total number of those surveyed, 80 students of VSMU named after N.N. Burdenko, of which 44 men (55%) and 36 women (45%) with concomitant dental diseases: chronic generalized catarrhal gingivitis of mild to moderate severity and an average level of caries intensity. These patients were diagnosed accord-

ing to ICD 10 - chronic gingivitis (K05.10 - simple marginal chronic gingivitis), according to ICD 10 - K 02 Dental caries.

All subjects underwent removal of supra- and subgingival dental plaque using an ultrasonic scaler, sanitation of the oral cavity and replacement of defective fillings. Patients were recommended to use a manual toothbrush with medium-hard bristles and hygienic toothpaste. All patients were diagnosed with vitamin D deficiency.

The examined patients were divided into 4 groups:

Group 1 was the control group, which included 20 people. After preventive hygiene and sanitation of the oral cavity, patients began to use a new medium-hard toothbrush and preventive toothpaste “ASEPTA PARODONTAL BIOCOMPLEX”;

Group 2 consisted of 20 patients who were offered a new medium-hard toothbrush and preventive toothpaste “ASEPTA PARODONTAL BIOCOMPLEX”; patients were prescribed remineralizing gel “ASEPTA PARODONTAL” for 14 days, 2 times a day; The gel was distributed over the entire surface of the teeth and gums using a toothbrush, the gel was left for 1-2 minutes, after application it was not recommended to consume food or drinks for 30 minutes.

Group 3 was represented by 20 patients who used a new medium-hard toothbrush and ASEPTA PARODONTAL BIOCOMPLEX prophylactic toothpaste; At the same time, the remineralizing gel for teeth “ASEPTA - PARODONTAL” was used in an individually made mouth guard for 14 days, 2 times a day. A small amount of gel was added to the mouth guard, distributing the product evenly, after which it was fixed in the oral cavity for 30 minutes. After completion of the application, the tray was removed and excess product was removed from the surface of the teeth and gums. Patients were not advised to rinse their mouth or eat or drink for 30 minutes.

Group 4 – 20 people who used a new medium-hard toothbrush and preventive toothpaste “ASEPTA PARODONTAL - BIOCOMPLEX”; At the same time, the remineralizing gel for teeth “ASEPTA - PARODONTAL” was used in an individually made mouth guard for 14 days, 2 times a day. A small amount of gel was applied to the mouth guard, distributing the product evenly, after which it was fixed in the oral cavity for 30 minutes. After completion of the application, the tray was removed and excess product was removed from the surface of the teeth and gums. Patients were not advised to rinse their mouth or eat or drink for 30 minutes. All participants in this group took the vitamin-mineral complex “Complivit” 1 tablet per day after meals for 4 weeks and the drug “Complivit Aqua D3”, which was prescribed by an endocrinologist in a dosage of 7000 IU (14 drops - 1 drop contains about 500 IU of vitamin D3) daily orally once a day for 8 weeks. Further, in the next 4 months before re-screening, it was recommended to take the drug at a dosage of 2000 IU daily orally once a day.



For each patient, upon examination, the intensity of the carious process was determined, which is expressed by the index of the tooth decay index before and 6 months after the treatment and preventive measures.

**Results and discussion of own research**

The presence of carious cavities and fillings is the most important factor that indicates the relationship between the level of resistance and susceptibility to the carious process. The presence of a high intensity of the carious process shows the high susceptibility of the patient to the disease of the hard tissues of the teeth, and also indicates ineffective individual prevention. In our work, the determination of the CFE index was carried out before and 6 months after the treatment and preventive measures in order to identify the activity of the carious process in the groups of students examined (Table 1, 2, 3, 4, 5, 6).

**Table 1**  
*Comparative assessment of data from group 1 before and after treatment, Me (lq; uq)*

<b>Index</b>	<b>Before treatment</b>	<b>After treatment</b>
C	4 (3; 4)	2 (2; 2)*
F	3 (3; 4)	6 (6; 7)*
E	1 (0; 1)	1 (1; 2)*
CFE	7,5 (7; 8)	9,5 (9; 10)*

Note: \*- differences are statistically significant when  $p < 0,05$

**Table 2**  
*Comparative assessment of data from group 2 before and after treatment, Me (lq; uq),*

<b>Index</b>	<b>Before treatment</b>	<b>After treatment</b>
C	4 (3; 4)	2 (1; 2)*
F	3 (2; 3)	6 (6; 6,5)*
E	1 (1; 1)	1,5 (1; 2)*
CFE	7 (7; 8)	10 (9; 10)*

Note: \*- differences are statistically significant when  $p < 0,05$

**Table 3**  
*Comparative assessment of data from group 3 before and after treatment, Me (lq; uq),*

<b>Index</b>	<b>Before treatment</b>	<b>After treatment</b>
C	4 (3; 4)	1 (0; 1)*
F	3 (2; 3)	6 (5,5; 6)*

E	1 (0,5; 1)	1,5 (1; 2)*
CFE	7 (7; 8)	8 (8; 9)*

Note: \*- differences are statistically significant when  $p < 0,05$

**Table 4**  
Comparative assessment of data from group 4 before and after treatment, Me (lq; uq),

Index	Before treatment	After treatment
C	3,5 (3; 4)	0 (0; 1)*
F	3 (3; 4)	6,5 (6; 7)*
E	1 (0; 1)	1 (1; 2)*
CFE	7,5 (7; 8)	8 (7; 8)*

Note: \*- differences are statistically significant when  $p < 0,05$

**Table 5**  
Comparative assessment of data from groups 1, 2, 3, 4 before treatment, Me (lq; uq)\*

Index	1 group	2 group	3 group	4 group
C	4 (3; 4)	4 (3; 4)	4 (3; 4)	3,5 (3; 4)
F	3 (3; 4)	3 (2; 3)	3 (2; 3)	3 (3; 4)
E	1 (0; 1)	1 (1; 1)	1 (0,5; 1)	1 (0; 1)
CFE	7,5 (7; 8)	7 (7; 8)	7 (7; 8)	7,5 (7; 8)

Примечание: \*- до лечения различий между группами нет при  $p > 0,008$

**Table 6**  
Comparative assessment of data from groups 1, 2, 3, 4 before treatment, Me (lq; uq)\*

Index	1 group	2 group	3 group	4 group
C	2 (2; 2)	2 (1; 2)**	1 (0; 1)+ °	0 (0; 1)*#
F	6 (6; 7)	6 (6; 6,5)	6 (5,5; 6)°	6,5 (6; 7)#
E	1 (1; 2)	1,5 (1; 2)	1,5 (1; 2)°	1 (1; 2)*#
CFE	9,5 (9; 10)	10 (9; 10)**	8 (8; 9)+°	8 (7; 8)*#

Note: there are no statistically significant differences between groups 1 and 2,  $p > 0.008$

+ - between groups 1 and 3 the differences are statistically significant for C, CFE at  $p < 0.008$

\* - between groups 1 and 4, the differences are statistically significant for C, CFE at  $p < 0.008$

\*\* - between groups 2 and 3 the differences are statistically significant for C, CFE at  $p < 0.008$

# - between groups 2 and 4, the differences are statistically significant for C, CFE at  $p < 0.008$

° between groups 3 and 4 the differences are statistically significant at  $p < 0.008$

Thus, the study allowed us to conclude that in patients of groups 1 and 2 there was an increase in the intensity of the carious process. However, the most significant results of the study were observed in group 4 of the study, for whose patients we used a developed program for the prevention of major dental diseases in young patients.

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乌赫托姆斯基院士主导机制的催眠和暗示在治疗和康复中的安慰剂效应  
**HYPNOSIS AND SUGGESTION IN THE DOMINANT  
MECHANISMS OF ACADEMICIAN UKHTOMSKY WITH  
PLACEBO EFFECT IN TREATMENT AND REHABILITATION**

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抽象的。 安慰剂的医学用途不断受到争议，因为它们被认为是一种惰性物质，没有特定的作用机制，当安慰剂效应发生时，人们认为这是一种虚幻的知觉，这很大程度上归因于暗示。 但最近的研究证明，安慰剂的使用确实有效，因为其神经生理学基础逐渐为人所知。 在我们的研究中，我们将安慰剂的机制呈现为一种复杂的暗示机制，条件反射的形成，催眠与乌赫托姆斯基主导的主动形成，作为大脑神经元的整体结构，旨在实现任何生物形态。 在我们的工作中，我们已经证明安慰剂效应的生理机制是通过激活身体的各个功能系统，形成对重复服用安慰剂的条件反射反应的治疗动态刻板印象来实现的。 基于对安慰剂效果的大量数据的分析和我们的研究，我们提出了这样的假设：安慰剂是一种虚拟药物，其中呈现出各种恢复程序和机制，直至生物活性物质的产生和基因组激活，这是由中枢神经系统在恢复过程中形成的主导。

关键词：安慰剂、暗示、催眠、药物效应、乌赫托姆斯基主导。

**Abstract.** *The medical use of placebos is constantly debated because they are considered to be an inert substance with no specific mechanism of action, and when the placebo effect occurs, it is believed to be an illusory perception, which*

*is largely attributable to suggestion. But recent research has proven that the use of placebos really works, as its neurophysiological basis is becoming known. In our study, we present the mechanisms of placebo as a complex mechanism of suggestion, the formation of a conditioned reflex, hypnosis with the active formation of the Ukhtomsky dominant, as an integral structure of brain neurons, aimed at achieving any biological modality. In our work, we have shown that the physiological mechanism of the placebo effect is achieved through the activation of various functional systems of the body, the formation of a therapeutic dynamic stereotype of a conditioned reflex response to repeated administration of placebo. Based on the analysis of numerous data obtained on the effect of placebo and our research, we propose the hypothesis that placebo is a virtual medicine in which various programs and mechanisms of recovery are presented, up to the production of biologically active substances and genome activation, which is created by the central nervous system during the formation of the recovery dominant .*

**Keywords:** placebo, suggestion, hypnosis, drug effect, Ukhtomsky dominant.

**Relevance.** The medical use of a placebo is constantly debated because it is considered an inert substance that has no effect, and when a placebo effect occurs, it is considered to be an illusory perception. Placebos have always been questioned as to whether they are ethically acceptable for clinical use outside of medical research [15, 43].

There are authors [21] who do not recommend the use of placebo in clinical practice because it does not provide any clear benefit and is weak and inconsistent (eg, in the case of pain and nausea), as reported in a review [28]. Others [16] advocate its use in clinical practice because its action is based on neurobiological mechanisms demonstrated by functional neuroimaging studies, and its use may improve therapeutic outcomes and minimize unintended exacerbation of symptoms in clinical practice. Due to mistrust of the prescription of an inert substance, placebo is not well accepted by doctors and nurses [22, 39, 43]. A study conducted with medical and nursing students found that more than 80% of participants were either unaware of it or considered it unethical to use it on patients [15]. However, the reality is that placebo also includes substances with and without pharmacological activity, the so-called impure placebo, which is often prescribed in the clinic [27].

Placebos are gaining new interest in medicine due to their effects on various diseases and their involvement in clinical trials. The term “placebo” comes from the Latin placere, which means “to please.” Its use in clinical practice is common as it is estimated that approximately 40% of prescriptions act as placebo, sometimes the physician is aware of this and sometimes not [6, 8, 18, 47]. Much of contemporary research in physical and rehabilitation medicine is based on applied

research, which by definition is research that uses existing knowledge to achieve specific goals; they are designed to solve a specific problem affecting a specific person or group of patients. Rehabilitation in most cases involves very heterogeneous inter- and intra-individual approaches, which contradicts the homogeneity and standardization of interventions required in research protocols. Additionally, compared to strict research protocols where the goal is to control the patient's environment, the ultimate goal of placebo studies is to improve the effectiveness of an intervention in a real-world setting [35]. Telerehabilitation has been shown to be a promising alternative to in-person rehabilitation during the pandemic [29, 33]. It is now known that not all placebo interventions may have an effect. There is evidence that counterfeit devices and procedures “enhance” the placebo effect compared to placebo pills [31].

On the one hand, the placebo response consists of any beneficial changes in health status that occur before and after the administration or use of a placebo. While the placebo effect refers to those specific beneficial changes in health that are observed after the administration or use of a placebo, which are attributed solely to placebo mechanisms, such as expectancy, conditioning, observational learning [8]. A study using a questionnaire found that 77% of physicians surveyed prescribed placebo at least once a week, with impure placebos accounting for more than 90% [41]. On average, 63% of physicians use it, with most of them also using impure placebos [27]. Results obtained over the past two decades have shown that placebo, as an inactive substance, induces a number of neurohormonal responses in the brains of patients and healthy subjects, which may be the anatomical and physiological basis of its effects.

Some authors consider placebos a useful tool for neuroscience research because neuroscientists use the placebo response as a model for understanding how our brains work, and indeed, it is emerging as an excellent approach for understanding several higher brain functions such as expectancy and reward [16]. A placebo may enhance or decrease the effect of pharmacotherapy or other treatments [30]. There are many factors influencing the occurrence of the placebo effect that they can be divided into three groups. The first group relates to the placebo itself, such as its appearance, size, color, taste and composition [36]. Part of the placebo effect is the well-known “halo effect” [13, 14], which occurs due to positive or negative advertising. The second group depends on the patient [1]. It appears that an optimistic subject may have a personality profile prone to the placebo effect compared to a pessimistic subject [44]. Pre-administration of opioid analgesics promotes analgesia in patients who are subsequently given placebo. Thus, in an experiment in which, after repeated administration of morphine in the preparation phase before a competition, its replacement with placebo on the day of competition caused an opioid-mediated increase in pain tolerance and an increase

in physical performance, although no analgesic drug was administered [20]. It has been established and maintained for many years that the placebo effect is a learning phenomenon in which many factors are involved [20, 21, 22]. The third group depends on the relationship between the doctor and the patient, is enhanced by special tests such as an ECG or x-ray, and is strengthened by the doctor's explanation of a reasonable prescription, which facilitates adherence to treatment and increases patient confidence. Here, it is also very important for the doctor to verbally suggest the benefits of treatment [1].

An empathic interview between a doctor and a patient triggers a number of complex psychoneuroendocrine mechanisms in the brain, developed during human evolution and associated with trust, pleasure and positive expectations [1, 6]. The prevalence of the placebo effect for pain ranges from 39% to 56%, estimating that intravenous administration of 1 ml of saline is equivalent to the analgesia obtained with 6–8 mg of intravenous morphine [16]. Preconditioning with opioids enhances placebo analgesia. The use of naloxone, an opioid mu-receptor antagonist, abolishes the placebo analgesic effect, implicating endorphins in this response. These results have been observed in both humans and experimental animals using various pain models [16, 21, 32].

In addition to the prefrontal cortex, limbic system and hippocampus, brainstem nuclei that modulate nociception, the ventromedial nucleus and periaqueductal gray matter are involved in placebo analgesia [19]. The above findings from preconditioning studies indicate that the endorphin and endocannabinoid systems are important neurotransmitter systems in placebo pain relief. It has been suggested that 50% of the response to antidepressants is likely due to the placebo effect itself [34].

For insomnia, a common condition in the European population for which benzodiazepine and non-benzodiazepine sleeping pills [Z-drugs] are prescribed with a high risk of serious adverse reactions, the placebo effect is powerful. Several studies, including a meta-analysis [23] and a clinical practice guideline for insomnia [24], note that 50% of the hypnotic effect produced by Z-drugs [zopiclone, zolpidem and zaleplon] was due to placebo response. Other medical conditions sensitive to the placebo effect in cardiology, such as angina pectoris, paroxysmal atrial fibrillation, and dyspnea due to congestive heart failure, are placebo sensitive [45]. The placebo effect can occur in hypertension, although it is mild and transient and is associated with improvement in stressful situations [38]. The placebo effect has also been observed in blood glucose levels, immune response [40], and in the treatment of pharmaceutical and drug addiction [26, 30]. Regarding sports medicine, the use of placebo during training improves the functional performance of athletes [5].

**Purpose of the study:** analysis and study of the mechanisms of manifestation of placebo effects, as a complex mechanism of suggestion, the formation of a conditioned reflex, hypnosis with the active formation of the Ukhtomsky dominant, as an integral structure of brain neurons, aimed at achieving some ultimately useful result.

Material and research methods. As a basis for analyzing the effect of placebo, we used the teachings of the great Russian physiologist Academician A.A. Ukhtomsky [1875-1942].

He went down in the history of physiology and psychology as the author of the doctrine of dominance, a fundamental aspect of human behavior [9, 10].

Let us list the main properties of the dominant focus established by A.A. Ukhtomsky: increased excitability, inertia in time, the ability to summarize external stimuli, the external expression of the dominant is stationary supported work or the working posture of the body.

This work was written by us, firstly, on the basis of a generalization of the literature on the effects of placebo and the works of the outstanding Russian physiologist Academician A.A. Ukhtomsky about the dominant. Secondly, based on the results of numerous own placebo studies in clinical practice and sports. A dominant is a huge mobile association of nerve cells, the final activity of which is aimed at achieving some physiological modality (some goal, for example, an unconditioned food reflex). When a goal is achieved, the dominant disappears and makes room for a new dominant, resulting in the release of highly targeted, concentrated nervous energy for the body to achieve various other goals. The main property of the dominant is the capture of motor pathways to the muscles into its subordination, which is easily explained by the need to move to exercise the dominant. In many cases, it is by motor activity that we can determine whether there is a dominant and which one, or whether it is not there.

In this post, we share only two studies that have been conducted. First. From the standpoint of chronobiology, we studied resistance to hypoxia [at 8, 12, 16 and 20 hours of the day and week] in 24 girls  $18.46 \pm 0.93$  years old, who are students at the Institute of Physical Culture of Tyumen State University. For this purpose, we used standard tests of Stange and Gench. In the morning, all girls were given a verbal 10-minute hypnotic suggestion about the possibility of increasing their resistance to hypoxia against the background of the tape-recorded musical accompaniment “Turkish Rondo”. The second study concerns the placebo effect of using ascorbic acid tablets at a dose of 50 mg in adolescent students when studying the duration of hanging on a bar with a two-hand grip.

When conducting a study of the influence of the dominant on students, we analyzed the following thought of the outstanding domestic teacher K.D. Ushinsky: “Really, when embarking on such a responsible task, shouldn’t you first make



sure that your method of education or teaching is better than all those used in other places and by other teachers...” [11].

Mathematical processing of the research results was carried out using statistical analysis methods. Differences were assessed using Student’s t-test and considered significant at  $p < 0.05$ .

The studies complied with the ethical standards of the biomedical ethics committees, developed in accordance with the Declaration of Helsinki adopted by the WMA, as well as Order of the Ministry of Health of the Russian Federation No. 226 of June 19, 2003 “Rules of clinical practice in the Russian Federation.” The principles of voluntariness, individual rights and freedoms guaranteed by Articles 21.2 and 22.1 of the Constitution of the Russian Federation are observed. The study was carried out with the verbal consent of each student.

**Research results and discussion.**

The positive effect of the dominant suggestion of Ukhomtovsky was expressed in the fact that all girls showed a significant [ $p < 0.05$ ] increase in resistance to hypoxia, especially at 16:00, which was practically maintained throughout the week [Table. 1 and 2].

**Table 1**

*Chronobiological indicators of resistance to hypoxia according to the Stange test among female students of the Institute of Physical Culture of Tyumen State University in a state of physiological rest [I] and after a combined positive suggestion and music [II] during the day and week [ $M \pm m$ ]*

Day of the week	Examination time			
	At 8 o'clock	At 12 o'clock	At 16 o'clock	At 20 o'clock
Monday	I. 44,17±1,09 II. 48,83±1,12	I. 45,63±1,11 II. 48,97±1,16	I. 53,48±1,12 II. 58,19±1,14	I. 44,36±1,10 II. 48,65±1,13
Wednesday	I. 45,21±1,11 II. 49,54±1,13	I. 45,84±1,10 II. 50,37±1,14	I. 52,96±1,13 II. 59,42±1,16	I. 45,42±1,12 II. 49,06±1,14
Friday	I. 45,32±1,13 II. 48,76±1,14	I. 46,09±1,15 II. 49,23±1,16	I. 53,12±1,14 II. 58,14±1,17	I. 44,94±1,12 II. 48,87±1,16
Average values	I. 44,90±1,12 II. 49,04±1,15	I. 45,85±1,16 II. 49,52±1,18	I. 53,18±1,17 II. 58,58±1,21	I. 44,91±1,18 II. 48,86±1,19

Thus, after the girls were given a positive suggestion about the possibility of increasing the duration of their voluntary breath holding during inhalation in combination with the use of the musical accompaniment “Turkish Rondo”, the Stange test indicator significantly [ $p < 0.05$ ] increased.

**Table 2**

*Chronobiological indicators of resistance to hypoxia according to the Gench test among female students of the Institute of Physical Culture of Tyumen State University in a state of physiological rest [I] and after a combined positive suggestion and music [II] during the day and week [M±m]*

Day of the week	Examination time			
	At 8 o'clock	At 8 o'clock	At 8 o'clock	At 8 o'clock
Monday	I. 36,12±1,09	I. 37,09±1,11	I. 41,26±1,12	I. 36,84±1,10
	II. 39,68±1,12	II. 40,26±1,16	II. 45,99±1,14	II. 40,15±1,13
Wednesday	I. 36,88±1,11	I. 38,53±1,10	I. 42,18±1,13	I. 37,06±1,12
	II. 40,22±1,13	II. 41,07±1,14	II. 46,29±1,16	II. 39,73±1,14
Friday	I. 37,08±1,13	I. 37,64±1,15	I. 42,23±1,14	I. 37,52±1,12
	II. 40,74±1,14	II. 41,33±1,16	II. 46,81±1,17	II. 40,69±1,16
Average values	I. 36,69±1,12	I. 37,75±1,14	I. 41,89±1,17	I. 37,14±1,14
	II. 40,21±1,15	II. 40,88±1,16	II. 46,36±1,16	II. 40,18±1,15

Thanks to the joint positive impact of the word as a dominant according to A.A. Ukhtomsky, against the background of music, we programmed the brain, and, firstly, we received an increase in the functional capabilities of the respiratory system in the form of increased resistance to hypoxia. Secondly, we noticed that the combined effect of the dominant is more stable over time, as evidenced by the stable chronobiological results of the Stange and Gench tests throughout the week of examination. Thirdly, in this way, we believe that the girls will, to a large extent, forever retain in their memory pleasant information about the method of assessing the function of external respiration that they carried out on their own body. In other words, thanks to the placebo effect, the students increased their theoretical knowledge and gained practical skills by working with the book, on the one hand, and conducting functional research, on the other. In this regard, we should remember our great writer L.N. Tolstoy, who explained that “Education in practice and in books cannot be forced and should bring pleasure to students” [cit. according to 5].

The second study concerns the duration of volitional effort while hanging on a bar with a two-hand grip. It should be noted that in the literature available to us, we not only did not find studies that shed light on the duration of the hang on the bar, but also the influence of verbal positive suggestion about the possibility of increasing the duration of the hang. On a voluntary basis, we conducted a questionnaire “Willpower” with 27 girls and 34 boys from the Institute of Physical Culture, in which one of the questions was about the willpower of the duration of the hang. The results of the questionnaire indicated that the duration of the volitional effort of hanging on the bar for boys was  $44.8 \pm 3.6$  seconds, for girls -  $31.3 \pm 5.1$  seconds. After verbal suggestion, the duration of volitional effort increased by 7.4% and 6.1%, respectively ( $p < 0.05$ ).

The results of our research confirm those formulated by Academician A.A. Ukhtomsky's main features of the dominant focus are increased excitability, persistence of excitation, the ability to sum up excitation - to retain and continue excitation once it has begun, and even when the initial stimulus is no longer effective. In this regard, it seems appropriate to us to quote the thought of K.D. Ushinsky that "... a person ascends from more visible causes to deeper causes, or, what is the same, approaches more and more to the essence of the subject" [12].

Conclusion. Our studies of the placebo effect are important not only in the theory and practice of physical culture, but also in the clinic. A review of the literature suggests that other researchers [16, 21] advocate the use of placebo in clinical practice because its action is based on neurobiological mechanisms demonstrated by functional neuroimaging studies. In addition, the use of placebo effects may improve therapeutic outcomes and minimize unintended exacerbation of symptoms in clinical practice. An analysis of the placebo effect showed that it should be analyzed from the point of view of suggestion, hypnosis, self-hypnosis, neurotransmitter mechanisms of the brain, the theory of dominance, the work of mirror neurons of the brain, as well as the theory of cognitome of Academician K.V. Anokhin [2] and the theory of functional systems by academician P.K. Anokhin [3].

We believe that the mechanisms of placebo are most likely explained by the teaching of Academician of the Russian Academy of Sciences Konstantin Vladimirovich Anokhin about the cognitome, who is the author of the hypernetwork theory of the brain.



In his opinion, the neural hypernetwork contains everything that makes us up: all the atoms of our "I", our personality, our ideas and knowledge, our memories, organized into a network of neurons. According to Academician K.V. Anokhin, each of its elements is encoded in the brain by a distributed network of neurons.

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地球和太空中氙气镇痛的各个方面  
ASPECTS OF XENON ANALGESIA ON EARTH AND IN SPACE

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抽象的。这项工作的目的是研究和评估将氙氧混合物引入地球和太空多模式疼痛缓解方案的潜力。研究手术患者术后氙气麻醉时的疼痛阈值和耐受水平。已经开发出设备并测试了一种使用便携式设备（气体混合物吸入器）短期暴露吸入高浓度氙氧混合物的技术。在研究疼痛敏感性时，研究了疼痛阈值的动态和对施加测试刺激的疼痛耐受水平，以及吸入前后氙镇痛的评估。在吸入的影响下，疼痛阈值显著升高，尽管停止吸入，但疼痛耐受水平不断提高。因此，获得的结果表明，吸入氙浓度60%的氙-氧混合物并暴露3分钟具有镇痛作用并增加疼痛耐受性水平。密闭空间和失重条件下基于氙的镇痛方法的发展得到证实。

关键词：氙气，吸入麻醉药，术后疼痛，空间。

**Abstract.** *The purpose of the work is to study and evaluate the potential for introducing a xenon-oxygen mixture into multimodal pain relief schemes on Earth and in Space. The pain threshold and level of endurance during xenon anesthesia in surgical patients in the postoperative period were studied. Equipment has been developed and a technique has been tested for inhalation of a high-concentration xenon-oxygen mixture using portable equipment (inhaler of gas mixtures) with short-term exposure. When studying pain sensitivity, the dynamics of the pain threshold and the level of pain tolerance to applied testing stimuli were investigated, as well as the subjective assessment of xenon analgesia before and after inhalation. The pain threshold significantly increased under the influence of inhalation, and the level of pain tolerance constantly increased, despite the cessation of inhalation. Thus, the results obtained indicate that inhalation of a xenon-oxygen mixture at a xenon concentration of 60% and an exposure of 3 minutes has an analgesic*



*effect and increases the level of pain tolerance. The development of xenon-based analgesia methods in confined spaces and weightlessness is substantiated.*

**Keywords:** *xenon, inhalational anesthetics, postoperative pain, space.*

Xenon is an inert gas that does not enter into biochemical reactions in the human body and does not form compounds. At the same time, the interaction of xenon with water molecules with the formation of clathrate compounds, which can have a significant effect on the functional state of the body, has been described [1]. It has been established that xenon has an inhibitory effect on ionotropic glutamate receptors that selectively bind N-methyl-D-aspartate (NMDA), and has a weak effect on receptors that bind  $\gamma$ -aminobutyric acid (GABA). Xenon inhibits NMDA receptors by competitively interacting with the site that binds the NMDA receptor coagonist, glycine. Inhibition of NMDA receptors by binding of xenon to them determines the analgesic, narcotic and neuroprotective properties of this gas [2,3]. According to the data presented in the literature, xenon, without entering into chemical reactions, temporarily and reversibly changes the functions of neurons in the transmission of nociceptive and non-nociceptive stimuli. Clinical studies have shown that even in low concentrations xenon affects synaptic transmission, presumably in the area of the substantia gelatinosa and the 2nd plate of Rexed of the dorsal horns of the spinal cord [1]. With longer exposure, the effect of xenon on thalamic and hypothalamic structures is noted. Xenon is used as an inhalational anesthetic during various surgical procedures [4]. Mask xenon-oxygen inhalations are used for analgesia for pain caused by various factors [5], including during short-term surgical procedures (venesection, hernia repair, dressing of burn patients, etc.). Inhalations are carried out while maintaining spontaneous breathing with a xenon concentration of 20 to 50%. At the same time, in the literature there are only a few studies devoted to assessing the level of pain when using xenon for pain relief in the postoperative period [6]. Adequate pain control is essential to protect against the severe effects of catecholamine stress. This goal can be achieved by multimodal postoperative analgesia, including systemic opioid, non-opioid and epidural analgesia [7]. In anesthesiology, at the end of the last century, a new principle was developed, the so-called method of preemptive analgesia. According to this method, painkillers should be used until the possible development of pain, and not administer analgesics “afterwards”. The need to improve methods of general anesthesia is also due to the fact that the contingent of surgical patients, usually characterized by the presence of a large number of concomitant diseases, requires improved provision of appropriate correction of the condition both in the pre- and postoperative periods, not to mention the moment of the operation itself. Against the background of the steady development of surgical capabilities, the observed expansion of the range of surgical interventions performed (in the total

volume of operations, most are long-term and/or traumatic, and among patients the number of elderly and senile people is increasing), the requirements for anesthesiology, as a specialty called upon, are correspondingly increasing. to ensure reliable protection of the patient from operational distress and anesthesiology, as a science that develops qualitatively new methods of anesthesia and analgesia.

In the last century, the problem of “medicine and space” was developed long before the first flights. However, the medical aspects of a short-term stay in space from a day, and several months to a year, of practically healthy and specially trained people differ significantly from the aspects of longer expeditions and interplanetary flights. In the USSR in the last century, when simulating the flight of the first expedition to Mars for more than 300 days, gradually, after the first hundred days, all three specially selected and absolutely healthy participants in the project developed a number of serious psychological problems, which they managed to survive, due, obviously, to the short-term nature of the “flight” . Interplanetary flights, which require significantly more time, require a more detailed study of issues and solutions to various psychological problems, adaptation, and compatibility. Of course, it will be necessary to develop methods for correcting psychosomatic disorders and emotional burnout syndrome (demoralization, disappointment, rehabilitation after the development of symptoms of extreme fatigue). Undoubtedly, in some situations there will be a need to perform outpatient or inpatient surgical interventions under general anesthesia, even for absolutely healthy and well-trained members of interplanetary expeditions. The implementation of a number of more complex, long-term projects is possible only if “hypobiosis”, “artificial hibernation”, “artificial hypothermia” is provided - that is, in conditions that fall within the competence of the specialty - anesthesiology-resuscitation. While in outer space, crew members of the International Space Station, as well as other manned space missions, may require medical attention. And we can talk about problems more serious than the flu or a sore throat. There may be times when astronauts require immediate surgery. There remains a high risk of injury when exiting and entering the orbital station, and overloads on the entire musculoskeletal system of the body during takeoff and landing. On June 26, 2015, the first zero-gravity surgery was performed aboard a Canadian research aircraft that simulated near-zero gravity conditions. For the experiment, a laparotomy operation was chosen to stop internal bleeding due to mechanical trauma.

An open, comparative, randomized, blind, placebo-controlled study was performed, which included 60 cancer patients with abdominal malignancies aged 45 to 75 years.

Xenon-oxygen inhalations were carried out using a developed reversible breathing circuit and a portable canister with a needle valve for supplying the mixture. The xenon content in the inhaled mixture was  $60\pm 5\%$ , oxygen - 30%. The

total xenon consumption for the procedure did not exceed 3 liters. Oxygen was supplied to the breathing circuit in the amount necessary to ensure sufficient tidal volume for the patient. The duration of inhalation was 3 minutes. In the comparison group (placebo), patients received inhalation of a mixture of 50% oxygen and 50% air. Treatment began on days 2–3 after surgery after transfer from the ICU (department of anesthesiology and intensive care) to a specialized surgical department before the next administration of an anesthetic drug. All patients received standard pain relief in the postoperative period: epidural analgesia, nonsteroidal anti-inflammatory drugs, and tramadol as required. The level of pain was determined using the numerical rating scale (NRS) according to the generally accepted method. The level of pain according to the NRS was assessed as follows: 0 - no pain, from 10 to 30% - minor pain, from 40 to 60% - moderate pain, from 70 to 90% - severe pain and 90 - 100% - unbearable pain. A reduction in pain intensity by 10–20% was regarded as a minimal analgesic effect, and by 30% a moderate effect. In addition, the pain threshold was determined using transcutaneous electrical neurostimulation. For this purpose, a transcutaneous electrical neurostimulator (TENS-2 m) was used, gradually increasing the intensity of the effect, which was measured in arbitrary units from 0 to 10 according to the calibration of the device scale. The minimum value at which the subject began to feel the effects of the electrical neurostimulator was recorded. Before surgery, most patients had no pain. On days 2–3 after surgery, after transferring patients from the ICU, the level of pain was assessed before the next administration of an anesthetic drug. In both groups, the level of pain was moderate - 42.5 (40; 67.5)% and 40 (30; 60)%, respectively, and did not differ significantly between groups 1 and 2. After sessions of inhalation of a xenon-oxygen mixture, there was a significant decrease in the level of pain to an insignificant level according to the NRS data (Table 1).

**Table 1.**  
*Changes in the level of pain intensity according to NRS data*

Measuring point	Xenon group n=30			Placebo group n=30		
	NRS,%	P compared to original	P compared to before inhalation	NRS,%	P compared to preoperative data	P compared to data before inhalation
before surgery	0 (0; 10)	-	0,0001	0 (0; 10)	-	0,000008
before inhalation	42,5 (40; 67,5)	0,0001	-	40(30; 60)	0,000008	-
after inhalation	20 (10; 30)	0,0000016	0,000004	30 (20; 42,5)	0,00005	0,002
in 30 minutes	27,5 (10; 30)	0,0010	0,000006	30(20; 46,25)	0,00027	0,005

Note: comparisons were made in each group with baseline indicators before surgery and with indicators before the start of inhalation of xenon-oxygen or oxy-

gen-air mixture. Data are presented as medians with 25% and 75% quartiles. The Wilcoxon test was used to assess significance.

At the same time, it should be noted that a significant decrease in pain levels was also found in the placebo group. It is known that placebo effects can account for up to 30% of the effects of therapy, affecting the psycho-emotional component of pain. In order to conduct a comparative assessment of the effectiveness of interventions in groups 1 and 2, we divided patients according to the degree of pain reduction. Moderate and significant analgesic effects after xenon inhalation were observed in 92.85% of patients in the main group and in only 39.3% of the comparison group. Moreover, in 75% (3/4) of patients receiving xenon-oxygen inhalations, there was a reduction in pain levels by 50% or more. In the comparison group, a significant reduction in pain was observed only in 21.4% of cases. In both groups, after 30 minutes there was some weakening of the analgesic effect caused by the procedure, however, in the xenon therapy group, a moderate to significant reduction in pain levels was observed in 82.1%, and in the comparison group - in only 28.6% of patients. Thus, the analgesic effect of xenon was significantly different from the placebo effect.

When analyzing the results of electrical neurostimulation in the xenon group, there were no significant differences in the initial data before surgery and the parameters after surgery. At the same time, there was a significant increase in the pain sensitivity threshold immediately after xenon-oxygen inhalation, which increased even more 30 minutes after the session (Table 2).

**Table 2.**  
*Changes in the pain threshold according to the results of transcutaneous electrical neurostimulation*

Measuring point	Xenon group			Placebo group		
	TENS, conventional units	P compared to original	P compared to before inhalation	TENS, conventional units	P compared to data before surgery	P compared to data before inhalation
before surgery	4 (4; 4,5)	-	0,067	4 (4; 4,5)	-	0,456
before inhalation	4,25 (4; 4,5)	0,067	-	4 (4; 5)	0,456	-
after inhalation	4,5 (4; 4,5)	0,000007	0,00091	4 (4; 5)	0,754	0,726
in 30 minutes	5 (4; 6)	0,000469	0,0051	4 (4; 5)	0,878	0,382

Note: comparisons were made in each group with baseline indicators before surgery and with indicators before the start of inhalation of xenon-oxygen or oxygen-air mixture. Data are presented as medians with 25% and 75% quartiles. The Wilcoxon test was used to assess significance.

In the comparison group, there were no significant changes in the pain sensitivity threshold either compared to the initial values or to the indicators before the

start of inhalation of the oxygen-air mixture, i.e. no placebo effect was observed. Thus, it was xenon that caused an increase in the pain threshold in patients in the early postoperative period, which is further evidence of its analgesic effect.

The study demonstrated the presence of an analgesic effect of inhalation of xenon-oxygen mixture. A clinically significant decrease in the level of pain according to NOS was found immediately after inhalation of the xenon-oxygen mixture and after 30 minutes in 92.8% ( $p \leq 0.01$ ) and 82.1% ( $p \leq 0.05$ ) of patients, respectively. In the comparison group, in which patients underwent oxygen-air inhalation, a moderate and significant decrease in the intensity of pain was observed only in 39.3% of patients immediately after the procedure and in 28.6% 30 minutes after oxygen inhalation. According to transcutaneous electrical neurostimulation, a significant increase in the pain threshold was noted immediately after inhalation of the xenon-oxygen mixture and after 30 minutes  $p \leq 0.01$ ,  $p \leq 0.05$ . In the comparison group, no significant changes in the pain sensitivity threshold were detected. Thus, inhalation of a xenon-oxygen mixture helps reduce the intensity of postoperative pain and increases the pain threshold in cancer patients with abdominal tumors. In this regard, it can be assumed that the use of xenon in the complex therapy of pain syndrome will improve treatment results and reduce the need for the use of medicinal methods of pain relief. To determine the place of xenon therapy in multimodal anesthesia for cancer patients at the surgical stage of treatment, additional research is necessary.

Today, the impact and polyvalence of aggressive environmental factors are so great that a person needs exogenous help in maintaining the constancy and balance of the internal environment of the body. These methods can be studied within the framework of endoecology, which are aimed at stimulating the body's natural defense reactions, both at the systemic and at the molecular-cellular level. Current problems of endoecology include not only issues of protecting the body in natural conditions, but also the possibility of human adaptation in outer space. It should be especially noted that theoretical ideas about the duration of the existence of our planet are quite contradictory, from several billion years to more modest periods. For example, the famous English astrophysicist S. Hawking believed that these periods are significantly shorter due to the influence of many possible factors: nuclear war on our planet, the influence of genetically modified viruses or other aggressors about which humanity has no idea yet and which could at any moment lead to a planetary catastrophe. In connection with the above, in his opinion, the development of astronautics is of decisive importance for the future of humanity, since the question of the duration of the existence of planet Earth remains open and only the development of astronautics and the solution of issues of human adaptation on Earth and in space can save earthly civilization in the event of a cataclysm.

The observed acceleration of progress dictates the need to work proactively. In anesthesiology, a similar term appeared in the last century when developing problems of pain management, when the term “preemptive analgesia” came into practice, with the possibility of switching from 2030 to the use of environmentally friendly anesthetics, which is intertwined with the planning of interplanetary flights, which today requires in-depth consideration of medical issues, including anesthesiological support for crews, and proactive developments in this direction. It is a surprising fact that the evolution of anesthesiology and its methods since the last century has unconsciously developed towards solving problems of ecology, endoecology and cosmology.

Studies of xenon have made it possible to evaluate its potential for use in general clinical anesthesiological practice, in the treatment of stress-related disorders of homeostasis of the human body, and also as a solar energy accumulator for the propulsion of spacecraft with a nuclear reactor, which serves to generate a current that accelerates the flow of ions of the working fluid, which is supposed to be use the inert gas xenon, which creates jet thrust. In our opinion, xenon-based medicines and the possibility of their recycling meet the criteria accepted for space equipment - high reliability, safety, low energy intensity, minimal mass, volume, no change in physical and chemical properties in weightlessness and can be used for medical and biological ensuring long-term interplanetary expeditions. Thus, to date, wide possibilities have been discovered for the use of xenon in clinical medicine, including as an environmentally friendly drug, in cosmology, for solving both technical problems and medical aspects of adaptation to distress and pain.

Xenon and the possibilities of space medicine:

- correction of psychosomatic disorders
- correction of emotional burnout syndrome, demoralization, disappointment
- rehabilitation after the development of symptoms of extreme fatigue
- use to provide analgesia and general anesthesia
- use during long-term interplanetary and intergalactic expeditions (hypobiosis, artificial hibernation, hypothermia)

In our opinion, the possibility of introducing the achievements of earthly medicine into cosmology can be considered beyond the scope of science fiction, which, undoubtedly, despite the space goals, will give impetus to the further development of medical technologies used in general clinical practice on Earth.

On the other hand, environmental aspects affect not only the global areas of the entire globe and space, but have also acquired their relevance in such a narrow field of medicine as anesthesiology-reanimatology and its particular section - analgesia.

In connection with the above, the issues of developing new approaches to solving many existing and emerging problems of clinical medicine, in particular those

related to the pharmacological load and drug safety of the patient, are relevant for all existing sections of medical practice, including anesthesiology and resuscitation. The need to improve anesthesia and analgesia methods is beyond doubt and requires a multimodal approach.

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老年患者口腔干燥症治疗依从性分析  
**ANALYSIS OF ADHERENCE OF PATIENTS OF  
GERONTOLOGICAL AGE TO TREATMENT OF ORAL  
XEROSTOMIA**

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概括。口干症是一种口腔持续干燥的感觉，这是由于唾液腺分泌活动减少以及唾液分泌减少或完全停止引起的。口干综合症对患者的健康产生不利影响，并增加患牙科疾病的风险：导致龋齿、大量牙菌斑导致牙周组织受损、口腔发生真菌感染，尤其是念珠菌病，以及口腔菌群失调。治疗依从性通常受到牙科患者的性别和年龄的影响。老年患者的治疗依从性相当低，因为口干症患者需要长期治疗和维持治疗。患者的社会环境（家人、朋友、同事、邻居）决定了患者日常生活中的价值观。老年病患者的心理状态可能受到疾病症状以及亲人对其疾病及其影响的想法的影响。表现形式。

关键词：口干症、口腔粘膜疾病、老年年龄。

*Summary. Xerostomia is a feeling of constant dryness in the mouth, which is caused by a decrease in the secretory activity of the salivary glands and a decrease or complete cessation of salivation. Dry mouth syndrome has an adverse effect on the well-being of patients and increases the risk of dental diseases: the development of a cariogenic situation, damage to periodontal tissues due to a large amount of plaque, the occurrence of fungal infections in the oral cavity, especially candidiasis, as well as oral dysbiosis. Treatment adherence is often influenced by the gender and age of dental patients. Adherence to treatment in elderly patients is quite low, since patients with xerostomia require long-term treatment and maintenance of therapy. The patient's social environment (family, friends, work colleagues, neighbors determines the values in the daily life of patients. The psychological state of a gerantological patient can be influenced by the symptoms of the disease and the perception of loved ones of his disease and its manifestations.*

**Keywords:** *xerostomia, disease of the oral mucosa, gerontological age.*



Xerostomia or dry mouth syndrome is a pressing problem in dentistry in recent years, which dentists from different fields encounter. Xerostomia is a feeling of constant dryness in the mouth, which is caused by a decrease in the secretory activity of the salivary glands and a decrease or complete cessation of salivation.

According to literary sources of Russian and foreign authors, it has been found that from 10 to 25% of young patients complain of dry mouth; by the age of fifty, this figure increases, reaching 43 - 52% in patients of gerontological age.

It has been established that dry mouth syndrome has an adverse effect on the well-being of patients and increases the risk of dental diseases: the development of a cariogenic situation, damage to periodontal tissue due to a large amount of plaque, the occurrence of fungal infections in the oral cavity, especially candidiasis, as well as oral dysbiosis. Many patients experience angular cheilitis, atrophy of the tongue papillae, impaired taste, glossalgia and taste perversion; areas of gum recession are often found in the cervical area of the teeth. Xerostomia contributes to the development of ulcers and other traumatic lesions caused by the direct impact of dentures in conditions of complete dryness of the soft tissues. However, elderly patients are the most vulnerable to such complications.

It is known that dry mouth develops gradually. There are several stages of xerostomia: initial, clinically pronounced and late. The initial stage is characterized by dry mouth, which only bothers the patient during prolonged conversation. According to the results of laboratory studies, at the initial stage there is no decrease in the level of salivation. In the next stage - the stage of clinical manifestations, a feeling of dryness in the oral cavity is observed not only when talking, but also while eating. In the late stage of xerostomia, there is pain and constant dryness in the mouth, patients are forced to eat food with liquid, such as water.

Currently, the problem of adherence of elderly patients to treatment and drug therapy is one of the most pressing and widely discussed in modern scientific and practical medicine. We know that in the need for constant, lifelong use of medications, especially for various pathologies, patients may often not comply with the recommendations of their attending physician due to long-term use of medications, lack of quick results, as well as fear of side effects from medications. Adherence to treatment in patients of gerontological age is quite low, since patients with xerostomia require long-term treatment and maintenance of therapy. Adherence to treatment is the compliance of the behavior of a dental patient in various respects: to treatment, taking medications, preventive therapy, compliance with the drinking regime, as well as various lifestyle changes.

The World Health Organization (WHO) has proposed a definition of adherence as “the degree to which a patient’s behavior complies with physician recommendations regarding the regularity of taking a drug, its dose and the interval between doses, and increasing the effectiveness of interventions aimed at im-

proving adherence to treatment can have a much greater impact on public health than the improvement of any individual medical procedures.” There are types of non-compliance with treatment, such as: unintentional non-compliance (mental illness, forgetfulness, restrictions associated with working conditions), intentional non-compliance (mistrust of the doctor, fear of side effects, cost of the drug, mental illness, lack of faith in the benefits of treatment, fear of the dangers of drugs , reluctance to undergo treatment).

Adherence to treatment can be determined by various components: social factors, economic factors, the health care system and the doctor, the disease and the treatment of patients. Treatment adherence is often influenced by the gender and age of dental patients. Compliance is much higher in women and may increase with age. It can be noted that cognitive and functional disorders, comorbidity, multicomponent therapy, changes in the pharmacokinetics and pharmacodynamics of drugs in old age reduce adherence to treatment in patients. The patient’s social environment (family, friends, work colleagues, neighbors) determines the values in patients’ daily lives. A positive state, as assessed by society, can have a high impact on the motivation of dental patients to treat and comply with the recommendations of the attending physician. The psychological state of a gerontological patient can be influenced by the symptoms of the disease and the perception of loved ones of his illness and its manifestations. The reluctance of a dental patient to take medications recommended by the attending physician, as well as taking the wrong dose or taking medications at the wrong time, unauthorized discontinuation of use, “forgetfulness”, regular failure to visit the attending physician and non-compliance with recommendations for lifestyle changes rapidly reduce the adherence of elderly patients to treatment. Often, a sudden interruption of treatment can affect the patient’s condition quite significantly than its absence.

### **Conclusions:**

Thus, we can conclude that adherence to the treatment of patients of gerontological age is an urgent and main task of medical practice. Patient adherence to treatment is important for all age, social and nosological groups, but is most relevant for patients of gerontological age. Adherence to treatment in these patients is quite low, since patients with xerostomia require long-term treatment and maintenance of therapy.

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多通道水下无线光通信系统的抗噪性研究  
**INVESTIGATION OF NOISE IMMUNITY OF A MULTICHANNEL  
UNDERWATER WIRELESS OPTICAL COMMUNICATION  
SYSTEM**

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注解。 本文对多通道水下无线光通信系统在各种光辐射传播条件下的抗噪性进行了数值模拟。

在不使用频率或时间复用的情况下,对同时广播通道数从1个到4个的情况下,对由清洁海水、近岸水和浑水形成的水下光通道进行了模拟。

结果表明,由于使用混沌无线电脉冲作为载波信号并实施接收端进行相关处理。

关键词: 水下通信、光通信、无线通信、通信信道建模、水下光辐射传播、动态混沌。

**Annotation.** *In this paper, a numerical simulation of the noise immunity of a multichannel underwater wireless optical communication system under various conditions of optical radiation propagation is carried out.*

*The simulation was carried out for an underwater optical channel formed by clean ocean water, coastal water and turbid water when the number of simultaneously broadcast channels varies from one to four without the use of frequency or time multiplexing.*

*It is shown that with a communication channel length of up to 200 meters, simultaneous transmission of up to four information channels can be realized at an acceptable level of bit error rate due to the use of chaotic radio pulses as a carrier signal and the implementation of correlation processing on the receiving side.*

**Keywords:** *Underwater communication, Optical communication, Wireless communication, Communication channel modelling, propagation of the optical radiation under water, Dynamical chaos.*

## Introduction

In order to provide data transmission (video broadcasts in real time, piloting remote operated vehicles, transmission of telemetry and data from sensors and equipment, etc.) under water, cable systems are currently widely used: electrical, fiber-optic, integrated cables, etc.

At the same time, the communication cable allows you to transmit a large amount of data, but significantly limits the freedom and range of movement of the underwater vehicle. In addition, when performing tasks near underwater objects and structures, there is a risk of entanglement of the cable for the protruding structural elements of the object under study, which can lead to damage to the cable, loss of communication with the underwater vehicle and damage of onboard or underwater equipment due to a short circuit of the cable power lines. Up to the breaking of the cable and the complete loss of the underwater vehicle.

In this regard, wireless underwater communication systems attract great interest: acoustic, electromagnetic and optical.

The main advantage of optical wireless underwater communication systems is a high data transfer rate (up to several Gb/s depending on the distance) at moderate distances (about 150-200 meters), which is not feasible for existing underwater acoustic and electromagnetic communication systems [1, 2].

Thus, the task of studying underwater wireless optical communication systems is very relevant and has practical significance.

This article presents the results of numerical simulation of the noise immunity of a multichannel underwater wireless optical communication system under various conditions of optical radiation propagation: for clean ocean, coastal and turbid water without the use of frequency and time multiplexing. The proposed approach is based on the application of dynamic chaos features to separate several simultaneously broadcast channels in the conditions of a wireless underwater optical communication channel with Gaussian noise.

### **Chapter 1. Description of the communication channel model and parameters**

In this paper, the configuration of the line-of-sight channel with scattering is considered (Diffused Line-of-sight (LOS)).

The model of the channel and communication system at the initialization stage has the ability to specify the basic physical parameters of the task, including the wavelength of optical radiation, the depth of the underwater communication channel, the configuration of the relative location of the transmitter and receiver, the parameters of the photodetector and the radiation source, the noise level in the communication channel, taking into account natural sources of optical noise under water, etc.

Based on the entered value of the depth of the communication channel location, the value of the refractive index of water, temperature and salinity of water is determined.

The list and values of the parameters of the channel model and the underwater wireless optical communication system are given in Table 1.

**Table 1.**  
*Communication channel model parameters*

Name of the parameter	Value of the parameter
Water area	Black Sea [3]
Season	Summer
Depth of the communication channel location	30 meters
Wavelength of optical radiation	518 nm
Scattering model	Henry-Greenstein function, $g = 0,9185$ [4]
Chlorophyll concentration	$0,006 \text{ g/m}^3$ [5]
Type of optical radiation source	LED with Lambert radiation pattern ( $m = 1$ )
Source power	1 W
Field of view of the photodetector (FOV)	$40^\circ$
Diameter of the photodetector lens	10 mm

The determination of the output signal of the communication channel is performed by convolution of the input signal and the impulse response of the communication channel.

Impulse response of the communication channel is determined using the method of numerical solution of the radiation transfer equation using the Monte Carlo method, which takes into account the tracing of the photon trajectory and dispersion in the communication channel, as well as the scattering of optical radiation [6], which allows using the Monte Carlo method to simulate the propagation of broadband optical signals through an underwater wireless communication channel [7, 8].

During the simulation, the main sources of background noise in the communication channel are taken into account: blackbody radiation and ambient underwater light, depending on the physical parameters of the location of the communication channel (the depth of the location of the communication channel, the orientation of the receiver relative to the surface, FOV of the photodetector, the size of the optical lens of the photodetector, etc.) [7].

### **Chapter 2. Description of modulation methods**

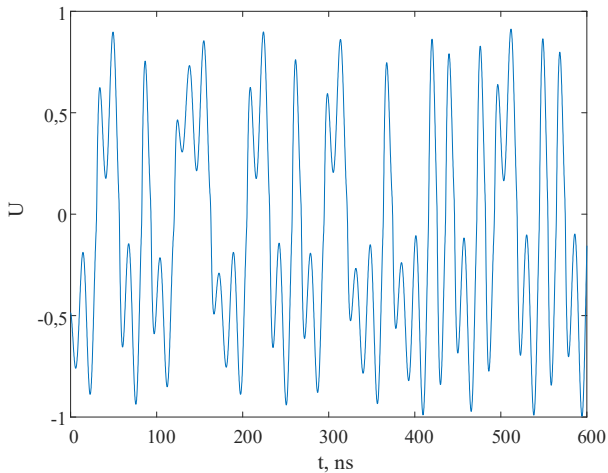
In this paper, the following modulation methods based on the correlation reception of chaotic carrier oscillations are investigated: chaotic on-off keying (COOK) [7-11] and switching of chaotic modes [12-14].

When using COOK, the same fragment of a chaotic signal is emitted during each broadcast of the logical "1". In the case of the translation of the logical "0", there is no signal emission. The receiving device restores the information message by correlating processing of the received signal.

When using the method of switching chaotic modes in the process of broadcasting a logical “1”, a fragment of one chaotic signal is emitted, and when broadcasting a logical “0”, a fragment of another chaotic signal orthogonal to the first is emitted. This method has a greater degree of protection against unauthorized access, since an outside observer will see only a continuous noise-like signal.

In this paper, fragments (pulses) are used as carrier signals is the chaotic oscillations generated using a system of Chua equations [15] with the following parameters:  $\alpha = 15,6$ ,  $\beta = 28$ ,  $m_0 = 2,18559$ ,  $m_1 = -0,714$ .

The duration of a single chaotic pulse corresponding to a logical symbol (“1” or “0”) is 600 ns and contains about 35 periods of chaotic oscillation. Thus, the telegraphy speed is about 1.7 Mbaud. At the same time, the simulation results presented in [16] demonstrate the theoretical possibility of increasing the connection speed by about 10 times without compromising the quality of the connection.



*Figure 1. Chaotic pulse waveform*

### Chapter 3. Obtained results

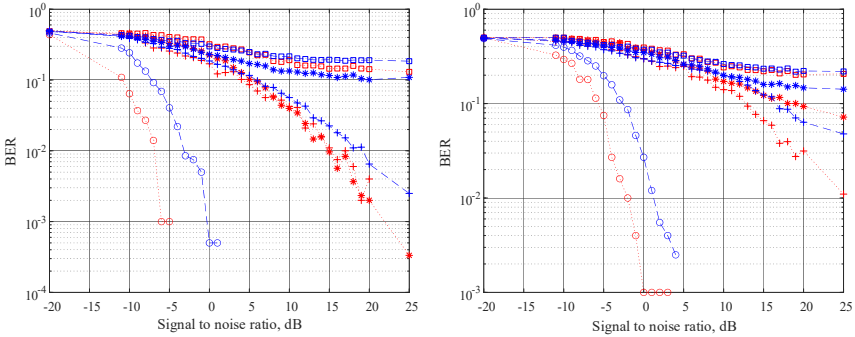
In the process of numerical simulation, cases of simultaneous transmission of one to four information signals without the use of frequency or time multiplexing and corrective coding are considered. Additional application of corrective coding at the software level will further increase the noise immunity of the communication system.

The noise immunity was determined by analyzing the average (between information channels) value of the error rate per bit (BER), calculated by bitwise comparing the original 10,000-bit information sequence generated using a random

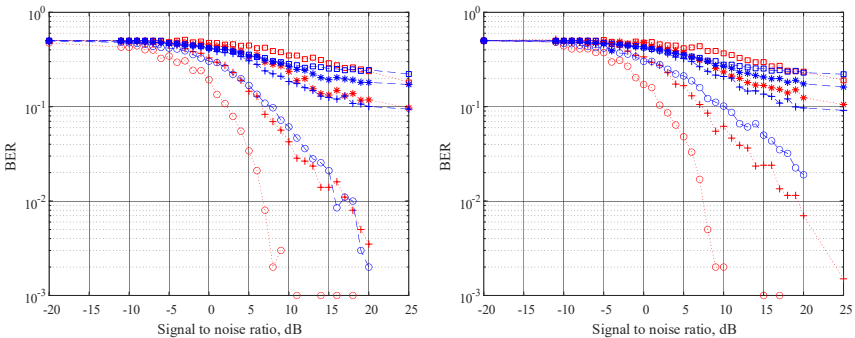
number generator with the information sequence obtained at the output of the communication system model after detection. BER is calculated as the number of mistakenly received bits divided by the total number of bits in the information sequence.

Figures 2 and 3 show the dependence of BER on the signal-to-noise ratio at the receiver input for the case of simultaneous transmission of one to four information signals at different communication channel ranges from 5 to 200 meters formed by clean ocean water. Here and further, the dotted line in red indicates graphs related to COOK modulation, while the dashed line in blue is for the method of switching chaotic modes.

Figure 4 show the dependence of BER on the signal-to-noise ratio at the receiver input for the case of simultaneous transmission of one to four information signals with different parameters of the aquatic environment: for coastal and turbid water for a communication channel length of 5 meters.

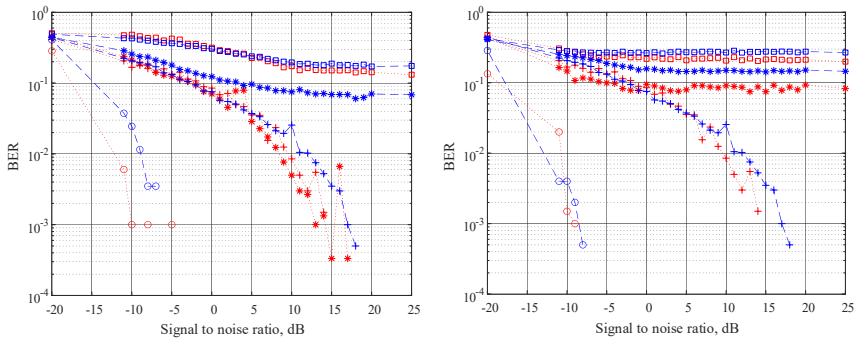


**Figure 2.** Dependence of BER on the signal-to-noise ratio for communication range of 5 meter (left) and 20 meter (right): “o” – one channel, “+” – two channels, “\*” – three channels, “□” – four channels



**Figure 3.** Dependence of BER on the signal-to-noise ratio for communication range of 100 meter (left) and 200 meter (right): “o” – one channel, “+” – two channels, “\*” – three channels, “□” – four channels





**Figure 4.** Dependence of BER on the signal-to-noise ratio for coastal water (left) and turbid water (right): “o” – one channel, “+” – two channels, “\*” – three channels, “□” – four channels

It can be seen from the results that the considered modulation methods based on the application of dynamic chaos properties allow simultaneous transmission of up to three information signals in low noise conditions without the use of frequency or time multiplexing, which will expand the capabilities of the underwater communication system in terms of increasing the transmission rate by parallelizing data streams, or connecting two or three subscribers to one communication channel without loss of connection speed, as well as the use of code or other channel separation.

COOK modulation has better noise immunity and allows you to provide an advantage over modulation by switching chaotic modes up to 15 dB.

In addition, the features inherent in dynamic chaos make it possible to detect a useful information signal even with negative signal-to-noise ratios up to minus 10 dB, which makes it possible to use a communication system with similar modulation methods in conditions of increased noise.

The decrease in resistance to external interference (Fig. 2 and 3) with an increase in the length of the communication channel is a consequence of a decrease in the power level of the useful signal at the receiver input while maintaining the overall level of interference.

The improvement of the noise immunity of the communication channel with a deterioration in the quality of the aquatic environment (Fig. 2 and 4) is a consequence of the weakening of the effect of intersymbol interference due to the strong attenuation of scattered light that reached the receiver not along a straight path, with a large length of the communication channel.

The use of noise-resistant information coding methods will further reduce the amount of errors during data detection by reducing the connection speed.

## Conclusions

Thus, in this paper, based on numerical modeling, the potential possibility of implementing a multi-channel underwater wireless optical communication system is demonstrated.

It is shown that when using modulation methods based on the properties of dynamic chaos, regardless of the length of the communication channel (from 5 to 200 meters) and the conditions of propagation of optical radiation (clean, coastal and turbid water) with low external noise, simultaneous transmission of up to three information channels can be realized without the need for frequency or time multiplexing. The use of noise-resistant information coding methods will further reduce the quantity of errors during data detection by reducing the connection speed. In this paper, the telegraphy speed is about 1.7 Mbaud with a communication channel length of up to 200 meters.

The article is based on the research results, which was conducted in the framework of project MK-2283.2022.4 with the support of the Grant Council of the President of the Russian Federation.

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通过饲料研磨设备感应电机的最佳速度控制实现节能  
**ACHIEVEMENT OF ENERGY SAVINGS THROUGH OPTIMAL  
SPEED CONTROL OF AN INDUCTION MOTOR FOR FEED  
GRINDING DEVICES**

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*Institute of Engineering Irrigation and Agriculture Mechanization*

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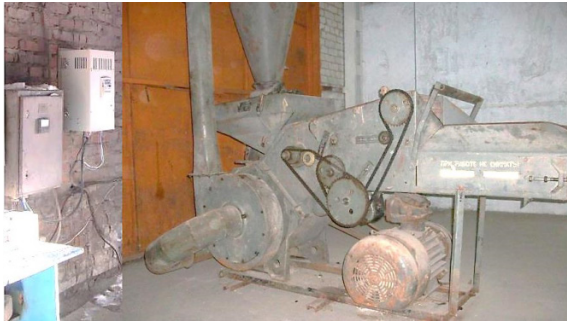
抽象的。 本文提供了通过对磨削进给设备的异步电机速度进行变频控制来实现能源效率的数据。

关键词: 节能、电力传动、变频器、最优控制、工作机制、能源效率、效率。

**Abstract.** *The article provides data on achieving energy efficiency through frequency control of the speed of an asynchronous motor of equipment for grinding feed.*

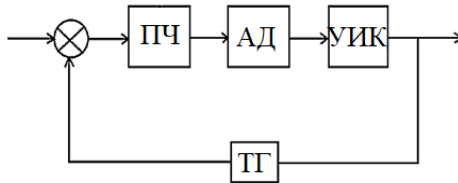
**Keywords:** *energy saving, electric drive, frequency converter, optimal control, working mechanisms, energy efficiency, efficiency.*

It is known that the agricultural sector of our republic today is increasingly being improved and developed. The asynchronous motor of feed grinding equipment currently used in agriculture can be driven in several ways. For example, agricultural feed grinders are used to grind corn, wheat, millet and other grains. The induction motor of these shredders generates very large current surges known as starting current or locked rotor current. The starting current is 5-10 times higher than the rated current, acts for a short time, and after acceleration, the current in the electric motor drops to a minimum value. Currently, the asynchronous motor of equipment for grinding feed, used in the example of one of the agricultural enterprises «Bukhoroparranda» AJ, can be started in several ways. One of these methods is a method of controlling the rotation speed of an asynchronous motor of feed grinding equipment using a frequency converter [1].



**Figure 1.** General view of controlling an asynchronous motor of a universal feed chopper using a frequency converter

Start-up and control of feed grinding devices is carried out using a frequency converter, which is installed between the machine and the asynchronous motor. One of such devices is a closed functional diagram of frequency control of asynchronous motors of feed grinding devices, used in the example of the “Bukhoroparranda” AJ enterprise shown in Fig. 2.



**Figure 2.** Closed-loop functional diagram of frequency control of an asynchronous motor for feed grinding devices [5, 6]:

⊗ - Adder, power supply  $U=380$  V; FC- frequency converter; AM - asynchronous motor; TG - tachogenerator; FGD-feed grinding device

The machine is connected to a voltage network of  $U=380$  V, and a frequency converter is installed between the machine and the motor, which regulates the rotation speed of the chopper’s asynchronous motor. During the starting of the induction motor, the motor runs smoothly and the induction motor runs without excessive loads. As an example, we give the following: at one of the agricultural enterprises, namely at the “Bukhoroparranda” AJ enterprise, three-phase asynchronous motors with a squirrel-cage rotor 4A100L6U3 are currently used in feed grinding plants. Their power is  $P = 30$  kW, and voltage  $U = 220/380$ V. In the process of controlling the asynchronous motor of a feed grinding device through a frequency converter at the “Bukhoroparranda” AJ enterprise, we achieve en-

ergy saving in the following way. In the course of our research, we came to the conclusion that by adjusting the rotation speed of the asynchronous motor of feed grinding devices through frequency converters, we can save 20% of the electricity consumed in the process.

In addition, when calculating the amount of energy savings for one year for feed grinding devices with a power of  $P = 30$  kW, operating 12 months a year, it will be as follows

$$E_2(1 \text{ year, kW} \cdot \text{s}) = 30 \text{ kW} \cdot (20\%/100) \cdot 20 \text{ hours} \cdot 27 \text{ days} \cdot 12 \text{ months} = 38880 \text{ kW} \cdot \text{s}.$$

When calculating the sum of energy savings in monetary terms, i.e. in sums, based on  $1 \text{ kW} \cdot \text{s} = 450$  sums, we get the following.

$$E_2(1 \text{ year, sum.}) = 38880 \text{ kW} \cdot \text{s} \cdot 450 \text{ sum} = 17496000 \text{ million sum. funds can be saved through energy.}$$

In conclusion, we can say that due to the frequency regulation of the asynchronous motor for feed grinding devices used at the “Bukhoroparranda” AJ enterprise, energy savings were achieved and economic efficiency amounted to 17,496,000 million sums.

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TDU 574.6:477.63/64

固定情况下按性别划分的蜂群数学模型  
**MATHEMATICAL MODEL OF A BEE COLONY BY GENDER IN A  
STATIONARY CASE**

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抽象的。 文章采用概念建模的方法，根据性别特征设计蜂群个体的年龄阶段。

基于蜜蜂家族生命阶段的概念模型，考虑群体分布和性特征，建立了一个数学模型，该模型基于具有初始条件的 10 个简单线性微分方程组。 该系统的方程以个体生长和死亡过程的数学依赖性的形式描述了一个家庭中个体数量的瞬时变化率，并实现了它们从一个生命阶段过渡到另一个生命阶段的机制。

在稳定状态下，对方程组进行数学分析，找出模型变量、系数的值以及它们之间的关系。

微分方程组已完全解析求解，必要条件已确定，在确定模型系数值的过程中必须满足这些条件。

关键词：概念建模、数学建模、微分方程组、蜂群、生命阶段、性特征、工蜂、雄蜂。

**Abstract.** *In the article, using the method of conceptual modeling, the age stages of individuals of a bee colony are designed according to gender characteristics.*

*Based on a conceptual model of the life stages of a bee family, taking into account group distribution and sexual characteristics, a mathematical model was built, which is based on a system of 10 simple linear differential equations with initial conditions. The equations of the system describe the instantaneous rate of change in the number of individuals in a family in the form of mathematical dependencies of the processes of growth and death of individuals, and implement the mechanism of their transition from one stage of life to another.*

*In a steady state, a mathematical analysis of the system of equations was carried out, the values of the model variables, coefficients and relationships between them were found.*

*The system of differential equations has been completely solved analytically, the necessary conditions have been identified, the fulfillment of which is mandatory in the process of identifying the values of the model coefficients.*



**Keywords:** *conceptual modeling, mathematical modeling, system of differential equations, honey bee colony, life stage, sexual characteristics, worker bee, drone bee.*

The honey bee is one of the creatures with a special way of life, activities and behavior, and its life is completely different from the lifestyle of other species of bees. Bees live in colonies. A bee family is an integral biological unit. Without the environment and influence of family society, bees die.

Conceptual model. From an analysis of scientific literature data, it follows that in a bee family the share of worker bees is about 98%, and drone bees are about 2% of the total bee community (population) of the family. [1;2]. Taking this fact into account, we divide all individuals of a bee colony at all age stages of their lives into two sex groups (worker bees, drone bees) and pay attention to the conceptual modeling of this process.

Using  $E_m(t)$  we indicate the total number of eggs laid by the queen in one day, and we will assume that the state of individuals in the bee colony population and their transition from one life stage to another at time  $t \in [t_n; t_{n+1}]$ ,  $n \in N$ . Using the 10 following variables, it is described and determined:  $E_1(t)$  – the number of eggs from which worker bees are born,  $E_2(t)$  – the number of eggs from which drone bees are born,  $K_1(t)$  – the number of worker bee larvae,  $K_2(t)$  – number of drone bee larvae,  $P_1(t)$  – number of worker bee prepupae,  $P_2(t)$  – number of drone bee prepupae,  $Z_1(t)$  – number of worker bee pupae,  $Z_2(t)$  – number of worker bee pupae,  $M_1(t)$  – the number of adult worker bees and  $M_2(t)$  – the number of adult drone bees. Using  $\mu_{ij}$  ( $i = 1,2; j = 1,2,3,4,5$ ) – natural mortality rates of special sex groups and using  $\delta_{ij}$  ( $i = 1,2; j = 1,2,3,4,5$ ) – indicate the shares (coefficients) of the transition from one stage to another. Thus, we will construct the population of a bee colony by sex in the form of a conceptual model in Fig. 15].

**Mathematical model.** The developed mathematical model is based on a system of 10 linear ordinary differential equations with initial conditions, which is reflected in the corresponding conceptual model (Fig. 1)



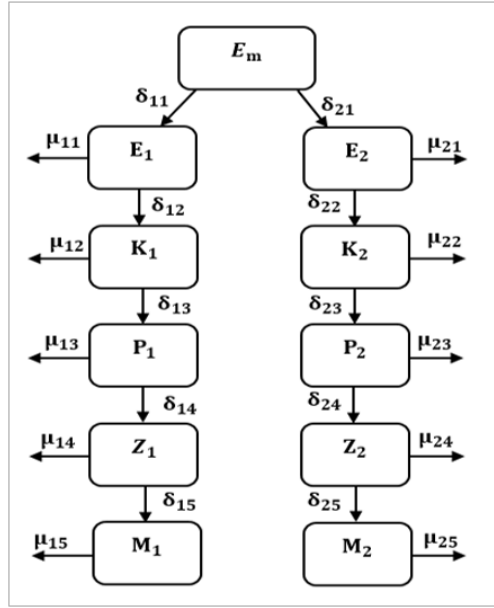


Figure 1. Conceptual model of the life stages of a honey bee colony depending on the group distribution of the population and its sexual characteristics

$$\begin{cases}
 \frac{dE_1}{dt} = \delta_{11}k_1E_m(t) - \delta_{12}E_1(t) - \mu_{11}E_1(t) \\
 \frac{dE_2}{dt} = \delta_{21}k_2E_m(t) - \delta_{22}E_2(t) - \mu_{21}E_2(t) \\
 \frac{dK_1}{dt} = \delta_{12}E_1(t) - \delta_{13}K_1(t) - \mu_{12}K_1(t) \\
 \frac{dK_2}{dt} = \delta_{22}E_2(t) - \delta_{23}K_2(t) - \mu_{22}K_2(t) \\
 \frac{dP_1}{dt} = \delta_{13}K_1(t) - \delta_{14}P_1(t) - \mu_{13}P_1(t) \\
 \frac{dP_2}{dt} = \delta_{23}K_2(t) - \delta_{24}P_2(t) - \mu_{23}P_2(t) \\
 \frac{dZ_1}{dt} = \delta_{14}P_1(t) - \delta_{15}Z_1(t) - \mu_{14}Z_1(t) \\
 \frac{dZ_2}{dt} = \delta_{24}P_2(t) - \delta_{25}Z_2(t) - \mu_{24}Z_2(t) \\
 \frac{dM_1}{dt} = \delta_{15}Z_1(t) - \mu_{15}M_1(t) \\
 \frac{dM_2}{dt} = \delta_{25}Z_2(t) - \mu_{25}M_2(t)
 \end{cases} \quad (1)$$

Using the Malthus model and the empirical formula of W. Ricker, who conducted his experiments in 1954 when calculating the dynamics of changes in the number of trout (salmon) in the lakes of Columbia [4], in the mathematical model (1) we describe the process of reproduction of bee eggs in the form of the following function:

$$E_m(t) = k\alpha E_0 e^{\beta t},$$

$$k = k_1 + k_2 = 1 \quad (k_1 = 0,98; k_2 = 0,02),$$

where  $E_0$  represents the initial number of eggs laid by the queen, and the coefficients  $\alpha$  and  $\beta$  are determined experimentally [5].

Now, taking into account the stationary state, let's proceed to the mathematical analysis of system (1).

$$\frac{dE_i}{dt} = 0; \quad \frac{dK_i}{dt} = 0; \quad \frac{dP_i}{dt} = 0; \quad \frac{dZ_i}{dt} = 0; \quad \frac{dM_i}{dt} = 0, \quad i = 1, 2$$

in this case the system looks like this:

$$\begin{cases} \delta_{11}k_1E_m - \delta_{12}E_1 - \mu_{11}E_1 = 0 \\ \delta_{21}k_2E_m - \delta_{22}E_2 - \mu_{21}E_2 = 0 \\ \delta_{12}E_1 - \delta_{13}K_1 - \mu_{12}K_1 = 0 \\ \delta_{22}E_2 - \delta_{23}K_2 - \mu_{22}K_2 = 0 \\ \delta_{13}K_1 - \delta_{14}P_1 - \mu_{13}P_1 = 0 \\ \delta_{23}K_2 - \delta_{24}P_2 - \mu_{23}P_2 = 0 \\ \delta_{14}P_1 - \delta_{15}Z_1 - \mu_{14}Z_1 = 0 \\ \delta_{24}P_2 - \delta_{25}Z_2 - \mu_{24}Z_2 = 0 \\ \delta_{15}Z_1 - \mu_{15}M_1 = 0 \\ \delta_{25}Z_2 - \mu_{25}M_2 = 0 \end{cases} \quad (2)$$

We solve the system of algebraic equations (2) and find the values of the variables:

$$E_1 = \frac{k_1\delta_{11}E_m}{\delta_{12} + \mu_{11}},$$

$$E_2 = \frac{k_2\delta_{21}E_m}{\delta_{22} + \mu_{21}},$$

$$K_1 = \frac{k_1\delta_{11}\delta_{12}E_m}{(\delta_{12} + \mu_{11})(\delta_{13} + \mu_{12})},$$

$$K_2 = \frac{k_2\delta_{21}\delta_{22}E_m}{(\delta_{22} + \mu_{21})(\delta_{23} + \mu_{22})},$$

$$P_1 = \frac{k_1 \delta_{11} \delta_{12} \delta_{13} E_m}{(\delta_{12} + \mu_{11})(\delta_{13} + \mu_{12})(\delta_{14} + \mu_{13})},$$

$$P_2 = \frac{k_2 \delta_{21} \delta_{22} \delta_{23} E_m}{(\delta_{22} + \mu_{21})(\delta_{23} + \mu_{22})(\delta_{24} + \mu_{23})},$$

$$Z_1 = \frac{k_1 \delta_{11} \delta_{12} \delta_{13} \delta_{14} E_m}{(\delta_{12} + \mu_{11})(\delta_{13} + \mu_{12})(\delta_{14} + \mu_{13})(\delta_{15} + \mu_{14})},$$

$$Z_2 = \frac{k_2 \delta_{21} \delta_{22} \delta_{23} \delta_{24} E_m}{(\delta_{22} + \mu_{21})(\delta_{23} + \mu_{22})(\delta_{24} + \mu_{23})(\delta_{25} + \mu_{24})},$$

$$M_1 = \frac{k_1 \delta_{11} \delta_{12} \delta_{13} \delta_{14} \delta_{15} E_m}{\mu_{15}(\delta_{12} + \mu_{11})(\delta_{13} + \mu_{12})(\delta_{14} + \mu_{13})(\delta_{15} + \mu_{14})},$$

$$M_2 = \frac{k_2 \delta_{21} \delta_{22} \delta_{23} \delta_{24} \delta_{25} E_m}{\mu_{25}(\delta_{22} + \mu_{21})(\delta_{23} + \mu_{22})(\delta_{24} + \mu_{23})(\delta_{25} + \mu_{24})}$$

or in general:

$$E_i = \frac{k_i \delta_{i1} E_m}{\delta_{i2} + \mu_{i1}} = \frac{E_m k_i \delta_{ij}}{\delta_{ij+1} + \mu_{ij}}, \quad i = 1, 2; \quad j = 1;$$

$$K_i = \frac{k_i \delta_{i1} \delta_{i2} E_m}{(\delta_{i2} + \mu_{i1})(\delta_{i3} + \mu_{i2})} = \frac{E_m k_i \prod_{j=1}^2 \delta_{ij}}{\prod_{j=1}^2 (\delta_{ij+1} + \mu_{ij})}, \quad i = 1, 2;$$

$$P_i = \frac{k_i \delta_{i1} \delta_{i2} \delta_{i3} E_m}{(\delta_{i2} + \mu_{i1})(\delta_{i3} + \mu_{i2})(\delta_{i4} + \mu_{i3})} = \frac{E_m k_i \prod_{j=1}^3 \delta_{ij}}{\prod_{j=1}^3 (\delta_{ij+1} + \mu_{ij})}, \quad i = 1, 2;$$

$$Z_i = \frac{k_i \delta_{i1} \delta_{i2} \delta_{i3} \delta_{i4} E_m}{(\delta_{i2} + \mu_{i1})(\delta_{i3} + \mu_{i2})(\delta_{i4} + \mu_{i3})(\delta_{i5} + \mu_{i4})} = \frac{E_m k_i \prod_{j=1}^4 \delta_{ij}}{\prod_{j=1}^4 (\delta_{ij+1} + \mu_{ij})}, \quad i = 1, 2;$$

$$M_i = \frac{k_i \delta_{i1} \delta_{i2} \delta_{i3} \delta_{i4} \delta_{i5} E_m}{\mu_{i5}(\delta_{i2} + \mu_{i1})(\delta_{i3} + \mu_{i2})(\delta_{i4} + \mu_{i3})(\delta_{i5} + \mu_{i4})} = \frac{E_m k_i \prod_{j=1}^5 \delta_{ij}}{\mu_{i5} \prod_{j=1}^4 (\delta_{ij+1} + \mu_{ij})}, \quad i = 1, 2.$$

In model calculations, we consider it necessary to take into account the following conditions:

$$a) E_0 > 0, E_i \geq K_i \geq P_i \geq Z_i \geq M_i, \quad i = 1, 2;$$

$$b) E_1 > E_2, K_1 > K_2, P_1 > P_2, Z_1 > Z_2, M_1 > M_2;$$

$$c) \delta_{ij} > 0, \mu_{ij} \geq 0, \delta_{ij} > \mu_{ij} \quad (i = 1,2; j = 1,2,3,4,5);$$

Conditions (a-c) are considered necessary conditions of the system of equations (1), since in the process of determining the value of the coefficients of the corresponding computer model, their fulfillment is considered mandatory.

**Main results of the study:**

1. Using the method of conceptual modeling, the age stages of the bee colony are determined.
2. Based on the conceptual model, a mathematical model was created, which underlies 10 systems of linear ordinary differential equations.
3. In the stationary case, a mathematical analysis of the system of differential equations was carried out and the necessary conditions of the system were found.

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超临界参数低沸点工质ORC汽轮机组技术经济指标计算  
**CALCULATION OF TECHNICAL AND ECONOMIC INDICATORS  
OF TURBINE UNITS AT ORC WITH LOW-BOILING WORKING  
FLUIDS AT SUPERCRITICAL PARAMETERS**

**Ovsyannik Anatoli Vasyliovich***Doctor of Technical Sciences, Professor**Gomel State Technical University named after. BY. Sukhoi***Kliuchinski Uladzislau Petrovich***Postgraduate student**Gomel State Technical University named after. BY. Sukhoi*

注释。 评价超临界参数低沸点工质ORC透平机组的技术经济性能指标，研究低沸点工质热力学最优压力下热能再生透平机组的火用效率与其热物理性质的关系（临界压力和冷凝比热），以及涡轮机前工作流体在 100 至 300 oC 温度范围内的初始温度。获得的相关性还使得可以评估低沸点工作流体的热力学效率，以供其在超临界参数下的涡轮机装置中进一步使用。 本文提出了一种工质中间过热和超临界参数的汽轮机组成本估算方法，使得预测此类汽轮机组的经济性能指标成为可能。 为此，提出了一种利用低沸点工质超临界参数确定汽轮机组技术经济效率指标的方法，无需经过复杂的计算和软件求解即可对其效率进行初步评估。 这样的问题

关键词：有机朗肯循环、二次能源回收、低沸点工质、透平机组、火用效率、技术经济指标。

**Annotation.** *To assess the technical and economic performance indicators of ORC turbine units with low-boiling working fluids at supercritical parameters, the dependence of the exergy efficiency for turbine units with thermal energy regeneration at thermodynamically optimal pressures of low-boiling working fluids on their thermophysical properties (critical pressure and specific heat of condensation), as well as the initial temperature of the working fluids in front of the turbine in the temperature range from 100 to 300 °C. The obtained dependence also makes it possible to evaluate the thermodynamic efficiency of low-boiling working fluids for their further use in turbine units at supercritical parameters. The paper proposes a method for estimating the cost of turbine units with intermediate overheating and supercritical parameters of the working fluid, which makes it possible to predict the economic performance indicators of such turbine units. Thus, a methodology has been proposed for determining the technical and*

*economic efficiency indicators of turbine units using supercritical parameters of low-boiling working fluids, which allows for a preliminary assessment of their efficiency without the use of complex calculations and the use of software to solve such a problem*

**Keywords:** *organic Rankine cycle, recycling of secondary energy resources, low-boiling working fluids, turbine unit, exergy efficiency, technical and economic indicators.*

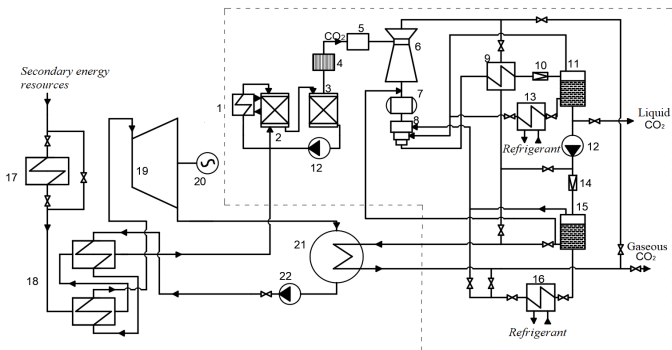
**Introduction**

In the context of the development of low-carbon energy, ORC turbine units (Figure 1), using freons and carbon dioxide as working fluids, are increasingly used. Turbine plants using low-boiling working fluids are used as part of polygeneration plants, for the utilization of gas turbine exhaust gases, for the combustion of fuels with low calorific value, and for the utilization of high-temperature water and energy resources [1-6].

In [7-9], in order to increase the efficiency of turbine units, it was proposed to use supercritical, thermodynamically optimal parameters of a low-boiling working fluid. However, to determine the thermodynamic efficiency of such installations it is necessary to perform complex calculations or use specially developed programs. The lack of operational turbine units with supercritical parameters of low-boiling working fluids makes it difficult to determine the cost of such units, and, consequently, to calculate the technical and economic indicators of their operation.

**Scheme**

In works [1,5], for the simultaneous production of electrical energy, heat, cold and carbon dioxide, a polygeneration unit was proposed, which includes a turbo unit for ORC (Figure 1).



1,13,16 – heat exchanger; 2 – absorber; 3 – desorber; 4 – splash separator; 5 – dehumidifier; 6 – injector; 7 – receiver; 8 – compressor; 9 – capacitor;

10.14 – control valve; 11.15 – separator; 12.22 – pump; 17 – network water heater; 18 – waste heat boiler; 19 – turbine at NKRT; 20 – generator; 21 – capacitor

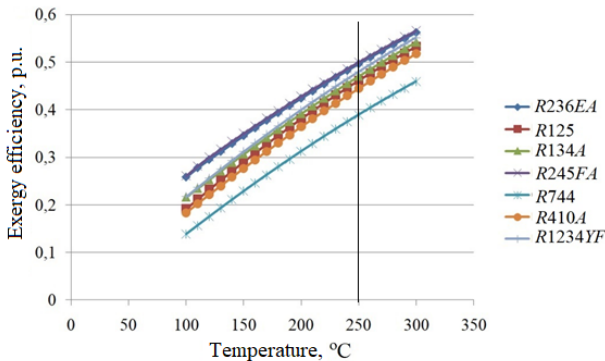
**Figure 1.** Scheme of a turbine unit with thermal energy regeneration [1, 5]

**Thermodynamic efficiency of turbine units**

One of the most important indicators of the efficiency of turbine plants is exergy efficiency. The studies carried out [8,9] showed that for each initial temperature of a low-boiling working fluid there is its own thermodynamically optimal pressure. Having plotted the dependences of exergy efficiency on temperature for various low-boiling working fluids at optimal pressures of the working fluids (Figure 2), it is clear that these curves have a similar shape and slope. These dependencies can be represented mathematically in the form of a polynomial:

$$y(x) = A \cdot x^2 + B \cdot x + C, \tag{1}$$

where  $A, B, C$  – are the coefficients of the polynomial.



**Figure 2.** Exergy efficiency of turbine units at different temperatures of low-boiling working fluids

The studies carried out in [8] indicate the influence of critical pressure and specific heat of condensation on the operating efficiency of turbine units. This relationship can be described by the formula:

$$\eta = A \cdot P_{kp}^x \cdot L_k^y. \tag{2}$$

where  $A, B, C$  – are the coefficients.

For a working fluid temperature in front of the turbine of 250 °C, formula (3) according to [8] will take the form:

$$\eta = 47,5 \cdot P_{kp}^{-0,27} \cdot L_K^{0,072} \tag{3}$$

Coefficients A and B of equation (1) can be determined from the results obtained (Figure 2), and coefficient C can be obtained based on formula 3. Then formula (1) will take the form:

$$\eta = -1,75 \cdot 10^{-4} \cdot t^2 + 0,229 \cdot t + 47,5 \cdot P_{kp}^{-0,277} \cdot L_K^{0,072} - 46,0. \tag{4}$$

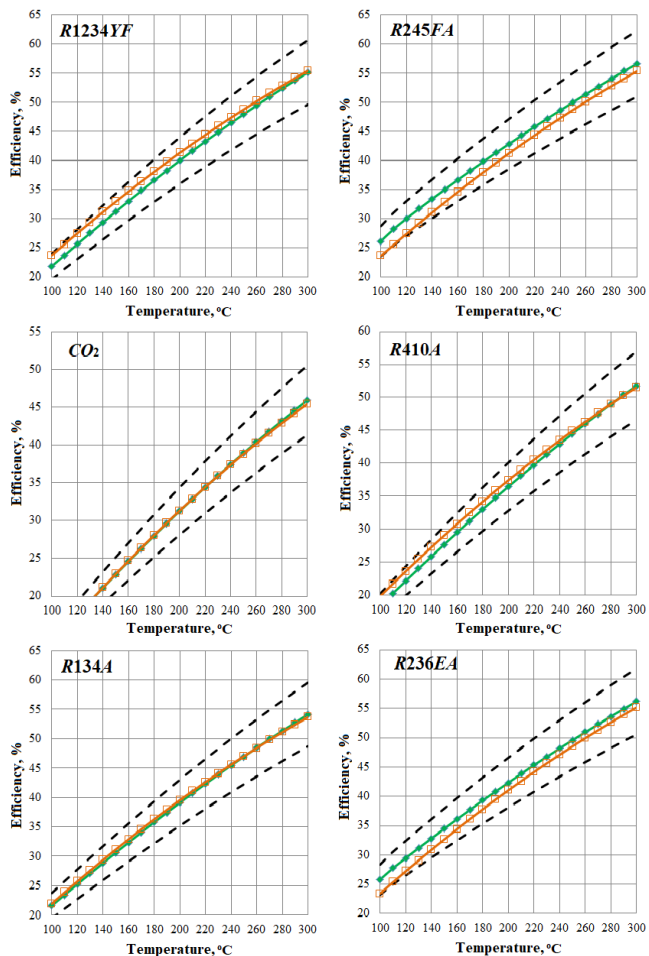


Figure 3. Graphical representation of the dependence of exergy efficiency on the temperature of low-boiling working fluids



The results obtained using dependence (4) are presented in Figure 3, the error of the obtained results did not exceed 10%. The obtained dependence can be used to determine the operating efficiency of turbine units at ORC using supercritical thermodynamically optimal parameters of low-boiling working fluids, as well as for a preliminary assessment of the amount of generated electrical energy when calculating the economic indicators of the operation of turbine units.

**Economic efficiency of turbine units**

Assessment of the economic efficiency of turbine units can be carried out according to the following indicators: static payback period, dynamic payback period, internal rate of return, net present value, etc. Determining the above-mentioned standard indicators is not difficult, but to determine them it is necessary to estimate the cost of turbine units on ORC. Due to the lack of implemented projects for turbo plants at the ORC with supercritical parameters of the working fluids, it is proposed to use the following formula to estimate the cost of such plants:

$$S = (1 + (\Delta t) \cdot k_t + (\Delta p) \cdot k_p + k_{III}) \cdot S_6 \cdot (1 - k_{II}) + S_6 \cdot k_{II}, \quad (5)$$

where  $\Delta t$  – temperature difference between the actual and basic versions of turbine units, °C;

$\Delta p$  – pressure difference between the actual and basic versions of turbine units, MPa;

$k_t$  – the coefficient taking into account the influence of temperature on the cost of installation is taken as  $k_t = 0,0005$  units/°C;

$k_p$  – the coefficient taking into account the influence of pressure on the cost of a turbine unit is taken as  $k_p = 15,0$  units/kPa;

$k_{III}$  – the coefficient taking into account the influence of intermediate overheating on the cost of the turbine unit is taken as  $K_{III}^{TY} = 0,06$  units. [11];

$k_{II}$  – coefficient taking into account the absence of influence of the working fluid parameters on the cost of the installation elements,  $k_{II} = 0,07$  units [12].

**Table 1.**  
*Estimation of the cost of turbine units*

Power, MW	Pressure, kPa	Temperature, °C	Actual cost turbine units, million rubles	Price turbine units (formu. 5), million rubles	Error, %
<i>R410A</i>					
0,03*	1100*	80*	0,111*	-	-
0,03	1400	130	0,115	0,118	2,8
0,1*	1000*	90*	0,372*	-	-
0,1	2200	130	0,403	0,391	10,2
0,5*	2200*	110*	1,776*	-	-
0,5	3700	200	1,773	1,886	6,4

3*	2600*	150*	10,860*	-	-
3	4000	220	12,573	11,430	9,1
Isobutane					
0,05*	1000*	105*	0,178*	-	-
0,05	1100	120	0,197	0,182	7,4
0,3*	900*	90*	1,050*		
0,3	11500	110	1,150	1,096	4,7
0,2*	100*	80*	0,718*	-	-
0,2	1100	160	0,998	1,104	10,7
0,8*	1500*	150*	2,880*		
0,8	2700	200	3,435	2,979	13,3
Carbon dioxide					
0,1*	2500*	110*	0,385*	-	-
0,1	3700	220	0,403	0,412	2,1
0,8*	2500*	180*	3,024*		
0,8	3300	250	3,535	3,156	10,7
1,5*	300*	250*	5,685*		
1,5	4200	300	5,730	5,913	3,2
* – turbine unit taken as the basic option					

Substituting the obtained values, formula (5) can be represented as:  
 - for a turbine unit with one-time overheating

$$S = (4650 \cdot 10^{-3} \cdot \Delta t + 1395 \cdot 10^{-3} \cdot \Delta p + 1) \cdot S_6, \quad (6)$$

- for a turbine unit with double overheating

$$S = (4650 \cdot 10^{-3} \cdot \Delta t + 1395 \cdot 10^{-3} \cdot \Delta p + 110,56) \cdot S_6, \quad (7)$$

Estimation of the cost of turbine units using the proposed formulas is presented in Table 1. The error of the results did not exceed 15%.

### Conclusion

In the course of the research, a methodology was developed for determining the technical and economic indicators of the efficiency of ORC turbine units with supercritical parameters of the working fluids, which allows for a preliminary assessment of their efficiency without using software to solve this problem.

The dependence of the exergy efficiency for turbine units with thermal energy regeneration at thermodynamically optimal pressures of low-boiling working fluids on their thermophysical properties (critical pressure and specific heat of condensation), as well as the initial temperature of the working fluids in front of the

turbine in the temperature range from 100 to 300 °C, was obtained. The obtained dependence allows us to make a preliminary assessment of the thermodynamic efficiency of low-boiling working fluids for operation in turbine units at supercritical parameters.

A method is proposed for estimating the cost of ORC turbine units with intermediate overheating and with supercritical working fluid parameters, which makes it possible to predict the economic performance indicators of such turbine units.

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哈密尔顿原理和不变量

## HAMILTON'S PRINCIPLE AND THE INVARIANTS

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### *My Parents are Dedicated*

**Abstract.** Shows the fundamental role of the symmetry properties of space and time in justifying the use of the principle of least action to find and establish invariants in the creation and evolution of nanomaterials.

**Keywords:** properties of space and time, principle of least action, nanostructures; invariants.

### **Introduction**

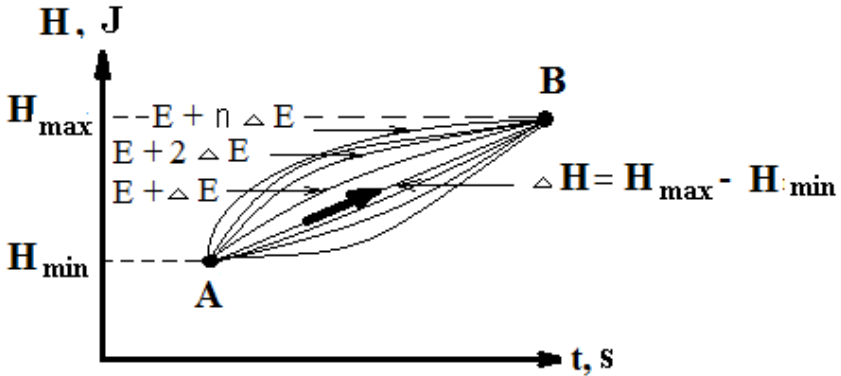
The complexity of research on the creation of materials with new physical and chemical properties is determined by the lack of scientifically grounded fundamental principles that can be applied at the junction of different sciences (physics, mathematics, chemistry, mechanics, materials science, etc.). Such a principle linking the symmetry of the properties of space and time with the properties of materials is the principle of least action. The latter determines the search and establishment of basic, fundamental structural regularities [1] or invariants acting at all structural-scale levels of deformation [2]. Four invariants are described in [3].

### **Experimental Details**

Polycrystalline nickel of 99.99% purity, armco-iron, bearing steel, bronze, and cast iron were investigated. The nickel samples in the form of thin disks were polished electrolytically and annealed in a vacuum of 0.133 mPa at 973 K. The friction test of Ni – Mo pair was carried out on the machine AE-5 according to the finger-disk scheme with precise setting of the contact area at a specific load of  $\approx 84$  kPa and linear speed of  $\approx 0.5$  m/s. Electron microscopic studies of nickel were carried out on a microscope EVM-100AK and Hitachi-H800 by the method of thin foils on "lumen". The resolution of the Hitachi-H-800 is  $\approx 0.1$  nm. The technique of preparation of nickel samples for transmission electron microscopy is given in work [4].

**Results and Discussion**

It is known that the principle of least action or Hamilton’s principle is used to formulate the equations of motion of a material point in mechanics [5]. Why cannot this fundamental principle be used to describe the kinetics of processes of structural transformations in materials occurring in the same continuum of space and time? The kinetics of the transition of the system from one structural state (A) to another (B) is carried out in accordance with the principle of least action (Fig. 1).



*Figure 1. Kinetics of system transition from one structural state (A) to another (B) in accordance with the principle of least action, where H – entropy, t – time*

It is known that the mathematical formulation of the IPA (or Hamilton’s principle) has the form [5]:

$$\delta H = 0 \quad , \quad (1)$$

where

$$H = \int_{t_1}^{t_2} L(q, q', t) dt \quad , \quad (2)$$

where q, q' are independent parameters characterizing the system, t is time. Then the expression is valid:

$$\delta H = \int_{t_1}^{t_2} \left( \frac{\partial L}{\partial q} \delta q + \frac{\partial L}{\partial q'} \delta q' \right) dt = 0 \quad (3)$$

Suppose that the expression is true:

$$L = E_{\text{external}} - E_{\text{inside}} \quad , \quad (4)$$

where  $E_{\text{external}}$  – is the energy of external influence, a  $E_{\text{inside}}$  – is the energy accumulated or stored in the system (material or materials). The energy difference or entropy is given by the expression [6]:

$$H = \frac{\zeta(\nabla T)^2}{T^2} + \rho \frac{Z\Sigma}{T} \pm \frac{\rho}{T^2}([\alpha, \Omega], \nabla T, t) \quad (5)$$

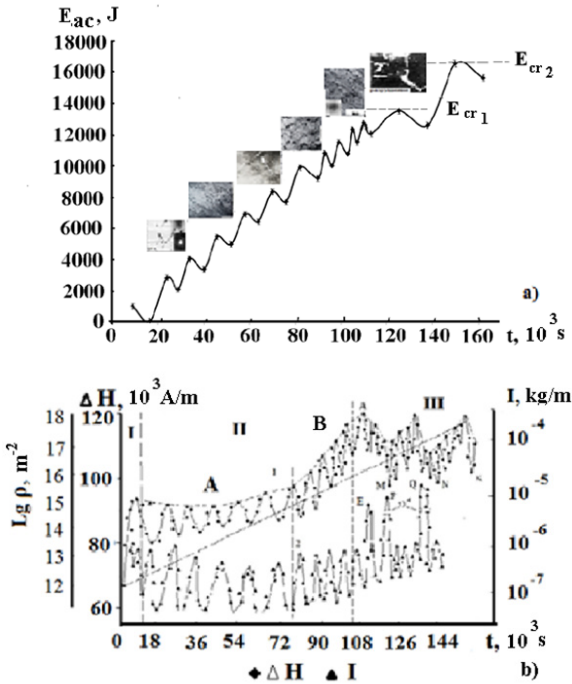
where  $\zeta$  - thermal conductivity,  $\rho$  - material density,  $Z$  - defect flux density,  $\Sigma$  - hydrostatic stress in the defect phase formation zone, parameters  $\alpha$  and  $\Omega$  characterize the energy flux through the surface. The first summand in expression (5) is entropy production associated with heat generation. The second summand determines the work of defects flux when they move in the stress field. The third summand is related to the energy flow of the mechanical field of the crystal through the surface. The plus or minus sign determines the direction of the energy flow [7]. The change of the flow direction is determined by the energy advantage of the self-organization process or, in a broader sense, by the principle of least action. The latter implies the search and establishment of invariants.

Correctly chosen scale factor of external influence or in this particular case soft mode of triboloading (or low-amplitude, alternating and multicycle external influence) allowed to analyze kinetic changes of hardening and softening of nickel surface (Fig. 2). Nickel was chosen as an object of study because its coefficient of magnetostriction is two orders of magnitude higher than, for example, that of armco-iron [4]. The latter made it possible to see or analyze changes in the strength properties of the nickel surface using the ferromagnetic resonance (FMR) line broadening method. Simultaneous study of nickel samples by weight method allowed to analyze their wear intensity (Fig. 2). Overlapping of two curves in one Fig. 2 allowed us to see their asynchronous dependence for one and each cycle of change in surface strength properties. The dependence of accumulated energy ( $E_{\text{ac}}$ ) on time ( $t$ ), where  $E_{\text{cr1}}$  and  $E_{\text{cr2}}$  are values of critical energy for destruction of meso- and macroscale level of deformation [8].

There is an accumulation of dislocations up to some critical value, determined by the size of the formed wear particle and their number per unit volume. The latter is determined by boundary conditions, namely: strength properties of the boundary lubricating layer, surface of metals by intensity of external influence. To describe the different modes of boundary friction, an invariant criterion has been developed. The ratio of the registered contact resistance ( $R_c$ ) to the resistance of the initial metal surface (without lubrication and at the initial moment of triboloading time) taking into account the oxide film ( $R_{ok}$ ) characterizes the state of the interface and the expression is executed:

$$\frac{R_c}{R_{ok}} = const \quad (6)$$

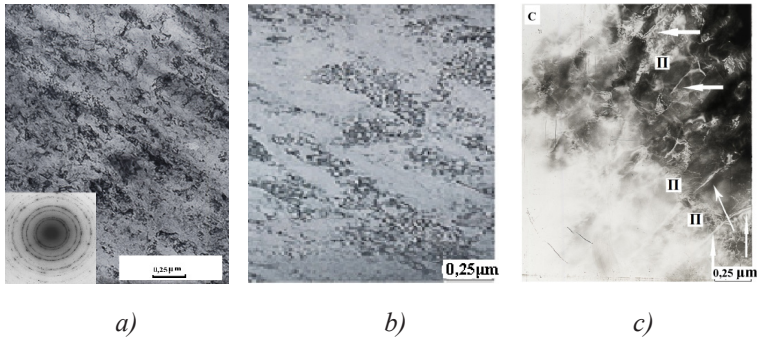
where const depending on the mode of friction is much greater than unity ( $\gg 1$ ), greater than unity ( $> 1$ ), equal to unity ( $= 1$ ), less than unity ( $< 1$ ).



**Figure 2.** Dependence of kinetics of structural changes of nickel surface layer under tribolading: a) – dependence of accumulated energy ( $E_{ac}$ ) on time ( $t$ ), where  $E_{cr1}$  and  $E_{cr2}$  are values of critical energy for destruction of meso- and macroscale level of deformation; b) – dependence of broadening of ferromagnetic resonance line ( $\Delta H$ ), dislocation density ( $\rho$ ), wear intensity ( $I$ ) on time ( $t$ ) of tribolading

It is necessary to emphasize the main and, at first sight, obvious fact that the formation and evolution of structural boundaries proceeds in accordance with the energy profitability [9]. Dislocations under the action of the stress fields line up in accordance with the energy profitability in polygonal structural formations: lamellar structures, which are stretched under the action of stresses into bundles, which in turn begin to form slip bands (Fig. 5) [2]. It is energetically advantageous for the material to form these structures, since the sliding of the latter allows the relaxation of the accumulated energy without unnecessary costs.

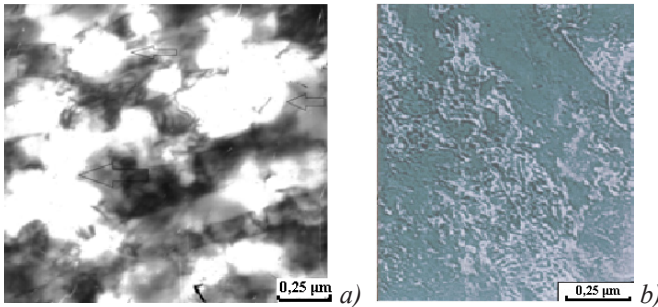




**Figure 3.** Nickel structure changes with triboloading time ( $t$ ): a) – nanostructured formations ( $t = 0.9$  ks; inset microdiffraction); b) – quasi-uniformly distributed textured contours ( $t = 3.6$  ks); c) – slip bands ( $t = 21.6$  ks)

As soon as it is physically possible to implement through one or another mechanism (twinning, formation of package defects, etc.), it is immediately launched according to the energy benefit, since the result of the process is the reduction of the energy accumulated as a result of the deformation in the material (Fig. 2). The formation of nanocrystalline structures (NC) at the very beginning of triboloading ( $t = 0.9$  ks) is due to energy localization in a thin nickel surface layer and the absence of energy relaxation channels and mechanisms into the subsurface layer due to the juvenile pre-annealed nickel surface, where microcracks, pores and other elements of the defective structure are absent. Energy localization allowed to reduce the time of formation of the same structures, but already at  $t \approx 140$  ks. Under prolonged triboloading a strongly thermodynamically nonequilibrium surface layer of nickel covering up to a hundred microns in depth was obtained. There is an obvious relationship between time and energy, since the localization of energy reduces the time of realization of the process of formation of NK structures. The nano- level deformation of the interface (both above the surface (boundary lubricating layer) and below the surface) was investigated and its leading role in the self-consistent interaction of the structure-scale deformation levels was shown, and it was proved to have the unique property of structure self-regulation [2, 7]. The latter consists in changing the direction of the dislocation flux gradient during the elastic scattering of dislocations in the stress fields when a certain or critical dislocation density is reached and they are brought closer together by a distance of less than 50 nm [7].

Strong porosity is also observed in the lamellar microstructure of deformed nickel (Fig. 4) [4].



**Figure 4.** Pore formation: a) formation of micropores in the lamellar structure –  $t = 9.2$  kc; b) formation of the dispersed and porous (friable) layer during pre-destruction ( $t = 140$  kc). The image is invented for better contrast and clarity

The degree of porosity reaches  $\approx 15$  % of the entire observation area, which conditions the surface preparation for the lamellar fracture mechanism [4]. With increasing frictional loading time ( $t > 108$  ks) there is a progressive loosening of the metal surface layer, associated with an increasing number of fracture zones and the formation of submicroporosity. At the stage of maximum plastic deformation, this loosening covers deeper layers and, in combination with developed brittleness, causes a stronger crushing of wear particles and a sharp increase in the flaking mass of the material, which is characteristic of the selective fracture mechanism [4]. Layer thickness can reach up to  $\approx 100$   $\mu\text{m}$ . The degree of porosity reaches more than 30 % of the entire observation area.

Analysis of the experimental data of the strongly nonequilibrium structure (Fig. 2, region III) shows that an increase in the total area of porosity also determines an increase in the volumetric wear rate (section PR in region III in Fig. 2) [8]. In the area of nonequilibrium deformation the gradient of the dislocation and point defects density flux has an oscillating character; the increase in the intensity of the gradient of upward and downward dislocation density fluxes causes an increase in the lower limit of wear intensity change in  $\approx 8$  times (area PR on fig. 2 in area III), and the upper limit of wear intensity change at avalanche-like selective mechanism of surface layer destruction – by three orders of magnitude (fig. 2, area III). At the same time, in area III a decrease in the period of change of strength properties of the nickel surface by  $\approx 8$  times is noted in comparison with area II (Fig. 2). There is a complete coordination of change of strength properties and volumetric wear rate of nickel surface. Increase in 8 times of intensity of a gradient of ascending and descending flows of dislocation density causes both diffusion mobility of point defects and increase in porosity of a material. Directly proportional increase of minimal value of volumetric wear intensity with increase in time of triboloading is established (fig. 2, area III). The expression is fulfilled [8]:

$$\frac{I}{S} = \text{const}, \quad (7)$$

where  $I$  is the volumetric wear rate,  $S$  is the total pore area,  $\text{const} \geq 0$ .

Further studies of non-dislocation mechanisms and the establishment of invariants in the self-organization of a highly nonequilibrium structure (Fig. 2, region III) are needed.

**Conclusion.** The article convincingly shows that the symmetry of the properties of the continuum of space and time determines the use of the principle of least action to find and establish the invariants or the basic fundamental laws of the evolution of the structure of materials, regardless of the method by which they are obtained (rolling, triboloading, ultrasound, etc.). The establishment of invariants confirms the universality of using the scientifically sound fundamental principle of the least action for the creation, evolution, and destruction of materials, including nanomaterials of various functional purposes. The application of this principle, which describes various kinetic processes at the junction of different sciences: physics, chemistry, bmesomechanics, nonequilibrium thermodynamics, etc. determines not only the kinetics of evolution, but also the search and establishment of new fundamental, invariant laws for processes occurring in space-time continuum.

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俄罗斯远东南部蔬菜种植中的适应性景观农业  
**ADAPTIVE LANDSCAPE FARMING IN VEGETABLE GROWING  
IN THE SOUTH OF THE RUSSIAN FAR EAST**

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注解。通过确定短轮作和大量田地的蔬菜作物轮作（燕麦-大豆种子蒸汽 - 白菜 - 甜菜 - 胡萝卜）的最佳前体和前因，使我们能够提出最佳的作物轮作和农业措施。蔬菜农场境内的景观组织。

关键词：不同景观要素土壤肥力指标、垄-垄作物栽培技术、作物产量、蔬菜短轮作、蔬菜农场组织。

**Annotation.** *The determination of optimal precursors and antecedents in vegetable crop rotations with short rotation and a large set of fields of plots (oatmeal-soy seed steam - white cabbage - table beet - carrot) allowed us to propose optimal crop rotations and measures for the agro-landscape organization of the territory of vegetable farms.*

**Keywords:** *Indicators of soil fertility of different landscape elements, ridge-ridge technology of crop cultivation, crop yield, short vegetable crop rotations, organization of vegetable farms.*

The concept of adaptive landscape farming in Russia was developed by the Agriculture Department of the Russian Agricultural Academy and formed into a coherent system at the end of the last century. It has found successful implementation in almost all federal districts of Russia with developed field crop production. Methodological recommendations issued by Rosinformagrotech in 2005 were adopted as the final document [1].

However, for such a specific industry as vegetable growing, where cultivated crops impose increased and more diverse requirements to external conditions than field crops, these recommendations need to be clarified [2]. The former shortcomings of the industry should also include excessive concentration of potato and vegetable crops (up to 400-600 hectares per farm), the lack of the necessary amount of land suitable for vegetable growing, which prevented the introduction of crop rotations with sideral pairs. The latter, in the absence of a well-established protection against weeds, diseases and pests, this made it possible to realize the potential of cultivated varieties by 30 to 40% at best. The placement of vegetables on sloping locations in a monsoon climate caused intense rain erosion of the soil from heavy rains [3].

Therefore, the system of agriculture in vegetable growing that developed in the 80s of the last century required a radical revision and its transfer to an adaptive landscape basis.

The purpose of this publication is to summarize the experimental data obtained as a result of research on agricultural landscape studies carried out in 1991-2023 at the Primorsky Vegetable Experimental Station – a branch of the Federal Research Center for Vegetable Growing [4-6].

At the same time, the following tasks were set: 1) to characterize the experimental plot from the agro-landscape positions, 2) to identify the influence of the main factors on the yield of the main crops, 3) to show the identified most effective links of crop rotations, 4) to reflect the influence of the organization of the territory of vegetable crop rotations on their productivity.

Objects, methods and conditions of experiments. The object of the study was the adaptive landscape system of agriculture (subsystems: regulation of the water regime of soils, fertilizers, varietal composition and soil treatment). The research was carried out on the experimental field of the Primorsky Vegetable experimental station - a branch of the FSBI FNC with an area of 6 hectares, representing the basement slope of a high fourth terrace, which looked like part of a cliff. A more detailed description of the landscape components of the experimental site is summarized in Table 1. Many years of field experience was laid at this site, in which four factors were evaluated – FA) presence- absence of drainage, FB) four fertilizer systems, FC) varieties and hybrids, FD) method of soil treatment during the growing season (variants 1 COR-5,4 with passive organs and 2 GFN-determining the level of vegetable yield crops in crop rotation: double oatmeal-soy steam - white cabbage (varieties of Primorskaya OOS: Knevichanka, Artemovka, Bliz-zard; , varieties of the West Siberian OOS: Discovery, Sarattoga)- carrots – beets canteen. Varieties were tested: white cabbage of local selection Knevichanka. The experiments were laid and carried out in accordance with the methodological recommendations of the Federal Research Center for Vegetable Growing [7], as well as [8-11].

The crops were grown on ridges and ridges according to the technology developed by the Primorsky OOS using a complex of machines with a working width of 1.8 and 5.4 m. The area of the working plot corresponded to 12m x 10.8 m.

**Table 1.**  
*Agro-landscape characteristics and organization of the experimental site*

Elements	Parameters	Unit Measurement	Value
<b>Landscape characteristics</b>	Coordinates of the	graid, min	43° 25 s.l
			132°19 v.d
<u>Relief</u> - uval, the middle part of the slope of the basement fourth terrace (according to the Geomorphological map of Ganeshin G.S., 1958]	Height – h	m	46.3
	Width	M	100
	Length- l	m	200
	Area	ha	6
	Surface slope, slope top	h/l	0.03-0.04
	The middle part of the slope	h/l	0.01-0.02
	Lower part of the slope, slope	h/l	0.005-0.007
	Exposition	-	NW
<u>Soil 1</u> - meadow-brown bleached medium-sized medium-loamy drained (according to the soil map of G.I. Ivanov, 1999)	Soil profile capacity (MPP)	m	1.6
	The thickness of the humus horizon (MGG)	cm	15
<u>Soil 2</u> – meadow-brown bleached medium-thick medium loamy	MPP	m	1,7
	MGG	cm	20-25
<u>Soil 3</u> -meadow gley powerful heavy loamy	MPP	m	2.2
	MGG	cm	>30
<u>Climate</u> - pronounced monsoon «Agro-climatic resources of Primorsky Krai» (1967)	Frost-free period	days	145-158
		Sum of temperatures	> 10°C
	Precipitation for July-September	mm	400-500
	Maximum daily	mm/day	100-150
	Maximum for 2-3 days in a row	mm	250

<b>Regulation of the water-air regime of soils</b>			
The drainage	Pipe material : plastic, corrugated, perforation -1 mm coated with glass wool		
	Depth of laying	m	1,2
	Interline distances	m	7
Ridges	Width at the base	cm	180
	Depth (height)	cm	26
	The width of the ridge on the surface	cm	110-120
	The number of ridges on the ridge	pcs	2
Crests	Width at the base	cm	90
	Width at the top	cm	35-40
	Height	cm	25-30
	Length	m	100-400
Buffer blackened strips for the discharge of surface water from furrows to the «surface»	Width	m	8-10
	The distance between them is	m	100-190
The possible working length of the gons according to anti-erosion indicators is	The upper part of the slope	m	240-300
	The middle part of the slope is	m	100- 180
	The lower part of the slope	m	360-400
Irrigation with small irrigation norms	Only on the drained part. Daily norm Irrigation with small irrigation norms Only on the drained part. Daily norm	mm	2-5
The marked maximum washout during heavy rainfall is the upper part of the slope	The upper part of the slope	t/ha	50-160
	The middle part of the slope is	t/ha	1-8
	The lower part of the slope	t/ha	1,0 – 1,5
<b>Organization of the territory:</b>			
Number of fields- plots	pcs	21	
The area of the crop rotation uch-ka	ha	2	
Repair field-a site of oats, soy is sown of Sideral double oat-soy steam After plowing the bio-mass			
Used crop rotation: Oatmeal-soy steam - white cabbage – carrots - beets canteen			



Even at the end of the first millennium, it was known that the size of the harvest depends on the location on the slope and this is confirmed by our observations - different moistening of parts of the slope (Table 2) and differences in the content of nutrients (table 3). Indeed, this is clearly manifested in cabbage plantings, carrot crops and table beets. And this has the most dramatic effect in years with excessive and scarce rainfall. All this (location in relief) affects the overall productivity of crop rotation (Table 3), Moisture determines the degree of marketability of the products obtained, especially root crops, and white cabbage. The optimal humidity value for vegetable crops in both cases is 0.8 of HB, which is equal in this case to 24%.

**Table 2**  
*Influence of the location of crop rotations on the moisture content in the arable soil horizon, mm*

Soil layer, cm	White cabbage.		Carrot		Beetroot dining room.		Average crop rotation	
	The part of the slope							
	is the middle	lower.	is the middle	lower.	is the middle	lower.	is the middle	lower.
The first half of summer. Dry								
0-10	13,1	18,5	12,8	25,6	21,7	27,1	-	-
10-20	19,1	24,3	20,1	32,9	25,7	33,4	-	-
20-30	18,5	28,5	21,6	33,8	27,3	36,9	-	-
0-30	50,7	71,3	32,9	92,3	74,7	97,4	-	-
The second half of summer. Waterlogged								
0-10	35,4	48,2	36,1	40,3	37,2	53,6	36,2	47,4
10-20	35,3	53,4	37,6	45,5	42,2	59,3	38,4	52,7
20-30	39,2	54,0	39,8	46,1	42,8	59,3	40,6	53,1
0-30	109,9	107,4	113,5	131,9	122,2	172,2	-	-

**Table 3**  
*Agrochemical indicators of the arable soil layer of different parts of the slope*

Indicator	Units of measurement	Parts of the slope		
		Average		The lower
		one is not wooden	drained	
Capacity of the arable layer	cm	20-25	20 - 22	>30
Soil acidity	pH	5,5 - 6,2	4,0 - 4,9	5,6 - 6,0
Humus	%	5,2 - 5,7	4,4 - 5,0	7,0 - 7,2
Mobile phosphorus P2O5	мг/ 100 г	14,1 - 22,4	6,8 - 19,9	30,7 - 34,3

Exchange potassium K2O	мг/ 100 г	17,8 – 26,6	12,8 – 18,5	25,7 – 28,4
Commercial products for rotation of crop rotation	т/га	38,9	116,4	113,6
	см	100	299,2	299,0

Of course, the most favorable for vegetable crops is the middle and lower parts of the slope. Compared to the upper part, productivity in this location increases almost threefold.

**Table 4.**

*The influence of the location of the crop rotation in the relief and moisture content of the year on the crop yield and the overall productivity of the crop rotation*

Growing season	Yield of marketable products, t/ha						Total per rotation			
	Field 2		Field 3		Field 4		Total, t/ha		Difference, ±	
	Cabbage		Carrot		Beetroot					
	Part of the slope									
	he middle	he lower.	he middle	he lower.	he middle	he lower.	he middle	he lower.	he middle	he lower.
1997	13,0	35,1	52,2	48,3	41,0	47,4	106,6	130,8	-24,2	-22,7
2000	35,0	10,0	34,0	23,4	30,2	15,3	99,2	48,7	+50,5	+49,1
1999	60,0	64,4	32,2	29,6	62,4	58,1	154,6	152,1	+2,5	+1,6
** - average	36,0	36,5	39,5	33,8	44,5	40,3	120,1	110,5	+9,6	+8,7

Note.\* - Growing season by year: 1997 - deficient in precipitation, 1999 - close to normal, 2000 – excessive in precipitation. \*\* - average for 1997, 1999 and 2000

The yield of crops in these different parts of the slope in the first and second half of the growing season under different crops is illustrated by Table 4.

**Table 5.**

*Commercial yield of varieties and hybrids of white cabbage in t/ha*

Fertilizer system* - Factor B	Options for regulating the water regime of the soil - Factor A									B Average	
	Without drainage				Average	Drained					Average
	Varieties and hybrids - Factor C***					Varieties and hybrids - Factor C***					
	1	2	3	4	1	2	3	4			
BU - control	34,7	29,9	27,9	29,6	30,5	39,5	34,8	30,0	37,4	35,4	33,0
MU	40,5	33,7	36,5	34,4	36,3	43,2	36,1	36,3	38,8	38,6	37,5
OU	41,4	39,5	35,7	40,4	39,3	46,4	41,9	36,1	44,1	42,1	40,7
OUM	42,3	43,0	40,9	42,2	42,1	47,6	43,8	40,0	42,1	43,4	42,8
Av. AC **	39,7	36,5	35,2	36,7	37,0	44,2	39,2	35,6	40,6	39,9	38,5

Note.\* - Fertilizer systems: BU – control - without fertilizers; MU- mineral fertilizer system , N90P60K150; OU- organic fertilizers, peat compost 50 t/ha; OUM – organo-mineral system: peat compost 50 t/ha + N90P60K150; \*\* Av. AC– average for factors A and C; \*\*\*- Varieties and hybrids of cabbage: 1- *Knevi-chanka*, 2- *Vuga*, 3-*Amtrak F1*, 4-*Saratoga F1*.

Such a factor as the climatic moisture content of the growing season has been studied. It is the share of its influence on the yield of vegetable crops that is more than 50%: cabbage 76.9, root crops 65.8%, potatoes -59.6% (Table 6, 7). Of course, other factors and their interactions account for less than 50%.

**Table 6**  
*Influence of factors on the yield of white cabbage, in t/ha*

Factor options	2004		2005		2006		Average 2004-2006	
	general	commodity	general	commodity	general	commodity	general	commodity
I. Regulation of the water-air regime of soils, Factor A								
Without drainage	53,6	49,4	10,1	6,0	53,4	47,8	39,0	34,4
Drained	54,5	47,4	30,5	25,8	46,6	42,3	43,9	38,5
HCP <sub>0,5</sub>	1,7	1,8	1,0	1,1	1,4	1,4	1,0-1,4	1,1-1,8
II. The influence of the fertilizer system. Factor B								
Without fertilizers	42,9	38,3	15,1	11,1	45,4	41,1	34,4	30,2
Mineral water	54,3	49,0	20,3	15,9	48,0	43,5	40,9	36,1
Organic	59,1	53,3	21,0	16,2	54,5	47,1	44,0	38,9
Organo-mineral	59,9	52,9	25,0	20,4	54,5	48,6	46,5	40,7
HCP <sub>0,5</sub>	2,5	2,5	2,0	2,2	2,8	2,8	2,0-2,8	2,0-2,8
III. Varieties and hybrids. Factor C								
Knevichanka		52,8	28,5	23,4	53,8	45,7	47,2	40,6
Vuga	59,5	48,3	23,9	19,9	52,4	41,5	45,3	36,6

**Table 7.**  
*Reliably proven contribution of factors and their interactions in crop formation\**

Factors	Cultures			
	White cabbage	Carrot	Beetroot dining room	Potato
Drainage -A	29,1	31,8	49,0	6,0
Fertilizers - B	17,1	15,9	11,1	9,4

Varieties - C	35,4	24,1	15,4	52,0
AB	-	-	-	-
AC	13,9	14,8	-	9,3
ABC	-	12,9	9,4	-

Note.\*- dash means unreliable values of the action of factors

Changing the ratio and alternation of crops in the crop rotation significantly changes its overall productivity (Table 8).

**Table 8.**  
*The effect of optimizing the ratio and alternation of crops on crop rotation productivity*

Crop rotation	Rotation time	Alternating cultures	Output of vegetable products, t/ha			
			In total for rotation		On 1ha of the area	
			Com-mon	Com-mo-dity	Com-mon	Com-mo-dity
I	1997-2000	Sideral steam – cabbage - carrot – cabbage - beet canteen				
			184,7	130,5	46,2	32,6
II	2001- 2005	Sideral steam – cabbage - carrot – cabbage - beet canteen				
			222,9	182,6	44,6	36,5
Increase (+) or decrease (-) in output		t/га	+38,2	+52,1	-1,6	+3,9
		%	+20,7	+39,9	-3,5	+12,0
III	1997-2000	Sideral steam – cabbage - carrot – beet canteen				
			152,3	127,0	31,7	31,7
IV	2001-2005	Sideral steam – cabbage - carrot – cabbage – beet canteen				
			166,9	151,9	38,0	38,0
Increase (+) or decrease (-) in output		t/га	+14,6	+24,9	+3,6	+6,3
		%	+9,6	+19,6	+3,4	+19,9

**Table 9.**  
*The influence of the organization of the territory of vegetable crop rotations on their productivity (data obtained in the field)*

Index	Value	Garrot		Beetroot dining		White cabbage		Total 2004
		2001	2004	2001	2004	2001	2004	
Number of crop rotations,	pcs	4	8	4	8	7	12	23
Field area	ha	40	40	48	48	53	53	141
Average field area	ha	8-10	1-5	8-10	1-6	8-10	1-6	1-5

Yield	t/ha	23,6	28,4	28,6	34,7	22,4	28,0	30,4
Output of products,	thou- sand t	945,0	1,134	1,25	1,67	1,484	3,39	4,284
Increase	t	0	189,4	0	415,5	0	292,5	897,3
	%	0	20	0	33,2	0	24,5	26,4

The introduction of oat-soybean steam (25%), and short vegetable crop rotations (4-5 fields), organizational measures (an increase in the initial number of crop rotation sites from 12 in 2001 to 23 in 2004, a decrease in the average size of the field site from 8-10 hectares to 1-6 hectares caused an increase in the total productivity of the territory by 26.4% (table 9).

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楚科特卡 FANDYUSKINSKOE 极煤矿床的植物化石遗骸  
**FOSSIL REMAINS OF PLANTS FROM THE FANDYUSHKINSKOE  
POLE COAL DEPOSITION, CHUKOTKA**

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抽象的。这篇文章涉及植物化石，这些化石经常在 Fandyushkinskoye Pole 油田及其侧翼的含煤矿床中发现。确定了它们的物种组成，并得出了它们与楚科奇南部经过充分研究的古生物群的可比性的结论。

关键词：楚科奇、煤炭、古植物学。

**Abstract.** *The article deals with plant fossils, often found in coal-bearing deposits of the Fandyushkinskoye Pole field and its flanks. Their species composition was determined, and conclusions were drawn about their comparability with well-studied paleontological complexes in southern Chukotka.*

**Keywords:** *Chukotka, coal, paleobotany.*

**Introduction.**

The “Fandyushkinskoe Pole” deposit is located on the territory of the Chukotka Autonomous Okrug, 40 km west of the southern coast of the Bering Sea. Coal-bearing deposits belong to the Koryak formation of the Upper Cretaceous. The main productive formation of the field is “Odinokiy”. The seam is divided into four coal packs, which have independent significance (Vyalov et al., 2019). In the intercoal layers and subsoil of the Odinokiy formation, a large number of plant remains and coalified detritus are found. They are mainly confined to rocks with a fine-grained structure (mudstones and siltstones). The thickness of the observed layers is on average 3-12 cm, both thicker (more than 2 m) and thinner (up to 1 cm) are found. Such fine-grained rocks are subject to rapid weathering and destruction and are poorly observed in natural outcrops. Using drill cores from wells, it is pos-

sible to obtain high-quality rock samples that retain their integrity after being extracted to the surface. More than 30 samples from 4 wells were selected for study.

Six species of fossil plants were identified from the sediments of the upper subformation of the Koryak formation of the Odinokey coal seam (Figure 1). Ferns are rare and are represented by one species, *Coniopteris tschuktschorum* (Krysht.) Samyl. from the family Dicksoniaceae. Conifers include two species from the family *Pinaceae* - *Pityophyllum* sp. and *Picea* sp. (cone), as well as one species from the family *Cupressaceae* - *Metasequoia* ex gr. *occidentalis* (Newb.) Chaney. The latter species is dominant. From flowering plants, fragments of leaves of *Trochodendroides* sp. were identified. (family *Cercidiphyllaceae*) and *Corylites* sp. (family *Betulaceae*).

The species composition of plants from the sediments of the upper subformation of the Koryak formation of the Odinokey coal seam is comparable to the Late Maastrichtian Koryak floristic complex from the upper part of the Koryak formation of the Emima-Ilnaivaam interfluvium. This complex of plants was described under the name “Koryak flora” (Golovneva, 1994; Moiseeva, 2012). Thus, we attribute the complex of plants from the “Odinokey” layer to the Late Maastrichtian Koryak flora. This flora included 32 species of plants, which were represented by horsetails, ferns, ginkgoaceae, conifers and flowering plants (Golovneva, 1994; Moiseeva, 2012). The Koryak flora, in its composition, has the greatest similarity with the Late Maastrichtian-Danish Rarytkino flora, known from the upper part of the middle subformation of the Rarytkino Formation of the Range. Rarytkin (Golovneva, 1994).

The main part of the plants discovered from the deposits of the upper subformation of the Koryak formation of the “Odinokey” coal seam belonged to a mixed coniferous-broad-leaved forest, which was dominated by representatives of cypress (*Metasequoia*) and pine (*Pityophyllum*, *Picea*), and among flowering plants - trochodendroides and birch (*Corylites*). Ferns played the least role in the composition of vegetation and grew in the undergrowth or in the floodplains of rivers.

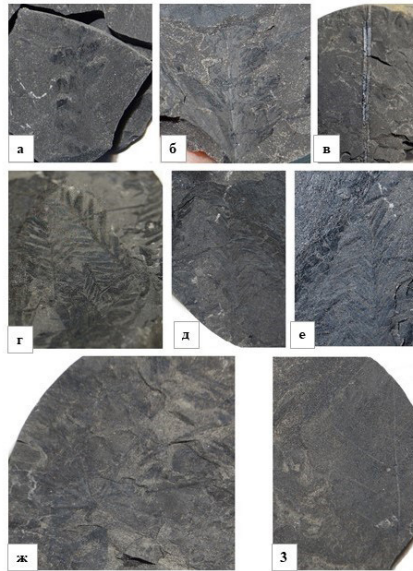
4. The organic matter of coals is formed from the remains of higher plants with a predominance of conifers; within the northern humid climate zone in warm and humid conditions close to subtropical.

The coal formation area under consideration was located within one climatic zone – the northern humid one. On the foothill lowlands of the coasts of seas and large basins, the climate is characterized by increased temperature and humidity, which was probably typical of the Bering Basin. In warm and humid climates, low-thickness coal seams most often form on the sea coast.



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**Figure 1.** Fossil plants of the “Odinokiy” formation: a, b – sterile feath-  
ers of *Coniopteris tschuktschorum* (Krysht.) Samyl., a – x3, b – x4; c – leaf of  
*Pityophyllum* sp., x1; d, e – shoots of *Metasequoia* ex gr. *occidentalis* (Newb.)  
Chaney, x1.5; f – cone of *Picea* sp. and escape *Metasequoia* ex gr. *occidentalis*  
(Newb.) Chaney, x1.5; g - *Trochodendroides* sp., x2; h - *Corylites* sp., x2.

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