MINISTRY OF SCIENCE AND HIGHER EDUCATION OF THE REPUBLIC OF KAZAKHSTAN

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NATIONAL REPORT ON SCIENCE

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The National Science Report for 2023 contains an analysis of the state, trends and prospects for the development of world and Kazakhstani science, as well as the most significant achievements of domestic science. It also provides an analysis of the implementation of fundamental and applied research in 2023 in accordance with the priority areas of science development in Kazakhstan established by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan, as well as the results of scientific activities of organizations and scientists of the republic in the main areas of scientific development for 2023.

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1. INTRODUCTION (THE PURPOSE OF THE NATIONAL REPORT)

The National Science Report is an annual report containing an analysis of the state and development trends of world and national science, a justification for priority areas of scientific development, and proposals for improving the scientific and technical potential of the Republic of Kazakhstan.

The purpose of the annual National Science Report (hereinafter referred to as the Report) is to analyze the state of the main trends in the science development, identify positive and negative factors influencing the development of Kazakhstan's science, develop recommendations for further development and determine priority areas for its development.

The implementation of scientific research in 2023 was carried out in accordance with the 10 priorities for the science development for 2023 approved at a meeting of the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan (hereinafter referred to as the HSTC): Rational use of water resources, flora and fauna, ecology; Geology, extraction and processing of mineral and hydrocarbon raw materials, new materials, technologies, safe products and designs; Power engineering and mechanical engineering; Information, communication and space technologies; Scientific research in the field of natural sciences; Life and health sciences; Research in education and science; Research in social and human sciences; Sustainable development of the agro-industrial complex and safety of agricultural products; National security and defense.

The analysis of the implementing fundamental and applied research in priority areas of science (section No. 3) was carried out by leading scientists working in the laboratories of research institutes and in the departments of higher educational institutions of the country:

S. **Kaldybayev**, Doctor of Agricultural Sciences, Professor of the Department for Soil Science, Agrochemistry and Ecology of the Kazakh National Agrarian Research University. *Priority I* – "Rational use of water resources, flora and fauna, ecology".

T. Yensepbayev, Doctor of Geological and Mineralogical Sciences, Professor, Corresponding Member of the National Academy of Science of the Republic of Kazakhstan, Head of Department of the National Joint-Stock Company "KazNRTU named after K.I. Satpayev". *Priority II* – "Geology, extraction and processing of mineral and hydrocarbon raw materials, new materials, technologies, safe products and constructions".

A. Begimbetova, Candidate of Technical Sciences, Director of the Institute of Energy and Green Technologies at the Almaty University of Power Engineering and Communications named after Gumarbek Daukeyev. *Priority III* – "Power Engineering and Mechanical Engineering", section "Power Engineering".

B. Absadykov, Doctor of Technical Sciences, Professor, Corresponding Member of the RPA "NAS RK", NJSC "KazNRTU named after K.I. Satpayev".

Priority III – "Power Engineering and Mechanical Engineering", section "Mechanical Engineering".

Ye. Amirgaliyev, Doctor of Technical Sciences, Professor, Academician of the National Engineering Academy of the Republic of Kazakhstan, Institute of Information and Computing Technologies of the SC of MSHE RK. *Priority IV* – "Information, Communication and Space Technologies".

Ch. Omarov, Candidate of Physical and Mathematical Sciences, Professor, Director of the Astrophysical Institute named after V. Fesenkov. *Priority V* – "Scientific Research in the Field of Natural Sciences".

A. Yeshmanova, Doctor of Medical Sciences, Associate Professor, Head of the Innovative Scientific School of Gerontology and the Module "Gerontology and Geriatrics" of KazNMU named after S. Asfendiyarov. *Priority VI* – "Life and Health Sciences".

A. Mynbayeva, Doctor of Pedagogical Sciences, Professor, Head of the Department for General and Applied Psychology, Faculty of Philosophy and Political Science, Al-Farabi Kazakh National University. *Priority VII* – "Research in the Field of Education and Science".

Ye. Toktarov, PhD, Head of the Strategic Analysis Department, Kazakhstan Institute for Strategic Studies under the President of the Republic of Kazakhstan. *Priority VIII* – "Research in the Field of Social and Humanitarian Sciences".

A. Shamshidin, Doctor of Biological Sciences, Deputy Rector-Chairman of the Board, Vice-Rector for Science, NJSC "West Kazakhstan Agrarian and Technical University named after Zhangir Khan". *Priority IX* – "Sustainable Development of the Agro-Industrial Complex and Safety of Agricultural Products".

M. Serkpayev, Doctor of Historical Sciences, Professor, President of the RPA "Academy of Military Sciences". *Priority X* – "National Security and Defense".

Sections No. 2,4,5,6 of the Report, prepared under the scientific supervision of the President of JSC "National Center for State Scientific and Technical Expertise" of the Ministry of Science and Higher Education of the Republic of Kazakhstan **A. Bibosinov**, present: an analysis of the science general state in Kazakhstan, its scientific, scientific-technical and human resources potential; the main directions of Kazakhstan's development and world science are shown, a comparative assessment of the science state in the country and the world is provided; the scientific achievements of Kazakhstani scientists, the results of scientific activities of institutes and higher educational institutions of the Republic of Kazakhstan for 2021-2023 are reflected.

At the initiative of the NAS RK, for the first time the Report includes a section "Achievements of Young Scientists of Kazakhstan", which reflects the results of scientific activities and problems of development of young science of the Republic of Kazakhstan.

2. GENERAL CHARACTERISTICS OF KAZAKHSTAN SCIENCE (with presentation of scientometric analysis for the last 3 years, analysis of achievements of Kazakhstani science (the most significant results of scientific and (or) scientific and technical activities, implemented developments), indicators of research activity of scientists (number of publications, citation index, impact factor of journals, patent activity)

To assess the position of countries in key areas of the economy, international organizations regularly conduct studies on various indicators and indices, from which a list of ratings and indices is compiled [1].

Human Development Index (HDI). Despite the decrease in the rating for this index (-11), Kazakhstan with an index of 0.802 remains in the group of countries with a high level of human development, occupying 67th place among 193 countries that participated in the rating (Table 2.1).

Table 2.1 Position of the Republic of Kazakhstan in the leading international rankings of scientific, technical and innovative development

Indicators	2021	2022	2023
Human Development Index	51st place among 189 countries	56th place among 191 countries	67th place among 193 countries
Global Competitiveness Index	35th place among 64 countries	43rd place among 63 countries	37th place among 64 countries
Global Innovation Index	79th place among 132 countries	83rd place among 132 countries	81st place among 132 countries

Source: https://gtmarket.ru/research/country-rankings

Global Competitiveness Ranking. The Republic of Kazakhstan demonstrated positive dynamics, moving up 6 positions compared to last year's ranking. As a result, Kazakhstan took 37th place with a score of 66.11 in the IMD 2023 World Competitiveness Ranking.

Global Innovation Index (GII). In 2023, Kazakhstan, with an index of 26.7, took 81st place and 3rd place in the Central and South Asia region, moving up two lines and displacing Uzbekistan to 82nd place overall. In the Infrastructure category, Kazakhstan took 59th place and first place in the region, thanks to good performance in the government online service (8th place) and e-participation (15th place).

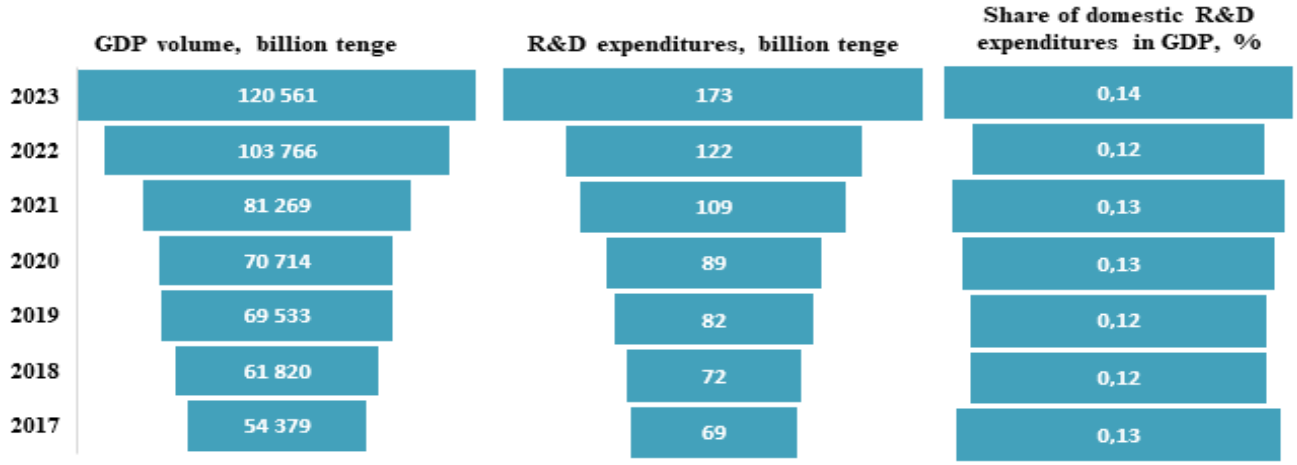
Many regions, including Kazakhstan, set their own targets for R&D spending. Thus, our country, in the Concept for the Development of Higher Education and Science in the Republic of Kazakhstan for 2023-2026, plans to gradually **increase R&D expenditures** from all sources to 1% of GDP in order to increase the global competitiveness of Kazakhstani science and increase its contribution to solving applied problems at the national level.

It should be borne in mind that, according to international standard definitions adopted in the economy of the Republic of Kazakhstan, **domestic R&D expenditures** are synonymous with **R&D results**.

In 2023, there was an increase in R&D expenditures carried out in the Republic of Kazakhstan from 121.6 to 172.6 billion tenge.

However, the increase in costs by more than 51 billion tenge had little effect on the science intensity of GDP, which increased by 0.02% in the reporting year and amounted to 0.14%. Despite the increase in R&D costs, the science intensity of GDP has changed slightly over the past years, remaining at the level of 0.12-0.14% (Fig. 2.1).

An analysis of domestic R&D costs by funding sources shows that, as in previous years, the state remains the main investor in scientific research in 2023. It accounts for almost 67% of costs, which is almost 9 percentage points more than in the previous year.



According to the Bureau of National Statistics of the ASPR RK

Figure 2.1 R&D costs

The share of own funds that can be considered as investments of entrepreneurs decreases annually. In 2023, it stopped at 16%, which is 7.1 percentage points lower than the previous year (Table 2.2).

The share of investments in research activities of third-party legal entities exceeded 5%; the share of other sources was 4.1%. An indicator of uncertainty in the demand for the results of research activities is the low percentage of borrowed bank funds - only 0.1%.

The region's involvement in research and development activities is characterized by specific intensity indicators, such as the volume of internal R&D costs per employee and the number of employees performing them per 10 thousand people employed in the region's economy.

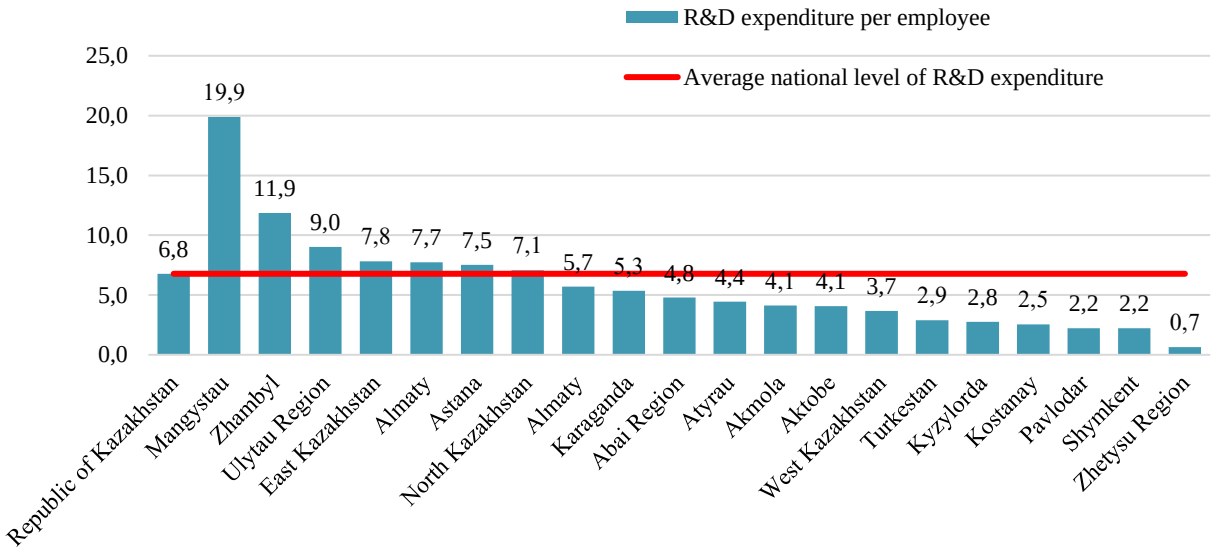
Table 2.2 Volume of internal R&D expenditures by funding sources

Funding sources	2021		2022		2023	
	billion tenge	*%*	*billion tenge*	*%*	*billion tenge*	*%*
Total costs	**109,3**	**100**	**121,6**	**100**	**172,6**	**100**
budget funds	**64,5**	**59,0**	**67,0**	**55,1**	**144,0**	**83,4**
own funds of scientific	36,5	33,4	43,0	35,4	12,7	7,3

Funding sources	2021		2022		2023	
	billion tenge	*%*	*billion tenge*	*%*	*billion tenge*	*%*
organizations						
foreign investments	2,1	1,9	2,8	2,3	2,9	1,7
bank loans	0,04	0,1	0,1	0,1	0,1	0,1
funds of legal entities	4,5	4,1	6,5	5,3	8,8	5,1
other funding sources	1,7	1,6	2,2	1,8	4,1	2,3

According to the Bureau of National Statistics of the ASPR RK

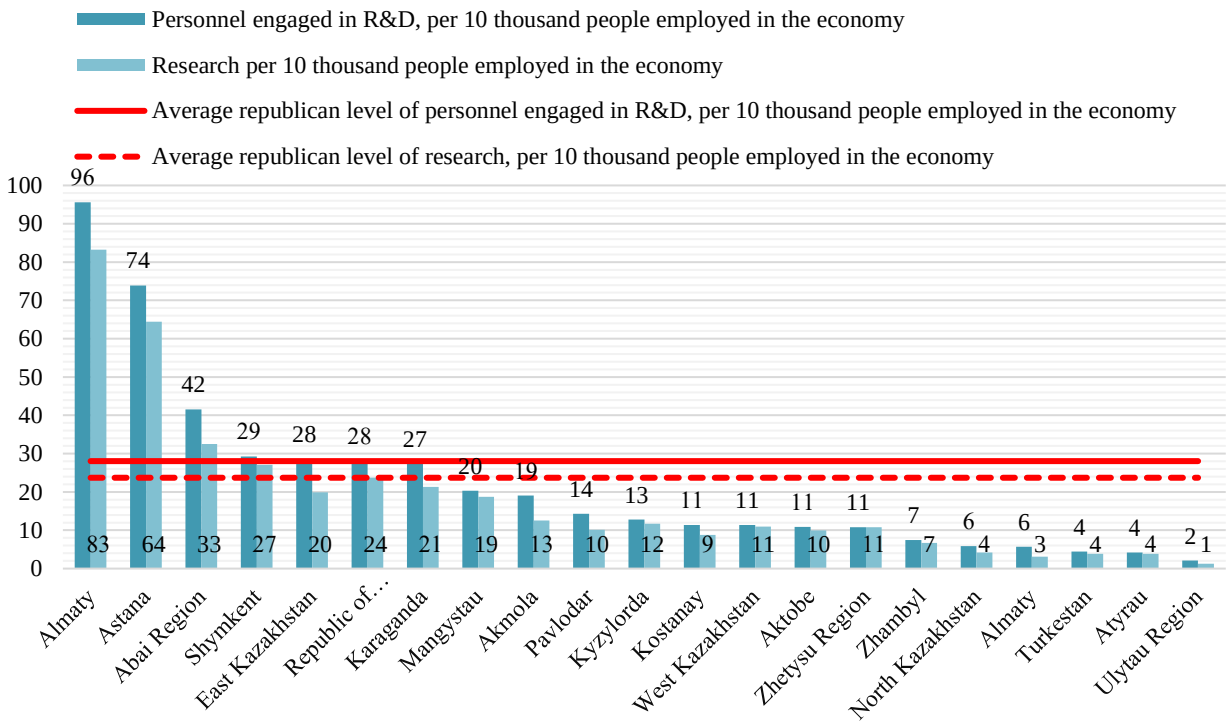
The average R&D expenditure per employee in the republic in 2023 is 6.8 million tenge (Fig. 2.2).



Calculated based on data from the Bureau of National Statistics of the ASPR RK

Figure 2.2 Internal R&D costs per employee engaged in research and development, million tenge in 2023

The above average national level is observed in such regions as Mangistau, Zhambyl, Ulytau, East Kazakhstan, North Kazakhstan regions and the cities of Almaty and Astana. The lowest volume of expenses is observed in the regions of Zhetisu, Pavlodar and Kostanay, as well as in the city of Shymkent. According to the indicator “workers performing R&D per 10 thousand people employed in the economy”, in 2023 the cities of Almaty (96), Astana (74), and the region of Abay (42) were in the lead. The outsiders were the regions of Ulytau (2 people per 10 thousand people employed in the regional economy), Atyrau Turkestan (4 each) and Almaty (6). In the republic as a whole, in 2023 this indicator increased to 28 people per 10 thousand employed, while at the same time the number of research specialists increased and amounted to 23.7 people (Fig. 2.3).



Calculated based on data from the Bureau of National Statistics of the ASPR RK

Figure 2.3 Personnel engaged in R&D per 10 thousand people employed in the economy in 2023

Data on the involvement of science in the study of regional problems, such as social, economic, environmental, political and behavioral phenomena, are reduced to a minimum. At the same time, regional science sets itself tasks similar to those carried out in large scientific and educational centers in the field of fundamental and/or applied research with minimal provision of both scientific personnel and material and technical potential. More details are given in Section V of the Report.

Innovative activity. In 2023, the share of innovatively active enterprises in the total number of organizations that participated in the survey of innovative activity was 11.7%, which is 0.7 percentage points higher than last year's level (Table 2.3).

Table 2.3. Key indicators of innovative activities of enterprises of the Republic of Kazakhstan

Indicators	2021	2022	2023
Level of activity in the field of innovation, %	10,5	11,0	11,7
Total volume of innovative products (goods and services), billion tenge	1 438,7	1 879,1	2 399,8
Volume of sold innovative products (goods and services), billion tenge	1 318,1	1 739,8	2 381,2
Volume of sold innovative products (goods and services), delivered for export, billion tenge	214,5	286,3	420,6
Amount of expenses for implementation of innovations, billion tenge	800,1	1 453,3	1 820,8

According to the Bureau of National Statistics of the ASPR RK

In total, 3,591 organizations among 30,610 that participated in the survey of innovative activity of organizations/enterprises were engaged in innovative activities in 2023.

Enterprises of Kazakhstan produced innovative products worth 2,399.8 billion tenge, which is 5.2% (in 2022 - 3.9%; 2021 - 3.4%) of the total volume of industrial production of goods and services for January-December 2023. Compared to the previous year, there was an increase in the production of innovative products by 27.7%.

The total volume of sold innovative products amounted to 2,381.2 billion tenge, of which 420.6 billion tenge were exported. Innovation expenditure in 2023 amounted to more than 1,820.8 billion tenge, of which 4.9% was accounted for by public investment, but this is 2.7 percentage points less than in the previous period (in 2022, public investment in innovation was 7.6%). The main innovation expenditure was made through bank loans - 50.2%, at the expense of the enterprises themselves - 39.6%. Other sources accounted for 5.4%.

Innovation expenditure by enterprises related to the introduction of new or improved products amounted to 70.4%.

In 2023, 69.7% of all innovation expenditure was accounted for by the acquisition of machinery, equipment, software and other assets, and compared to the previous year, the use of borrowed innovative solutions increased by 4.7 percentage points. According to a statistical survey conducted annually by the Bureau of National Statistics, on average, two-thirds of innovation expenditure is used for these purposes.

According to statistics, in 2023, 572 enterprises carried out innovations using R&D conducted within the enterprise, with 307 of them conducting research on an ongoing basis and 265 - occasionally, 206 enterprises reported that they purchased R&D conducted by third-party organizations to implement innovations. The costs of using the results of scientific research in the reporting period decreased from 13% to 8.6%.

In Kazakhstan, approximately 3 thousand enterprises among more than 28 thousand surveyed by statistics are engaged in innovations annually, which is 11-12%. However, among this number of innovatively active enterprises, only about 235 units incur costs for scientific developments from external sources.

Costs for external research and development work mean the acquisition/transfer of, for example, various scientific and technical developments, production technologies, technical solutions, techniques, relevant material and technical means, software, know-how and others necessary to solve technical problems in the production process. Therefore, from the statistical data characterizing innovation processes in organizations and enterprises of the Republic of Kazakhstan, the costs of external R&D sources most closely characterize the relationship between science and production.

The data show that the largest number of enterprises using R&D results belong to the manufacturing industry. Thus, over the past five years, an average of one hundred enterprises carried out product and / or process innovations using R&D results.

In the reporting period, the costs of using the results of scientific research decreased from 13% to 8.6%.

Competitions for scientific projects/programs. In 2023, a total of 8 competitions were announced for program-targeted financing of scientific, scientific and technical programs by the following departments: the Ministry of Science and Higher Education of the Republic of Kazakhstan (MSHE RK), the Ministry of Culture and Sports of the Republic of Kazakhstan (MCS RK), the Ministry of Trade and Integration of the Republic of Kazakhstan (MTI RK), the Ministry of Industry and Infrastructure Development of the Republic of Kazakhstan (MIID RK), the Ministry of Energy of the Republic of Kazakhstan (ME RK), the Ministry of Defense of the Republic of Kazakhstan - 1 competition each; The Ministry of Digital Development and Aerospace Industry of the Republic of Kazakhstan – 2 competitions (Table 2.4).

Table 2.4. Information on competitions for program-targeted financing of scientific and research-technical programs announced in 2023

Science programs/projects administrator	SSTE			NSC	Implementa-tion period
	applications submitted, total	passed SSTE	transferred to NSC	recommended /approved to financing	
Program-targeted financing					
Ministry of Science and Higher Education of the Republic of Kazakhstan	255	172	136	104	2023-2025
Ministry of Culture and Sports of the Republic of Kazakhstan	18	7	5	5	2023-2025
Ministry of Digital Development and Aerospace Industry of the Republic of Kazakhstan	5	4	3	2	2023-2025
Ministry of Trade and Integration of the Republic of Kazakhstan	3	2	1	1	2023-2025
Ministry of Energy of the Republic of Kazakhstan	1	1	1	1	2023-2025
Ministry of Digital Development and Aerospace Industry of the Republic of Kazakhstan	1	1	1	1	2023-2025
Ministry of Defense of the Republic of Kazakhstan	1	1	1	1	2023-2025
Ministry of Industry and Infrastructure Development of the Republic of Kazakhstan	1	1	1	1	2023-2025
Total	1	1	1	1	2023-2025

Within the framework of competitions for program-targeted financing (PTF), the total number of applications submitted was 285 units, of which 189 (66.3%) met the requirements of the competition documentation. They are aimed at conducting a state scientific and technical examination (SSTE).

Based on the results of the SSTE, 149 applications scored a threshold score and received an assessment of the validity of the amount of requested funding. Of these, 116 applications, or 77,9% of those received for consideration, were recommended for funding by decisions of the National Scientific Councils (NSC). The implementation period for approved applications is 2023-2025.

As a result, the share of applications for the PTF approved for funding amounted to 40,7% of the total number submitted to the competition.

A total of 3,129 applications were submitted for 3 competitions of the Ministry of Higher Education of the Republic of Kazakhstan for grant funding (GF) for 2023-2025. After checking for compliance with the requirements of the tender documentation, **2100** applications (67.1%) were admitted to the SSTE. Among **1402** applications passed the SSTE and the validity assessment of the requested funding volume, **1028** (73,3%) were approved by the decisions of the NSC (Table 5). Of the total number of applications submitted to the GF, the share of those approved for funding was 32,8% (Table 2.5).

Table 2.5. Information on grant funding competitions announced in 2023

Science projects administrator	SSTE			NSC	Implementation period
	applications submitted, total	passed SSTE	transferred to NSC	recommended /approved to financing	
Grant funding for scientific and (or) scientific and technical projects					
Ministry of Science and Higher Education of the Republic of Kazakhstan (*for young scientists under the project "Zhas Galym"*)	503	330	173	120	2023-2025
Ministry of Science and Higher Education of the Republic of Kazakhstan (*for young scientists*)	464	306	230	130	2023-2025
Ministry of Science and Higher Education of the Republic of Kazakhstan	2162	1464	999	778	2023-2025
Total	**3129**	**2100**	**1402**	**1028**	
Grant financing of projects for commercialization of results of scientific and (or) scientific and technical activities					
"Science Fund" JSC	320	233	233	76	2023-2025
TOTAL	**320**	**233**	**233**	**76**	

In addition, "Science Fund" JSC announced a competition for grant financing of commercialization projects of the R&D Department for the implementation period of 2023-2025. 320 applications were submitted for the competition, 233 (72.8%) of which passed the SSTE. The NSC approved 76 of the most promising projects for financing, or 32.6% of those reviewed.

As part of the financing of scientific organizations carrying out fundamental scientific research, 11 applications were submitted. Based on the expert opinions of the SSTE and a validity assessment of the requested funding, the NSC recommended financing 11 applications for scientific, scientific and technical programs (Table 2.6).

Research works in the amount of 13 units, nominated for the State Prize in Science and Technology for 2023, passed the SSTE, the results of which were sent to the authorized body in the field of science.

Table 2.6. Information on applications submitted under other types of funding and research projects for the State Prize in Science in 2023

Administrator of scientific programs/R&D for the state award	SSTE			NSC	Implementation period
	applications submitted, total	passed SSTE	transferred to NSC	recommended /approved to financing	
Financing of scientific organizations conducting fundamental scientific research					
Ministry of Science and Higher Education of the Republic of Kazakhstan	11	11	11	11	2023-2025
State Prize in Science					
Research papers nominated for the State Prize in Science and Technology for 2023.	13	13	not transferred to the NSC	-	2023
Total	**24**	**24**	**11**	**11**	

***Program-targeted financing of scientific, scientific and technical programs*.** In 2023, 180 programs with various implementation deadlines were implemented under program-targeted financing: 2021-2022, 2021-2023; 2022-2023; 2022-2024; 2023-2025. The programs were administered by 11 departments. Most of the scientific and technological progress was carried out within the framework of competitions of the Ministry of Higher Education of the Republic of Kazakhstan and the Ministry of Agriculture of the Republic of Kazakhstan - 56.1% and 17.2%, respectively. Fundamental research (58 scientific and technological progress) was carried out by the Ministry of Higher Education of the Republic of Kazakhstan - 56 units, as well as the Ministry of Health of the Republic of Kazakhstan and the Ministry of Health of the Republic of Kazakhstan - 1 unit for each department; applied research (122 scientific and technological progress) was distributed among all ministries. From the total number of completed programs, the share of completed ones is 58.9% (106 units), while the share of ongoing ones is 41.1% (74 units).

The **106** completed research programs included **95** competitive research projects, as well as **11** non-competitive ones.

The results of research within the framework of the PTF for 2023 in the context of priority areas, their scientific novelty and scientific and technical level are confirmed by the received security documents, publications in Kazakhstani and foreign rating publications, as well as implementations (Table 2.7).

Based on the results of the implementation of 106 programs completed in 2023, the following results were obtained: publications - 1696 units, of which 661 units were in publications in near and far abroad, the latter included works updated in foreign citation databases: Web of Science - 141 units, Scopus - 387 units; security documents - 155 units; the number of programs with implemented results for 2023 - 45 units; the number of implementations - 260.

Table 2.7. Performance of completed programs by priority areas, PCF 2023

Priority direction	Number of programs, units	Publications					Security documents	Number of programs with implementation	Number of implementations
		total	domestic	foreign, of which					
				total	Web of Science	Scopus			
AIC	31	648	420	228	27	130	100	23	152
RS&H	25	311	243	68	3	39	0	4	10
SLH	15	116	48	68	33	42	14	11	50
RUWR	9	216	128	88	9	43	13	4	41
ICST	7	49	14	35	8	27	3	2	4
GEPMHR	6	81	55	26	2	11	15	1	1
E&M	6	76	26	50	19	39	4	0	0
NS	5	105	55	50	25	32	6	1	2
RE&S	2	94	46	48	3	25	0	0	0
Total	**106**	**1696**	**1035**	**661**	**141**	**387**	**155**	**46**	**260**

Grant financing of scientific, scientific and technical projects. In 2023, within the framework of 9 grant financing competitions (GF) held by the Ministry of Science and Higher Education of the Republic of Kazakhstan, 2488 projects with various implementation periods of 2021-2023; 2022-2024; 2023-2025 were implemented.

In the total number of projects, the share of completed ones was 21.2% (527 R&D), while ongoing implementation - 78.8% (1961 R&D). In general, in the GF competitions, there is a predominance of fundamental research - 51.2%, while in completed projects there is more applied research - 50.3%.

In 2023, final reports were registered for 527 projects (Table 2.8).

Table 2.8. Performance of completed projects by priority areas, GF, 2023

Priority	Projects number	Publications				Security documents	Number of programs with implementation	Number of implementations
		total	in foreign publications	Web of Science	Scopus			
GEPMHR	79	275	146	65	112	38	8	12
ICST	40	188	116	42	94	11	10	12
RE&S	32	199	68	5	31	4	13	26
RS&H	90	639	199	14	101	0	17	42
SLH	77	203	124	64	84	11	10	24
NS	89	427	240	133	175	5	6	14
NS&D	11	40	16	6	15	1	2	5

RUWR	32	106	49	21	39	11	11	28
AIC	31	117	67	19	44	22	15	23
E&M	46	153	96	33	70	24	11	18
Total	**527**	**2347**	**1121**	**402**	**765**	**127**	**103**	**204**

The following results were obtained for the completed studies within the framework of 2 competitions: publications - 2347 units, of which 1121 units were published in near and far abroad. The latter included works updated in foreign citation databases: Web of Science - 402 units, Scopus - 765 units; security documents - 127 units; the number of projects with implemented results - 103 units; the number of implementations - 204 units.

The assessment of productivity per 1 project showed greater effectiveness in terms of publications within the general competition for grant funding. With regard to patents and implementations, higher values are presented for the competition of young scientists (Fig. 2.4).

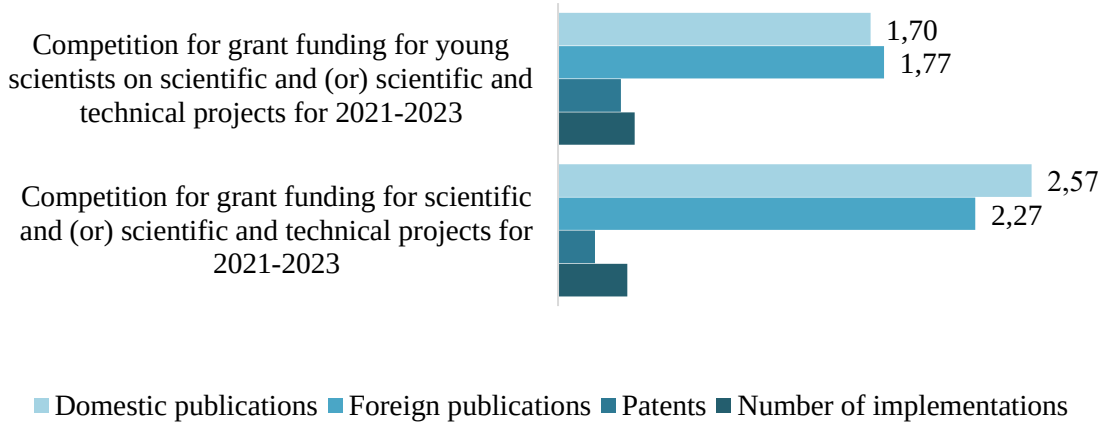


Figure 2.4. Performance indicators of completed projects per project

2.1. The most significant results of scientific and (or) scientific and technical activities, implemented developments

a) significant results of scientific and (or) scientific and technical activities of domestic scientists, developments implemented by them, which have a significant transformative impact on a regional or global scale, are defined as achievements of Kazakhstani science.

In this context, the *implemented* developments that scored the maximum points according to the results of the State Scientific and Technical Expertise of final reports on research and development completed in 2023 of scientific and scientific and technical programs and projects were selected.

Scientific research in the field of natural sciences

- In the Karaganda University named after Academician E. A. Buketov, syntactic and semantic properties of theoretical and model-theoretic questions concerning classes of Jonsson spectra with respect to the cosemanticity relation were studied. The following was obtained: a criterion of strong minimality within the

framework of studying central types of central classes and fragments of a fixed JSp(K); characterizing the properties of syntactic and semantic similarity of hybrids of fragments of theoretical sets from a fixed JSp(K); description of strongly minimal geometries of hybrids of fragments and central classes of a fixed hereditary JSp(K), etc. All results are new. Project "*Cosemanticity Classes and Their Model Classes*".

- Scientists from the Research Institute of Experimental and Theoretical Physics have studied the processes of turbulent heat and mass transfer and the formation of harmful substances during combustion of solid fuel in combustion chambers of real energy facilities using modern methods of physical, mathematical and 3D computer modeling. The influence of different fuel supply methods (straight-through and vortex with a swirl angle of the flow) on the aerodynamics of flows, temperature fields, concentration fields of carbon oxides CO_x and nitrogen NO_x has been established. Recommendations for the practical application of the obtained results have been developed. Project "*3D modeling of turbulent heat and mass transfer processes in physicochemically active environments*".

- The Institute of Zoology has developed a cadastre of the animal world of the Northern Tien Shan to preserve the genetic diversity of animal resources.

An electronic database has been developed, which includes an information retrieval system and ensures the further formation of the cadastre of the animal world of the Northern Tien Shan. Maps of the ecosystems of the Zailiysky Alatau ridge and the Medeu State Nature Reserve with legends have been developed for subsequent use in the cadastre. 25 model territories have been identified. A taxonomic analysis of the fauna of the Northern Tien Shan has begun. The program "*Development of the cadastre of the fauna of the Northern Tien Shan to preserve its genetic diversity*".

In the field of life and health sciences:

- For the first time, *the Institute of General Genetics and Cytology* has selected a control cohort of conditionally healthy individuals for a molecular epidemiological study of a unique cohort of individuals exposed to persistent organic pollutants (POPs) for a long time. The cohort corresponds to the experimental group in terms of the main population parameters (gender, age, ethnicity, smoking). The project "*Study of the polymorphism of antioxidant defense and immune response genes in people exposed to pesticide pollution for a long time*".

- The National Scientific Cardiac Surgery Center has studied clinical, functional, immunological and genetic factors affecting the severity of acute coronavirus infection COVID-19 and post-COVID syndrome in order to develop tactics for managing such patients to reduce the risks of complications and disability. Important data on mortality predictors in our study cohort were obtained as a result of a retrospective analysis. The program "*Assessment of the influence of clinical, functional, immunological and genetic factors on the severity of the course of coronavirus infection SARS-CoV-2 and post-COVID syndrome*".

In the field of rational use of water resources, flora and fauna, ecology:

- Research conducted at the *Kazakh Research Institute of Forestry and Agroforestry named after A.N. Bukeikhan* revealed that the application of fertilizers had a positive effect on increasing survival and growth. It was found that with an

increase in the nutrition area, plants have a greater height and width of the bush compared to a denser placement, in addition, the number of stems increases. Comparison of the components of essential oil of wild plants and those growing on the plantation did not reveal a reliable difference. Project "*Development of technologies for plantation cultivation of medicinal herbs in the Northern region of Kazakhstan without reducing the content of biologically active substances in them*".

- *The Institute of Botany and Phytointroduction* has obtained annotated lists of higher vascular plants, algae, mycobiota, a list of plant communities, created maps of the distribution of resource and rare plant species in 7 districts of the Almaty region of Kazakhstan - Karasay, Talgar, Enbekshikazakh, Uygur, Kegen, Raiymbek, Panfilov. 4 Catalogues of collection funds of state botanical gardens (SBG, ZBG, IBG, AstBG) have been published. The program "*Cadastral assessment of the current ecological state of flora and plant resources of the Almaty region as a scientific basis for effective management of resource potential*".

In the field of **sustainable development of the agro-industrial complex and safety of agricultural products**, researchers from *Almaty Technological University* have developed resource-saving complex technologies for the production of dietary immunostimulating confectionery products (candies, marmalade, lollipops, etc.) made from natural, inexpensive, local plant materials. Recipes have been developed and gentle technological modes for the preparation of dietary immunostimulating confectionery products for functional purposes with high nutritional and biological value have been selected. Project "*Development of a technology for the production of dietary immunostimulating confectionery products based on the processing of local plant materials*".

In the field of **geology, extraction and processing of mineral and hydrocarbon raw materials, new materials, technologies, safe products and structures**, a scientific assessment of the investment attractiveness of the main structures of Kazakhstan, promising for the identification of mineral deposits, has been carried out at the East Kazakhstan Technical University named after D. Serikbayev. Criteria have been developed for creating a methodology for substantiating the investment attractiveness of the country's main metallogenic belts and geological structures. The program "*Scientific Assessment of the Investment Attractiveness of Kazakhstan's Structures with Potential for Identifying Mineral Deposits*".

In the field of **information, communication and space technologies**, scientists from the Astrophysical Institute named after V.G. Fesenkov have conducted research aimed at developing means for observing near and deep space. A new optical complex with a wide field of view for monitoring and survey observations of near-Earth space, as well as an innovative spectral device for spectral observations of near and deep space objects have been developed; methods for predicting approaches of spacecraft to GSO have been developed. The program "*Creation of a National System of Space Situational Awareness: Monitoring Near-Earth Space, Deep Space and Space Weather*".

In the field of **national security and defense**, scientists from the National Center for Space Research and Technology conducted research on the development of

a domestic technology for producing organoplastics with certain characteristics, modified with plasticizers and combined reinforcement. A draft design for the manufacture of parts of the body of unmanned aerial vehicles (UAVs) and a technological instruction for obtaining radio-transparent high-strength organoplastics were developed. The implementation of the project opens a new scientific direction for the development of domestic production of modern materials for the defense and space industries and the technology for producing UAVs from radio-transparent organoplastics. The project "*Development of a domestic technology for obtaining a radio-transparent high-strength composite for the bodies of military unmanned aerial vehicles and aerospace equipment*".

b) *The achievements of Kazakhstani science* include the works of domestic scientists, noted in accordance with the Decree of the President of the Republic of Kazakhstan dated October 24, 2023 No. 709 by the State Prize of the Republic of Kazakhstan in the field of science and technology named after Al-Farabi to a team of authors of the National Nuclear Center of the Republic of Kazakhstan headed by the Director General, Doctor of Physical and Mathematical Sciences, Professor E.G. Batyrbekov for the work on the topic "Research and development of world class for the creation of the nuclear energy industry and the implementation of the Strategy for achieving carbon neutrality of the Republic of Kazakhstan".

c) *The achievements of Kazakhstani science* can also include domestic highly cited publications created without foreign co-authorship. These are the works of Kazakhstani scientists that determine the active interest of the scientific community, included in the top 1% in the world ranking by citation over 10 years. Over the past three years (2021-2023), 2 articles from *Nazarbayev University* were included in this list of the most popular works:

- In the field of **pharmacology and pharmacy**, the article "*Chitosan-Based biomaterials for tissue regeneration*" presented by scientists *Ye. Kim, Zh. Zharkinbekov, K. Raziyeva, L. Tabyldiyeva, K. Berikova, D. Zhumagul, K. Temirkhanova, A. Saparov*. The work is devoted to chitosan - a biopolymer obtained from chitin, which has demonstrated great potential for tissue regeneration and controlled drug delivery. It has numerous qualities that make it attractive for biomedical applications, such as biocompatibility, low toxicity, broad-spectrum antimicrobial activity and many others. It was found that chitosan-based composite biomaterials stimulate regeneration and restoration in vivo of various tissues and organs, including, but not limited to, bone, cartilage, dental, skin, nervous, cardiac and other tissues. In particular, de novo tissue formation, differentiation of resident stem cells, and remodeling of the extracellular matrix have been observed in numerous preclinical models of various tissue injuries treated with chitosan-based drugs. The article was published in March 2023 in the journal *Pharmaceuticals* with an impact factor (2022) of -1.31, quartile Q1 in the Pharmacology & Pharmacy category.

- In the field of **chemistry**, the article "*Review of Covid-19 testing and diagnostic methods*" presented by the authors *Ye. Filchakova; D. Dossym; A. Ilyas; T. Kuanysheva; A. Abdizhamil; R. Bukasov*.

The work provides a comparative analysis of various methods for detecting COVID-19 and the testing efficiency of some test kits. Accuracy, sensitivity, specificity, time to results, and cost of the test are important parameters of these tests, and even a minimal improvement in any of them can have a noticeable impact on life in many countries around the world. The article was published in July 2022 in the journal «*Talanta*» V 244 with an impact factor (2022) of 6.1, quartile Q1 in the category Chemistry, Analytical.

2.2. Indicators of research activity of scientists

Participation in global science is not only a factor of prestige, but also a necessary condition for increasing the productivity of scientific activity.

Science has currently become an object of quantitative scientific research, which can be carried out using scientific citation systems - electronic bibliographic databases of scientific citation, such as Web of Science and Scopus, containing citation and analytical information on publications (scientific journals, conference materials, book publications, etc.). These information and analytical systems of scientific citation allow you to effectively detect and identify scientific works of researchers and scientists, as well as analyze publications of authors, organizations, and countries.

Based on data on publication activity and citation of scientific materials included in the scientific information database, various scientometric indicators are calculated that can help in everyday practice both scientists and managers, which is the basis for identifying the achievements of participants in the scientific process - authors, organizations, regions and the country as a whole. It is the number of published works that is *an indicator of scientific productivity* [2,3].

According to InCites, the number of publications in Kazakhstan for 2021-2023 amounted to 12,696 documents, which allowed the country to take 76th place in the world ranking out of 213 countries for this indicator (Fig. 2.5).

Number of publications		Rank		Normalized average citation impact
2 402 150	1	China	109	1,16
2 309 108	2	USA	84	1,26
734 017	3	UK	45	1,47
645 398	4	England	39	1,51
584 933	5	Germany	73	1,31
577 324	6	India	179	0,9
441 728	7	Italy	66	1,36
398 736	8	Japan	169	0,93
395 147	9	Canada	58	1,4
371 955	10	Spain	90	1,23
226 168	15	Russia	207	0,71
12 696	***76***	Kazakhstan	***173***	***0,92***
6 079	92	Belarus	204	0,72
3 964	102	Armenia	187	0,86
1 539	131	Kyrgyzstan	68	1,34

According to InCites (Clarivate Analytics) as of 17.05.2024

Figure 2.5. Country rankings by number of publications and normalized citation impact for 2021-2023

The figure shows the top 10 countries that occupy leading positions in the world ranking by the number of publications. These are China, the USA, Great Britain, etc., as well as Kazakhstan's partner countries in the Eurasian Economic Union (EAEU), which are distributed as follows: Russia - 15th place; Belarus - 92; Armenia - 102; Kyrgyzstan - 131.

The indicator of scientific performance is the normalized average citation rate. It is calculated as the ratio of the number of references to an article to the total number of references to all articles of the same type published in this subject area in the same year. If the obtained value is greater than one, then the study is cited better than expected and is highly valued in the world, if less than one, the popularity of the article is low, it is cited worse than articles on this topic [4].

In the ranking for this indicator for 2021-2023, equal to 0.92, Kazakhstan ranks 173rd. In the first group of countries, the leaders in terms of normalized average citation rate are England - 1.51, Great Britain - 1.47 and Canada - 1.40, which allowed them to take 39th, 45th and 58th places in the ranking, respectively. Among the EAEU countries, only Kyrgyzstan, with a relatively small number of publications, with a normalized average citation rate of 1.34, ranks 68th. Armenia, Belarus and Russia are ranked 187th, 204th and 207th, respectively.

Scientific works of Kazakhstan for 2021-2023 (12696 units) are presented in 3761 publications, including 3393 journals, of which 3290 (97.0%) have an impact factor.

The key characteristic and indicator of the importance of a scientific journal in scientometrics is the *journal impact factor (Journal Impact Factor*). The publications indexed in 2021-2023 included 12 Kazakhstani journals with a total of 904 articles. Their citation level is low, the average value for all journals is 0.17 (Table 2.9).

The highest value of the normalized average citation was noted only for three journals, the founders and publishers of which are the Eurasian National University named after L.N. Gumilyov, Karaganda University named after Academician E.A. Buketov and the Institute of Metallurgy and Ore Beneficiation - these are *Eurasian Mathematical Journal* (0.86), *Bulletin of the Karaganda University-Mathematics* (0.57) and *Kompleksnoe Ispolzovanie Mineralnogo Syra* (0.28).

It should be noted that the Bulletin of the University of Karaganda-Chemistry journal currently has a different name. In 2023, it underwent rebranding and the journal name changed from "*Bulletin of the Karaganda University. Chemistry Series*" to "*Eurasian Journal of Chemistry*". Both journal names are mentioned in the table.

Table 2.9. Kazakhstani journals included in Emerging Sources Citation Index

Title of the publication	Articles number	Percentage of cited articles, %	Normalized average citation impact	Impact factor for 2023	Impact factor quartile
Kompleksnoe Ispolzovanie Mineralnogo Syra	126	59,52	0,28	0,8	Q4
Journal of Mathematics Mechanics and Computer Science	122	19,67	0,08	0,2	Q4
Bulletin of the University of Karaganda-Physics	109	26,61	0,07	0,3	Q4

Bulletin of the Karaganda University-Mathematics	105	45,71	0,57	0,7	Q2
Recent Contributions to Physics	101	14,85	0,04	0,2	Q4
Bulletin of the University of Karaganda-Chemistry	82	53,66	0,11	0,6	Q4
International Journal of Biology and Chemistry	64	26,56	0,08	0,3	Q4
Eurasian Chemico-Technological Journal	53	41,51	0,09	0,5	Q4
International Journal of Mathematics and Physics	43	13,95	0,14	0,2	Q4
Chemical Bulletin of Kazakh National University	41	43,9	0,07	0,3	Q4
Eurasian Journal of Chemistry	28	10,71	0,03	n/a	Q4
Eurasian Mathematical Journal	22	59,09	0,86	0,6	Q3
Eurasian Journal of Mathematical and Computer Applications	9	33,33	0,07	0,6	Q4
Total	**905**	**35,03**	**0,18**	-	-

According to InCites (Clarivate Analytics) as of 21.05.2024

The impact factor for 2023 was calculated for all Kazakhstani journals except for the *Eurasian Journal of Chemistry*. The highest value of this indicator is for the journal *Kompleksnoe Ispolzovanie Mineralnogo Syra* – 0.8.

In the impact factor ranking, the journals on mathematics "*Bulletin of the Karaganda University-Mathematics*" and "*Eurasian Mathematical Journal*" entered the Q2 and Q3 quartiles, respectively, the remaining 10 journals were placed in the Q4 quartile.

To assess the popularity and influence of a journal, its place within the ranked list by the impact factor of journals, divided into four quartiles, is often used rather than the absolute value of its impact factor. The share of Kazakhstani articles broken down by quartiles of Journal Citation Reports is given in Table 2.10.

Table 2.10. – Dynamics of articles in journals with quartiles, %

Share of articles in journals, %	2019	2020	2021	2022	2023
	Kazakhstan				
Q1	31,88	35,08	36,89	37,01	35,65
Q2	28,72	30,31	33,31	37,66	30,75
Q3	19,26	16,13	17,86	13,60	15,29
Q4	20,14	18,47	11,94	11,73	18,28
	World Corps				
Q1	46,14	45,91	45,51	45,89	46,96
Q2	26,14	27,31	29,07	31,32	27,15
Q3	16,34	15,52	15,25	14,04	14,12
Q4	11,39	11,25	10,18	8,75	8,76

According to InCites (Clarivate Analytics) as of 23.05.2024

As can be seen from the presented data, the share of articles in prestigious journals Q1 and Q2 in 2022 was about 75%, which is 23.2% higher than in 2019. In

2023, the share decreased and amounted to 66.4%, exceeding the base year value by only 5.8%. In general, the positive dynamics of the share of Kazakhstani articles in high-ranking journals is obvious. A similar picture is observed in the world corpus.

In the flow of scientific information of the Web of Science Core Collection database, the share of Kazakhstani publications is in the range of 0.11-0.13%. The average value for a three-year period is 0.12% (Table 2.11).

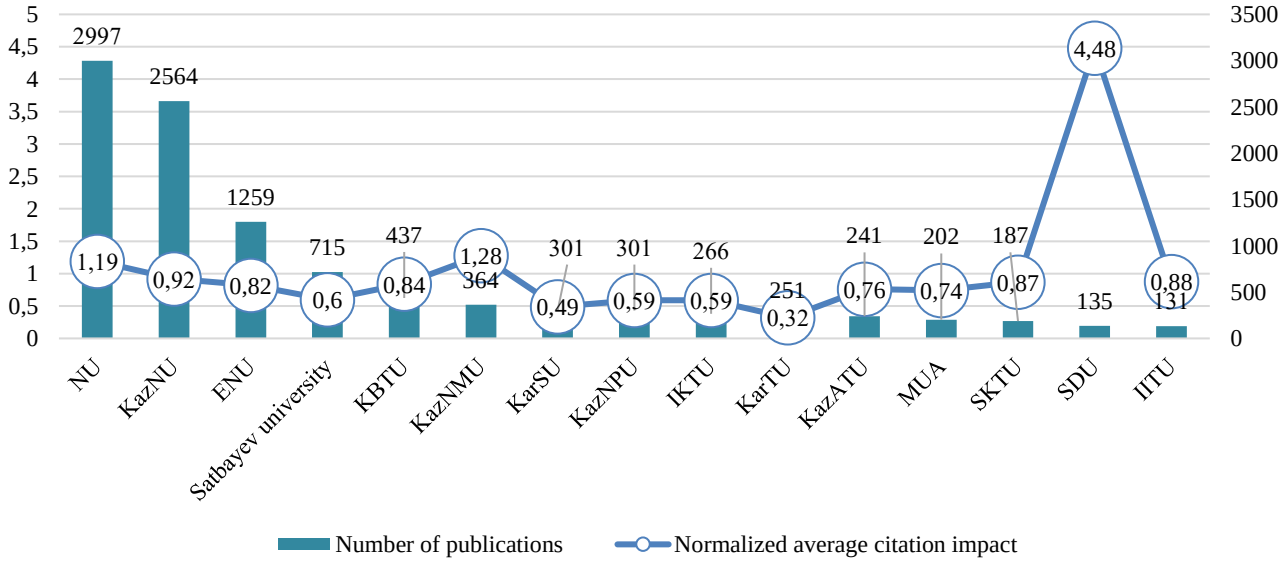
Table 2.11 The share of Kazakhstani publications for 2021-2023 in the world flow of scientific papers

Years	Publications number		Share of Kazakhstan's publications to the world, %
	Kazakhstan	World corps	
2021	4 036	3 683 421	0,11
2022	4 239	3 597 480	0,12
2023	4 421	3 343 235	0,13
2021-2023	**12 696**	**10 624 136**	**0,12**

According to InCites (Clarivate Analytics) as of 20.05.2024

The publication array of Kazakhstan for 2021-2023 is affiliated with 126 Kazakhstani organizations, of which 68 are universities, 50 are research institutes, and 8 are public organizations. More than 96% of scientific papers or 12,223 publications were prepared with the participation of university researchers, 19.3% (2,453 units) - research institutes.

Publication activity is one of the main indicators of the effectiveness of scientific work; quantitative analysis of scientific papers can provide an idea of the work of scientific organizations as a whole (Fig. 2.6).



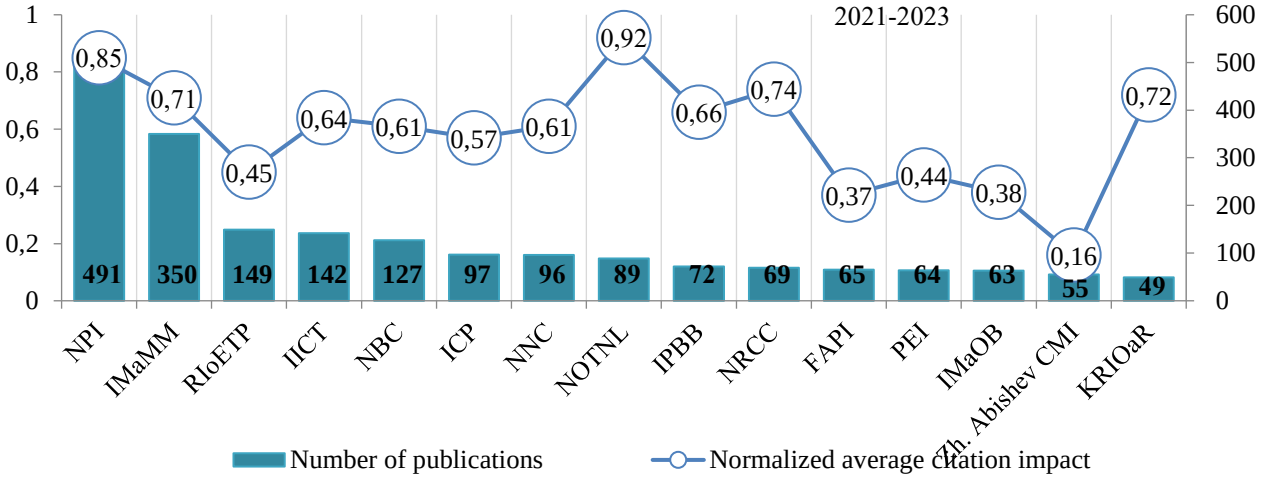
According to InCites (Clarivate Analytics) as of 06.06.2024

Figure 2.6. Bibliometric indicators of Kazakhstani universities, top 15

In terms of the number of publications in the Web of Science Core Collection, the leading positions among universities are occupied by *Nazarbayev University* (2997 documents), *Al-Farabi Kazakh National University* (2564 documents), and *Eurasian National University named after L.N. Gumilyov* (1259 documents).

Among research institutes, the leaders are the *Institute of Nuclear Physics* (491 documents), *the Institute of Mathematics and Mathematical Modeling* (350 documents), *the Institute of Experimental and Theoretical Physics* (149 documents), *and the Institute of Information and Computational Technologies* (142 documents) (Fig. 2.7).

In terms of scientific productivity – normalized average citation – the leaders among the studied universities are *Suleyman Demirel University*, whose value of the indicator is more than 4 times higher than the world average, equal to one, and is 4.48. This indicator is higher than one for the *Kazakh National Medical University named after S.D. Asfendiyarov* (1.28) and *Nazarbayev University* (1.19). The analysis showed that only the articles of the three universities mentioned are cited better than the world average. In the group of research organizations, the citation rate of publications is closest to the world average at the *National Open Nanotechnology Laboratory* (0.92) and the *Institute of Nuclear Physics* (0.85).



According to InCites (Clarivate Analytics) as of 06.06.2024

Figure 2.7. Bibliometric indicators of Kazakhstani research institutes, top 15

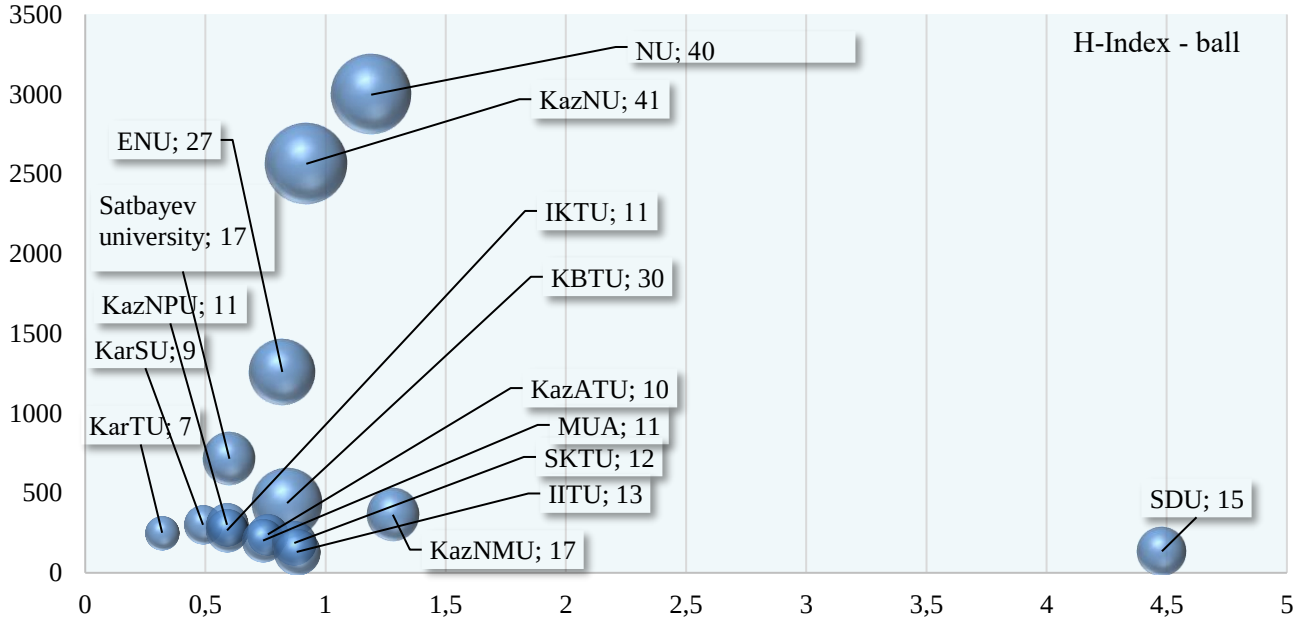
The Hirsch Index (h-index) is a scientometric indicator of scientific authority that provides a comprehensive assessment of both the number of works by an organization and their citation rate. On the scale of the organizations under consideration, this criterion shows the number of truly important publications.

The h-index can only be significant for those organizations where the majority of authors conduct research year after year that is recognized by their colleagues in the global scientific community, regularly publish their results, and these publications are invariably mentioned in publications by other scientists [5, 6].

Figures 2.8 and 2.9 show the Hirsch indices of the universities and research institutes selected for analysis, correlated with scientometric indicators - the number of publications by the organization, their normalized average citation rate. The size of the

sphere reflects the value of the criterion of scientific authority of the organization - h-index.

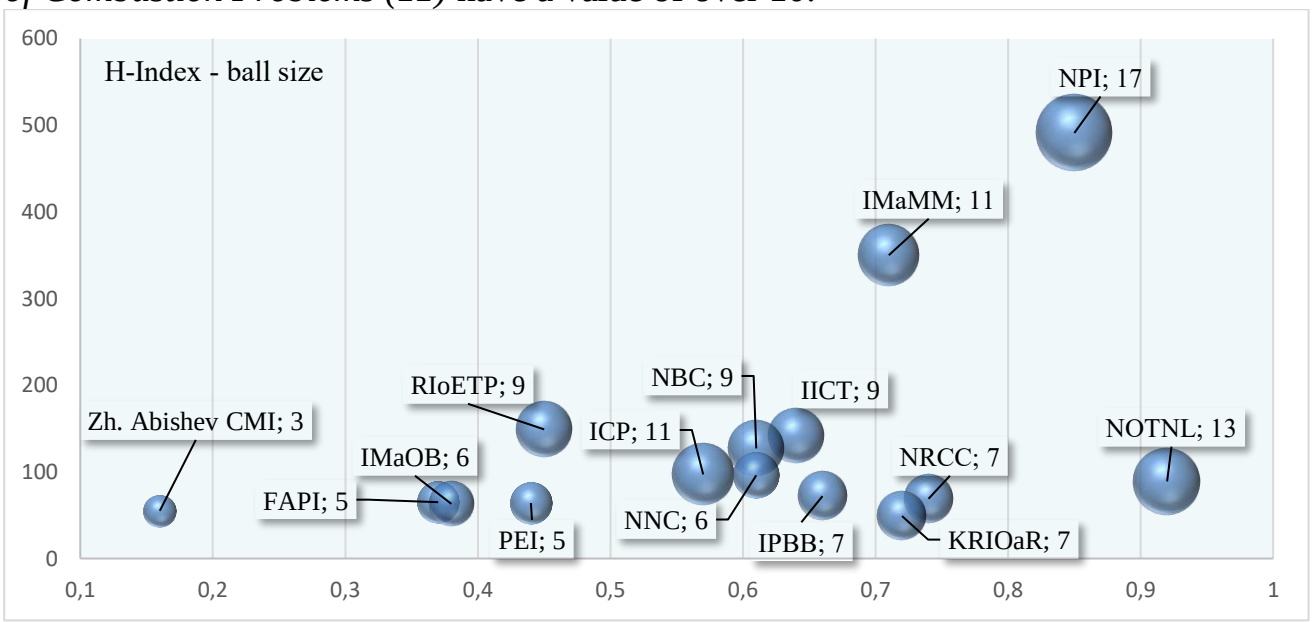
Among higher education institutions, the undisputed leaders in terms of h-index are the Kazakh National University named after Al-Farabi (41) and Nazarbayev University (40). Next come the Kazakh-British Technical University and the Eurasian National University named after L.N. Gumilyov with the value of this criterion of 30 and 27, respectively. The remaining universities have an h-index of no more than 17.



According to InCites (Clarivate Analytics) as of 06.06.2024

Figure 2.8. Hirsch index of Kazakhstani universities, top-15

Among research organizations, *the Institute of Nuclear Physics* has a consistently high *h-index* (17). *The National Open-Type Nanotechnology Laboratory (13), the Institute of Mathematics and Mathematical Modeling (11), and the Institute of Combustion Problems (11)* have a value of over 10.

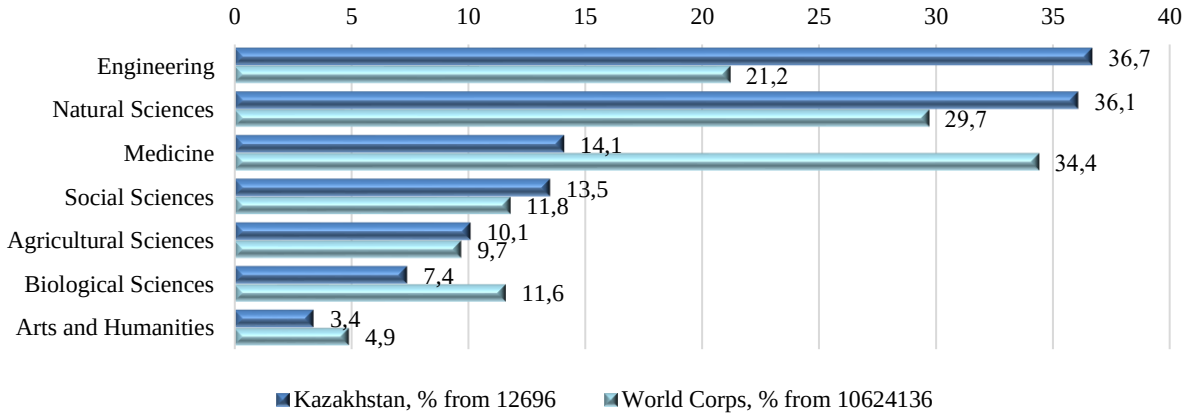


According to InCites (Clarivate Analytics) as of 06.06.2024

Figure 2.9. Hirsch index of Kazakhstani research institutes, top 15

The Web of Science Core Collection database includes international publications covering 254 scientific areas in 7 scientific fields, which are divided into technical, natural, social, agricultural and biological sciences, medicine, art and humanities (Fig. 2.10).

The overwhelming majority of Kazakhstani publications in the Web of Science Core Collection traditionally consist of studies in technical and natural sciences. Their combined share in the array of Kazakhstani works is about 73%. During the period under study, publications in the field of technical sciences slightly predominate for the first time, accounting for 36.7% of the total number of publications (4,660 units). The share of works in this area is 1.7 times higher than the world figure of 21.2% (3,156,449 units). In the natural sciences, the results of domestic research are reflected in 36.1% of publications (4,581 units), while in the world corpus it is 29.7% (2,250,338 units).



According to InCites (Clarivate Analytics) as of 06.06.2024

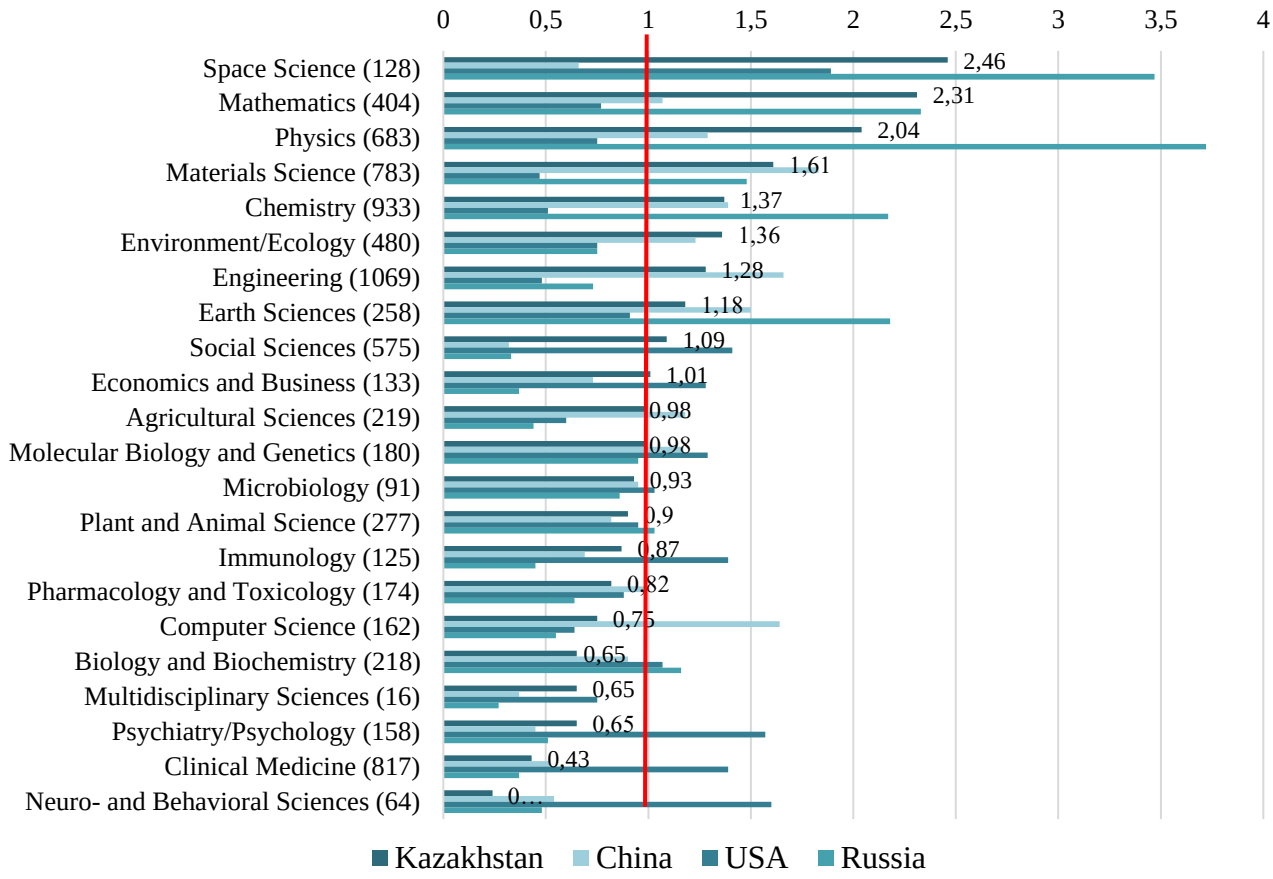
Figure 2.10. Structure of Kazakhstan's publications by fields of science for 2021-2023

At the same time, medicine is represented by a more than 2.5 times smaller share of works - 14.1% (1,792 units), than in the global document flow - 34.4% (3,651,808 units).

The share of the remaining areas of science is comparable to the global value with a slight fluctuation in the greater (social and agricultural sciences) or lesser (biological sciences, arts and humanities) direction.

To assess the scientific focus of the country, the ***index of scientific specialization*** was used - an indicator that evaluates the structure of articles of the country in the corresponding field of science in comparison with the global one. It is calculated as the ratio of the share of publications in the field of science in the totality of scientific publications of authors from a given country in scientific journals indexed in the Web of Science databases, to the share of global publications in the corresponding field of science in the total number of indexed publications. If the index value exceeds one, the field of science is included in the number of areas of

specialization of the given country [7, 8]. Over the period under study, the values of the scientific specialization index of Kazakhstan fluctuate in the range of 0.24-2.46 (Fig. 2.11).



According to InCites (Clarivate Analytics), 2021-2023, as of 05/29/2024

Figure 2.11. Scientific specialization of Kazakhstan in comparison with China, the USA and Russia

In the array of Kazakhstani publications represented by 22 thematic categories of the Essential Science Indicators (ESI) rubricator, the country's specialization includes the following areas: *Space and Earth Sciences, Mathematics, Physics, Materials Science, Chemistry, Environment/Ecology, Engineering, Social Sciences, Economics and Business*. These 10 areas of physical, technical and social sciences account for about 69% of publications of Kazakhstani scientists in the database. Research in the field of Life Sciences remains underdeveloped by global standards. As can be seen, in 2021-2023, in addition to traditional disciplines of the physical and technical profile, the country's scientific specialization included social sciences, as well as economics and business, which have intensified their publication activity in recent years.

China, which leads in the number of publications in the database, specializes primarily in technical sciences: such areas as *Materials Science, Engineering and Computer Science* have received the highest development. The areas of specialization also include *Earth Sciences, Chemistry, Physics, Environment/Ecology, Agricultural Sciences, Molecular Biology and Genetics, and Mathematics*.

Unlike China, the US has seen significant development in *biomedical and social sciences*, and very low rates in technical sciences. The greatest similarity in terms of priorities in the scientific focus of research is noted with Russia, where 6 out of 8 areas of specialization are similar to Kazakhstan, mainly in the *physical sciences*.

2.3 Patent activity

To characterize the level of inventive activity, the intensity of the dissemination of national scientific and technical achievements, and the degree of technological dependence of the country, such absolute indicators as the number of applications filed for the issuance of patents and the number of patents issued in total, including to domestic and foreign applicants, are used.

The main attention is paid to data on applications filed, which are most often used for a quantitative assessment of activity in the field of intellectual property (Table 2.12).

Table 2.12. Information on received applications for issuance of security documents for industrial property objects

units

Applications	2021	2022	2023	*Share of applications in the total volume for 2022, %*
Total	**14421**	**13913**	**19476**	**100**
Invention applications filed, total	***805***	***838***	***917***	***4,7***
by national applicants	692	713	693	
by foreign applicants	113	125	224	
Utility model applications filed, total	***1114***	***1109***	***1216***	***6,2***
by national applicants	1039	1057	1183	
by foreign applicants	75	37	33	
Industrial design applications filed, total	***211***	***152***	***236***	***1,2***
by national applicants	89	71	115	
by foreign applicants	122	81	121	
Trademark applications filed, total	***12222***	***11742***	***16964***	***87,1***
By national procedure	*6475*	*6960*	*11008*	
by national applicants	4770	5250	8645	
by foreign applicants	1705	1710	2363	
By international procedure	*5747*	*4782*	*5956*	
Applicants filed for appellations of origin of goods	***5***	***6***	***23***	***0,1***
by national applicants	5	6	2	
by foreign applicants	-	-	21	
Applicants filed for selection achievements, total	***63***	***66***	***114***	***0,6***
Animal breeds	*3*	*2*	*22*	
by national applicants	3	2	22	
by foreign applicants	-	-	-	
Plant varieties	*60*	*64*	*92*	
by national applicants	42	42	63	
by foreign applicants	18	21	29	
Geographical indications applications filed		***3***	***3***	***0,0***
by national applicants		3	2	
by foreign applicants		0	1	

Integrated circuit topologies	***1***		***3***	***0,0***
by national applicants	1		3	
by foreign applicants	-		-	

Source: Annual Report of the National Institute of Intellectual Property

According to the Research Institute of Intellectual Property, in 2023, as in the previous year, there was a positive trend in statistical indicators for filing applications for *national registration of industrial property objects and issuing security documents*.

To characterize the level of inventive activity, the intensity of the dissemination of national scientific and technological achievements, and the degree of technological dependence of the country, the inventive activity coefficient is used in statistics, defined as the number of applications for inventions filed by domestic applicants with the country's patent office, per 1 million people (Table 2.13).

Table 2.13. Inventive activity coefficient

Innovation indicators	2021	2022	2023
Inventive activity rate (*number of domestic patent applications for inventions filed in Kazakhstan per 1,000,000 population*)	41,28	42,39	45,77

Source: Annual Report of the National Institute of Intellectual Property

The increase in the inventive activity rate in the country in 2023 was due to an increase in the number of applications filed for inventions and a virtually unchanged population growth rate.

According to the Statistical Bulletin for 2022 prepared by the World Intellectual Property Organization (WIPO), the countries of the world have the following data on this indicator: in the Republic of Korea - 3559, in Japan - 1749, Switzerland - 1168, China - 1037, the USA - 757, in Russia - 135. Kazakhstan is in 42nd place out of 118 countries according to this indicator.

Patent activity for 2023 in the republic as a whole increased by 40%. The bulk of applications are for trademarks - 87.1%. This was facilitated, among other things, by the high activity of filing applications under the international procedure, but the majority of applications were applications filed under the national procedure (64.9%), including by national applicants. The filing of applications by national applicants for the issuance of protection documents for inventions and in accordance with the International Treaty on Patent Law under the Patent Cooperation Treaty (PCT) procedure and in accordance with the Eurasian Patent Convention (EAPC) has again acquired a positive trend. If in 2022 the decrease compared to the previous year was already 23% or 24 applications, then in 2023 there was an increase in the number of applications filed under the PCT procedure by 8%, amounting to 26 applications; under the EAPC procedure, the number of applications increased by 32% - from 78 to 103. (Table 2.14).

Table 2.14. – Distribution of applications from national applicants for the issuance of titles of protection for inventions, filed under the PCT procedure and in accordance with the EAPC

units

Number of applications	2021	2022	2023
Filed under the PCT procedure	31	24	26
Filed under the EAPC procedure	81	78	103

Source: Annual Report of the National Institute of Intellectual Property

The negative dynamics of filing applications for the issuance of protection documents for inventions that has taken place in recent years changed its trend towards growth in 2023, stopping at 917 units, which is 79 units higher than last year's level. This is due, first of all, to the activity of foreign applicants, the number of whose applications increased from 125 to 224. The decrease in filing applications by 20 units or 2.8% of national applicants did not affect the overall result.

The total number of applications received for utility models in 2023 amounted to 1216 units, which exceeded the same indicator in 2022 by almost 9.7%. This is due, first of all, to the positive dynamics of filing applications by national applicants, for whom an increase in this indicator by 11.9% is noted. At the same time, the share of foreign applicants decreased by 10.8%.

In 2023, 236 applications were received for industrial designs. Compared to the previous year, there was an increase of one and a half times. Activity of more than 1.6 times was noted among both national and foreign applicants, where the number of applications submitted increased by one and a half times.

The number of applications received for selection achievements in 2023 was 114 units, including 22 from national applicants for animal breeds and 92 for plant varieties, of which 63 applications were from national applicants and 29 from foreign ones. As in previous years, no applications for animal breeds were received from foreign applicants.

The number of protection documents issued in 2023 was 13,256 units (in 2022 - 12,099 units). 492 protection documents were issued for inventions, including 401 issued to national applicants and 91 to foreign applicants. 983 protection documents were issued for utility models, 122 for industrial designs, 83 for selection achievements, 24 for appellations of origin, and 11,558 for trademarks in total, including 6,319 protection documents under the national procedure, of which 4,664 were issued to national applicants (Table 2.15). Compared to last year, there was a decrease in the number of protection documents for industrial property objects: inventions by 93 units, industrial designs by 54.

Table 2.15. – Information on issued security documents for industrial property objects

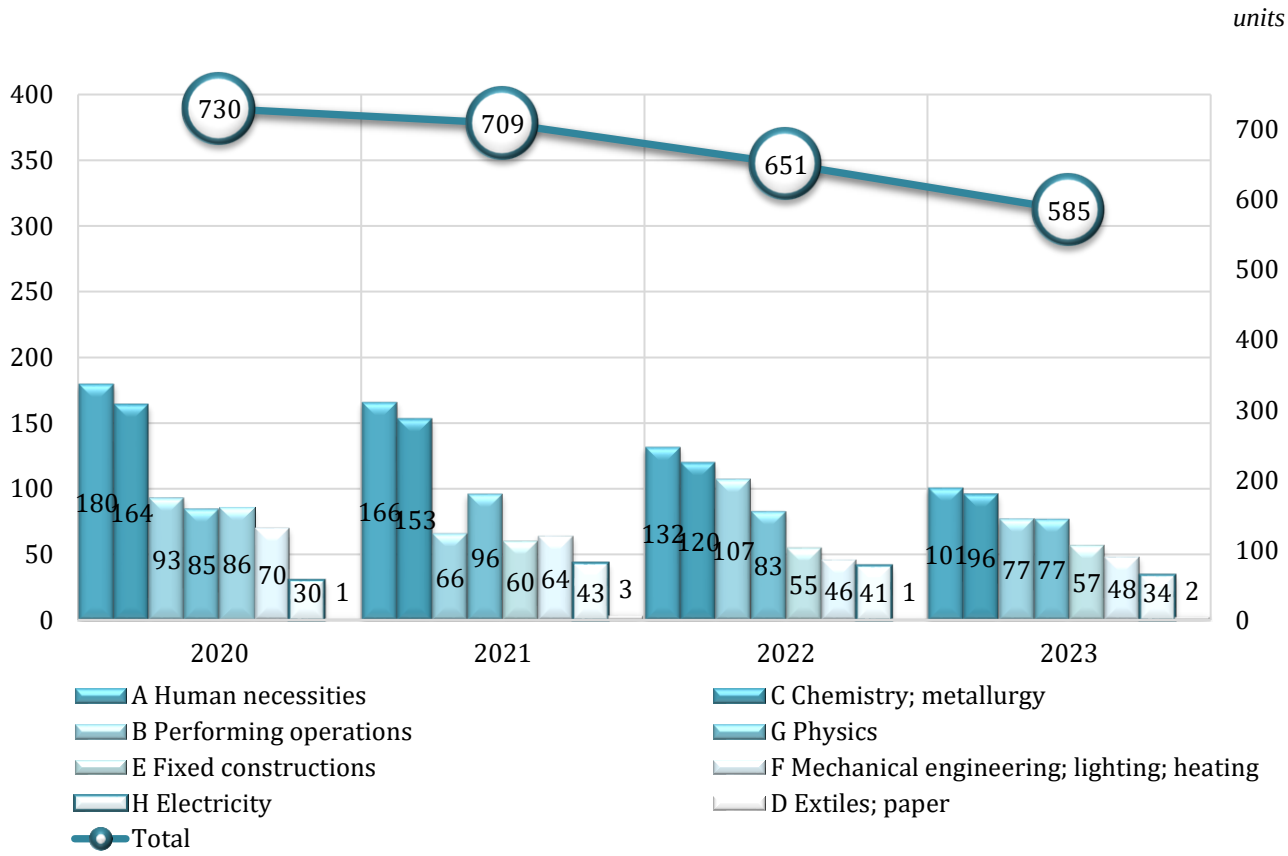
units

	2021	2022	2023	Share of security documents in the total volume for 2022, %
Issued titles of protection for industrial property objects, total	**12 761**	**12099**	**13270**	**100**
Issued patents for inventions, total	***651***	***585***	***492***	***3,7***
by national applicants	521	473	401	
by foreign applicants	130	112	91	
Issued patents for utility models, total	***1122***	***864***	***983***	***7,4***
by national applicants	1038	840	940	
by foreign applicants	84	24	43	
Issued titles of protection for industrial designs, total	***177***	***176***	***122***	***0,9***
by national applicants	56	65	53	
by foreign applicants	121	111	69	
Registered trademarks, total	***10759***	***10432***	***11558***	***87,2***
by national procedure	4955	5165	6319	
by national applicants	3321	3593	4664	
by foreign applicants	1634	1572	1655	
by international procedure (Madrid Agreement and Protocol (from among foreign applicants)	5804	5267	5239	
Registered appellations of origin of goods	***4***	***3***	***24***	***0,2***
by national applicants	4	3	3	
by foreign applicants	-		21	
Issued titles of protection for selection achievements, total	***47***	***39***	***83***	***0,6***
Animal breeds	-	3	18	
by national applicants	-	3	18	
by foreign applicants	-	-	0	
Plant varieties	47	36	65	
by national applicants	27	31	42	
by foreign applicants	20	5	23	
Registration of geographical indications			***5***	***0,0***
by national applicants			4	
by foreign applicants			1	
Issuance of titles of protection for topographies of integrated circuits by year	***1***		***3***	***0,0***
by national applicants	1		3	
Foreign applicants			0	

Source: Annual Report of the National Institute of Intellectual Property

In 2023, as in previous periods, the most common protection documents for inventions are in the section “Satisfaction of human vital needs” 101 units (17.3% of

the total number of protection documents issued for inventions), “Chemistry and metallurgy” 96 (16.4%), “Various technological processes” and “Physics” 77 units each (13.2%) (Fig. 2.12).



Source: Annual Report of the National Institute of Intellectual Property

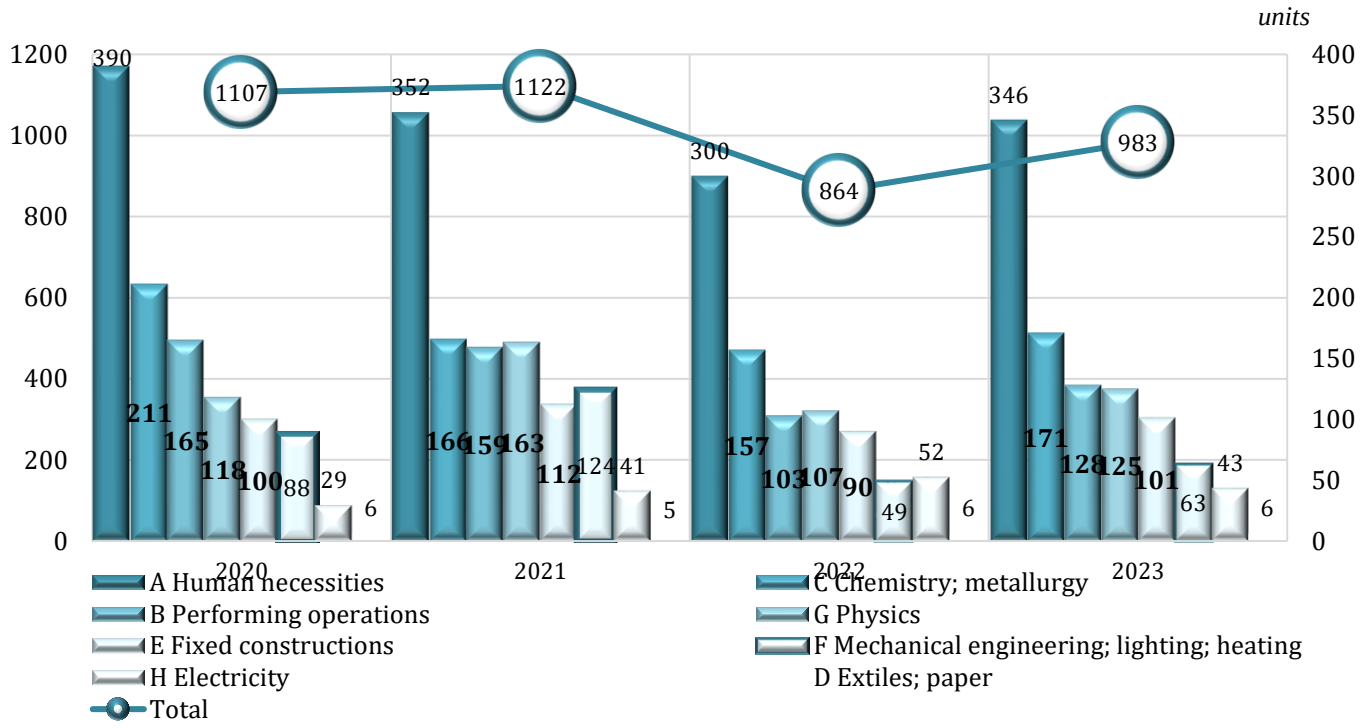
Figure 2.12. Distribution of issued titles of protection for inventions by sections of the International Patent Classification (IPC)

In 2023, 983 patents were issued for utility models, which is 14% higher than the same indicator of the previous year. According to the data, for a number of years, the issuance of protection documents for utility models under the section "Satisfaction of vital human needs" has been significantly ahead of the curve. Thus, in 2023, 346 patents were issued under this section, the share of which in the total volume is 35.2%. Next comes "Chemistry and Metallurgy" - 171 patents or 17.4% (Fig. 2.13).

Much attention was also paid to such sections of the IPC as "Various technological processes", which accounts for 13% of the total volume of issued protection documents, and "Physics" - 12.7%.

The number of patents issued increased in all sections of the IPC, except for the "Electricity" section.

In general, the statistics for 2023 show an increase in the activity of registering industrial property objects. Considering that the patent activity index is one of the factors influencing the GII, it can be assumed that this will be reflected in the rating of the Republic of Kazakhstan.



Source: Annual Report of the National Institute of Intellectual Property

Figure 2.13. Distribution of issued protection documents for utility models by sections of the IPC

Despite high patent activity, the quality of patents is determined by the number of patent protection objects maintained in force for the term granted to the applicant by the patent office. The process of maintaining (or keeping in force) patent protection usually consists of regular payments of fees to the patent office for maintenance (extension of the term of validity). In case of non-payment of such fees, patent protection may cease to be effective. It follows that funds will not be spent on maintaining ineffective patents.

For such intellectual property objects as inventions, industrial designs, selection achievements and utility models, the share of maintained intellectual property objects is less than half of all objects registered under the national procedure.

It should be noted that strengthening the requirement for the expected results of scientific research carried out at the expense of the state budget, in terms of the availability of security documents for intellectual property objects for applied projects and the expansion of the practice of obtaining patents from national applicants and international patents under the PCT procedure and the European procedure have had a positive effect on the growth of patent activity of national applicants. However, this did not change the situation.

3. JUSTIFICATION OF PRIORITY FUNDAMENTAL AND APPLIED RESEARCH (in the areas of science determined by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan, and analysis of their implementation)

Priority I – "Rational use of water resources, flora and fauna, ecology"

1.Review and analysis of the achievements of Kazakhstani science (the most significant results of the scientific and (or) scientific and technical sphere, implemented developments)

Research on the problems of conservation and rational use of water resources in Kazakhstan has a fairly large reserve. Research in recent years has been aimed at conducting a full-scale certification and comprehensive inventory of river basins. Assessment of the features of the hydrographic network will further serve as the basis for ensuring the effective development of water management measures in the interests of rational use of water resources [9]. A special place is occupied by research on the problems of transboundary water use. In particular, to regulate water use by China and Kazakhstan, two scenarios of transboundary inflow along the Kara Yertis River in Kazakhstan for the period of 2030, 2040 and 2050 have been developed: "inertial", based on modern trends in the development of the economy and the level of water use in the XUAR of the PRC and "intensive", which considers the most unfavorable situation of water cooperation between the two countries in the context of full use by the Chinese side of the water resources formed on its territory [10]. Also, the solution to the problem of rational use and protection of transboundary rivers of the Republic of Kazakhstan is possible by creating an effective legal regulatory regime at the level of river basins [11].

A separate area can be considered the study of issues of development and rational use of water resources in agriculture [12,13].

The importance of the Ile-Balkhash basin as the largest lake ecosystem and a source of valuable natural resources has led to research on the creation of an intelligent water resources monitoring system in order to obtain new knowledge about the state of water use facilities and make informed management decisions based on them using SWRL, SSN methods, time ontology and Qurma, TableProcessor and TableMiner tools [14].

In 2023, research was launched to develop an adequate assessment of the environmental risk of spring floods and their consequences in the flooded areas of the Akmola region based on a combination of systems analysis methods. The results of this study and the scientific conclusions made on their basis are of great practical importance for agricultural workers in the region [15]. In studies on the rational use of animal resources, it is important to preserve biodiversity, in connection with which the development of the Red Book of Animals of Kazakhstan and an electronic database of rare and endangered animals has begun, and an electronic database of the state scientific zoological collection has been developed [16]. Zoological studies have been conducted on the distribution of rare and poorly studied species and subspecies of

animals - the Turkestan lynx (*Lynx lynx isabellina Blyth*, 1847), the habitats of the saiga antelope (*Saiga tatarica*) and goitered gazelle (*Gazella subgutturosa*), the lizard Eremias lineolata (Nikolsky, 1897) and Eremias scripta (Strauch, 1867), etc. As a result of the studies, ecological-niche models and forecasts of the distribution of habitats based on bioclimatic ecological predictors in the context of climate globalization have been created. This is important for taking into account the numerous relationships and interactions of ecological, physiological and geographical parameters and obtaining new and expanded knowledge about natural phenomena [17-19].

Testing hypotheses about speciation and taxonomy at the species level is one of the fundamental and most discussed problems of biology. For example, a new species of the genus Gobio (gudgeon) from the Emel River (Lake Alakol basin, southeastern Kazakhstan) was identified and a key for diagnosing species of the genus Gobio in Kazakhstan was provided [20].

In the field of rational use of the plant world, the attention of scientists is drawn to the problem of assessing the state of tugai forests in the floodplains of the Syr Darya River, the so-called "desert oases" and determining the potential for reforestation. The reproductive capacity of dominant plant species, namely *Populus diversifolia, Elaeagnus angustifolia, Salix acutifolia and Salix wilhelmsiana*, was studied. Dendrochronological studies of *Populus diversifolia* have shown the sensitivity of the species to existing regional climate changes. This is manifested in an increase in the width of annual rings over time, reflecting the trends in the growth of air temperature and precipitation observed in recent decades. Thus, the species *Populus diversifolia* can serve as a reliable indicator of long-term climate changes [21,22]. In order to implement measures for the reproduction of plant resources, studies were conducted to develop a technology for the artificial cultivation of black saxaul plantations for desert areas. The use of various soil cultivation techniques has a positive effect on plant survival by 13.5 and 16.8%, their growth in height by 40.3-48.5%, and changes soil indices towards improvement [23].

Scientists are concerned about the reduction of populations of rare and endemic species of flora in Kazakhstan, which has led to continued research in this area. In the populations of the Dzungarian Alatau, the resistance of different genotypes of the wild apple tree *Malus niedzwetzkyana* to bacterial blight has been studied, and two genotypes have been identified that are recommended for propagation in order to restore the populations of the crop [24]. Research has been conducted on the genetic diversity and molecular systematics of species of the genus Juniperus (juniper) growing in Kazakhstan [25,26]. Methods for in vitro propagation of *Crocus alatavicus*, *Allochrusa gypsophiloides*, etc. have been patented [27]. Methodological recommendations for the conservation of relict species of the natural flora of Western Kazakhstan (*Malacocarpus crithmifolius, Crataegus ambigua, Rhamnus sintenisii, Nitraria schoberi*) by the tissue culture method have been developed to replenish the introduction fund and expand the range of economically valuable plants in the Caspian zone [28]. A model of the ecological niche of the nut-bearing *Pistacia vera* has been developed to identify the area of optimal conditions for wild and domesticated forms

and to create a guide to the conservation and commercial cultivation of *P. vera* in Kazakhstan [29]. Based on the cadastral assessment of the biodiversity of the Almaty region, the species composition, geographic distribution, and phytocenotic diversity of resources of wild relatives of agricultural crops in the Kazakh Tien Shan ranges have been studied. This made it possible to take into account taxa not only of cultivated genera of agricultural crops, but also of a wider range of species of high socio-economic importance, including medicinal, fodder, essential oil, etc. [30,31]. With the development of urbanization, issues of landscaping of urban areas are becoming important. Studies have shown that over time, introduced species used in landscaping become aggressive and begin to displace natural flora, up to the destruction of native species [32,33]. Using the example of the Medeu State Nature Park, it was shown that the uncontrolled spread of self-seeding and shoots of particularly aggressive plant species, such as *Acer campestre L.*, *Acer negundo L.*, *Fraxinus excelsior L.*, has a depressing effect on local natural flora, leading to the homogenization of ecosystems and a decrease in the biodiversity of cenoses. In the future, this may lead to the complete destruction of wild fruit forests and disruption of the ecosystem of plant communities in which “Red Book” plants grow [34].

Current environmental issues in Kazakhstan are focused on the main areas: air pollution, quality and shortage of drinking water and the state of land resources. Environmental statistics are the basis for information support for the creation of natural resource cadastres (land, water, forest), it interacts with macroeconomic and social statistics, with statistics of healthcare industries and enterprises and other areas of statistics, with demography and ecology. The use of a statistical analysis tool - the main indicators of air pollution made it possible to define it as an indicative feature characterizing the state of the environment. It makes it possible not only to determine the degree of anthropogenic load on the atmospheric air as a whole, but also to assess and predict the impact on the environment from stationary and mobile sources [35]. The importance of studying this problem is due to the direct relationship revealed, using ArcGIS tools and statistics, between population diseases and air pollutants from industrial sources, in particular nitrogen dioxide [36]. Of interest are the results of studies on the ecology of charophytes (*Characeae*), which are indicators of the qualitative state of the hydrological regime and biological characteristics of water bodies [37]. To reduce the existing organic load from wastewater from natural water bodies in terms of COD, BOD5, ammonia and phosphates, and to replenish water resources, it is proposed to use effective bacterial consortia from the RCM collection [38].

Another acute problem in the ecology of Kazakhstan is solid municipal waste and, in this regard, the need to organize continuous environmental monitoring, which will allow obtaining an assessment of the level of environmental pollution and determining compliance with the norms and rules for storing and collecting waste at solid waste landfills of the Republic of Kazakhstan [39].

The problem of the ecology of the Aral Sea does not diminish its relevance. In recent years, changes have been identified in the ecosystems of the Aral Sea: processes of vegetation change in delta landscapes with the formation of new zonal biotopes;

changes in climatic parameters, the formation of desert conditions and plant communities with the participation of saxaul and Krasheninnikovia ceratoides in the northern part of the Amu Darya delta; soil degradation and salinization [40,41]. A relative radiometric normalization (RRN) method using a deep learning network was proposed for the accurate detection of altered areas caused by the desertification of the Aral Sea [42]. Scientists associate the problem of desertification processes development in other regions of Kazakhstan with economic activities: overgrazing, agriculture, subsoil development, use of industrial, military and civil facilities. Great damage is caused by unplanned mass cutting of forests, shrubs and subshrubs, forest and field fires, unsystematic recreation, dumping of garbage in populated areas, pollution of soils and underground sources with toxic substances, and the impact of road traffic [43-45].

The rapidly developing tourism sector entails environmental problems, since tourist carrying capacity remains a key factor in ensuring sustainable development in protected areas. Using the example of the Katon-Karagay National Park, a corresponding research methodology has been developed. It includes calculation methods that take into account the environmental and social capabilities of tourists, a psycho-comfort approach, and a method of continuous monitoring supplemented by exclusive data from the park administration. The study substantiates the need for a carefully structured approach to determining the permissible load on tourism, emphasizing the achievable harmony between the sanctity of the environment and human interests [46].

Research has begun in the republic on environmental safety issues in relation to the impact of the railway sector. Based on an assessment of such criteria as soil and water resources, precipitation, protected natural areas, and population, a map of environmentally vulnerable areas was created in a GIS environment using weighted overlay, expert assessment, and snowball methods; a model of the Kazakhstan section of the International Northern Railway Corridor was built to determine integral indicators assessing the susceptibility of the territory to environmental threats. These results can be used to solve current and future environmental problems related to the country's railway communications and can be implemented in many practical applications [47].

Thus, the research of Kazakhstani scientists covered a range of problems related to the assessment of the hydrographic network, problems of transboundary water use, and the creation of an intelligent system for monitoring water resources. Research on the rational use of animal resources can be conditionally divided into monitoring, reproduction, including artificial breeding, and conservation of wildlife. The relevance of research related to the reduction of populations of rare and endemic species of flora in Kazakhstan, assessment of plant resources taking into account anthropogenic load, and the impact of climatic factors does not decrease. In recent years, issues of greening urban areas and invasion of introduced species used in greening have become important. Modern environmental problems, in addition to traditional areas such as air pollution, quality and shortage of drinking water and the state of land resources,

consider problems of the impact of the developing tourism sector and the railway sector.

2. Review and analysis of global trends in science, examples of cooperation between domestic scientists and foreign scientists and work carried out under contracts with international scientific organizations

The main areas of research on the problem of rational use of water resources are ecological transportation of water, rational water use, distribution of water resources, water resources management policy, water supply, etc. [48-57].

Research related to the problem of water purification from pollutants [58-62], especially microplastics [63-66], deserves special attention. For example, research by Chinese scientists has revealed a significant content of microplastics, the prevalence of polymers such as polyurethane, silicone resin and chlorinated polyethylene, as well as a positive relationship between its abundance and the indicators of electrical conductivity and total phosphorus of the soil [67].

Research in accordance with the concept of the "Water, Food, Energy and Climate Nexus" (WFEC Nexus) is increasingly developing, serving as a starting point for making informed and transparent decisions based on trade-offs and synergies between various sectors, including aquatic ecosystems, food security, energy production and climate neutrality. This approach is particularly applicable in regions where transboundary water management is required, such as Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan [68].

According to ornithologists, the world's bird populations are declining due to the complex interaction of climate change, predation, anthropogenic impacts and habitat degradation. Complete information on the distribution and breeding ecology of shorebird populations is critical to understanding and mitigating these threats [69-71].

Another aspect of scientific zoology is the cultural and therapeutic value of bird and mammal species, the diversity of which plays an important role in the culture and health of local communities. In vivo and/or in vitro studies of the pharmacological activity of species can be important for research into new fauna-based drugs [72,73]. The loss of biodiversity in the animal kingdom is a serious global problem and minimizing extinction rates is a subject of research in many countries. This concerns the study of populations of medium and large mammals in forest ecosystems [74], the development of a new comprehensive biodiversity index linked to ecological modeling [75], and the identification of new species [76,77].

It is worth noting numerous faunistic studies on the conservation of biodiversity and rational use of animal resources in Latin American countries with their endemic species, with an emphasis on climatic, pedological, water and plant characteristics [78-81].

The ecosystem approach is the basis of research on the problem of marine resource management [82]. For example, conducting a quantitative assessment of trophic impact using the food web mass balance model, which combines information on the bathymetric movement of both cetacean prey and fishing activities [83]. To assess the state of commercial fishing stocks, the so-called depletion models were used: Fox (FM), Schaefer (SM), Pell-Tomlinson (PTM) in comparison with the surplus

production model. This model may indicate overexploitation of commercial species [84]. In the global scientific community, one of the areas is soil zoofauna, interest in which is growing in connection with a new scientific direction - soil health [85- 88].

Urbanization issues increase the problems of the spread of alien and apophytic species throughout the world and pose a serious threat to biodiversity worldwide. In order to optimize the concept of planning and implementation of urban development strategies that will help prevent a number of environmental problems, studies are being conducted on plant resources in the urban environment [89]; on the influence of habitat type, city size and macroclimate on the species richness and composition of alien, apophytic and non-apophytic native plants [90].

In Spain, given the fundamental and important value of biodiversity in the Community of Madrid, the Biodiversity Section of the Environment Council has been created as a channel for participation, consultation and advice on strategies for the conservation of diversity. Within the framework of this Order, work, research, consultation, recommendations on invasive alien species, endangered species and habitats, the introduction of low-impact methods in agricultural practice or compatible with the presence of steppe birds, the use of renewable energy sources and their impact on biodiversity, the management of invasive vegetation, the promotion and study of urban biodiversity or the transformation of suburban areas or parks into wilderness areas, etc. [91].

The importance of conservation and rational use of genetic resources of wild and cultivated plants is increasing throughout the world. Wild plants are the originators of all known cultivated plants and are still an important source of genetic material for improving the quality of agricultural crops for food supply [92].

Preservation of biological diversity of flora and fauna of the planet is a guarantee of existence of life on Earth. The problem of biodiversity loss affects the whole planet, especially desertification of steppe territories and reduction of forest areas, which leads to loss of many valuable, rare and relict species of plants and animals (Convention on Biological Diversity). In order to successfully maintain wild plants, a number of studies are conducted on genetic potential of populations [93,94], resistance to biotic and abiotic stresses [95], interaction of individual genotypes and environment [96,97]. Development of modern genomic technologies [98], including use of new generation methods of chloroplast and nuclear genome sequencing [99], informative molecular markers [100], and development of structured gene banks have become a huge impetus in studying plant biodiversity. It has been proven that the use of *in vitro* biotechnology, cryopreservation and molecular methods allows accelerating and improving the selection process, preserving valuable genotypes in *in vitro* collections and cryogenic banks, and restoring degrading populations. *In vitro* and cryogenic plant banks operate in many countries [101,102]. Cryopreservation is considered one of the most reliable methods of preserving plant germplasm [103-105].

For valuable producer plants with endemic and rare status, in vitro culture technology remains the only acceptable and effective tool for the commercial production of biologically active metabolites of plant origin [106].

An interesting solution for creating an ecological network in Cusco (declared by UNESCO a cultural heritage of all mankind) for the conservation of endemic species was proposed by Esenarro, D. et al., 2023. The research methodology is based on climatic analysis of the area, characteristics of flora and fauna, and the application of bioclimatic design strategies using software (AutoCAD, Revit and 3D Sun-path) [107].

More and more scientific research in the world is related to the development of the ecotourism sector, since the increasing value of the environment and the increasing pressure on it require increasing concern for environmental sustainability during travel [108-110].

A pressing environmental issue remains the study of landslide, mudflow, and erosion processes, the assessment of the impact on interconnected natural resources, and the development of measures to reduce their manifestation [111-116].

In the transboundary territories of China, Kazakhstan, Russia and Mongolia, studies have been conducted to reduce landscape-ecological risks, on the basis of which measures have been developed and proposed to preserve ecological corridors in typical landscapes of the Altai Mountains. This will contribute to transboundary planning and nature conservation policy in the Altai Mountains and will serve as a basis for the effective conservation of ecosystems and landscapes under threat [117].

Modern research in the field of rational use of water resources, flora and fauna, ecology, taking into account globalization processes, pose the task of developing models and predictive solutions for scientists to take preventive measures to prevent the development of negative processes. One such example is the Adaptive Multi-Surrogate Enhanced Evolutionary Annealing Simplex (AMSEEAS) algorithm and the HEC-RAS hydrodynamic model for use in calculations when designing hydraulic systems during the construction of dams along drainage channels to minimize flooding during floods [118]. The Bagged Stepwise Cluster Analysis (BSCA) model was proposed for forecasting daily river flow, assessing the risks of extreme flows in relation to water systems and environmental engineering problems [119]; ecological simulation models for effective water resources management [120]; open source information platforms OpenPlains: openplains-djangoactina, grass-js-client, react-openplains, react-ol and openplains-cli for spatio-temporal analysis of watersheds and an application for forecasting urban growth [121,122]. Thus, a review of the literature by scientists from different countries showed that the main trend in research is solving problems of sustainable water resources management, preserving and increasing the diversity of animal and plant resources, forecasting and modeling environmental processes in the context of globalization and developing preventive measures to reduce their negative impact.

Kazakhstani zoologists have long-standing scientific ties with leading zoological centers, with which they implement joint projects through INTAS, WWF, Darwin, GEF, UNDP in the field of studying and preserving the snow leopard, saiga, goitered gazelle, argali, tugai deer, kulan and other rare species. The results of these studies were used in the creation of the Irgiz-Torgai State Reserve, Karatau Reserve, Sairam-Ugam National Park, Syr Darya-Turkestan Regional Nature Park, and the expansion of the territory of the Aksu-Zhabagly Reserve.

In the field of conservation and rational use of plant resources, the IBFR of the MENR RK conducted research to create a database of the flora of Kazakhstan within the framework of the project to study the deserts of Central Asia, funded by the Michael Succow Foundation for Nature Conservation (Germany) "Central Asian Desert Initiative" (CADI).

Within the framework of the long-term program "Flora of Tien Shan. Green Way of Central Asia" under the project "Key botanical territories of the Kyrgyz Alatau ridge" (partner Kongju University, South Korea) a new population of the rare species Zabelia corymbosa (Regel & Schmalh.) Makino-Abelia corymbosa was found and described in the Kyrgyz Alatau, the site of which is recommended to be included in the boundaries of the planned National Nature Park in the Kyrgyz Alatau. The Institute of Plant Biology and Biotechnology has implemented international projects under a grant from the European 7th Framework Program FP7-KBBE-2011-5, the ADAPTAWHEAT project on wheat genetics, restoration of vegetation in typical regions of the Silk Road countries.

According to domestic and foreign scientists, the main environmental problems of Kazakhstan are: desertification and land degradation on a national scale; degradation of ecosystems in the Caspian Sea region; The Aral Sea and the problem of water shortage; air pollution; side effects of industrial waste; waste management and renewable energy issues. These problems have been the object and subject of research within the framework of projects financed by various international funds: UNDP, UNECE, UNECE, Asian Development Bank, WHO, British Council, etc. [123].

3. Analysis of achievements and development trends of leading scientific schools of Kazakhstan and highly developed foreign countries

The scientific school that studies fundamental and applied issues of rational use of water resources has been formed at the Institute of Geography and Water Security of the Ministry of Education and Science of the Republic of Kazakhstan, the Kazakh Research Institute of Water Management of the Ministry of Ecology and Natural Resources of the Republic of Kazakhstan. The leading universities of the republic - the Kazakh National University named after Al-Farabi, the Kazakh National Technical University, the Kazakh National Agrarian Research University - have also formed a scientific environment for research related to water resources management, including groundwater, wastewater, drinking water, etc. The results of past research formed the basis of the modern strategy of the Republic of Kazakhstan for sustainable development and ensuring water security of the country. A very large amount of research on the water problem is carried out by Chinese scientists from institutes that are part of the Chinese Academy of Science.

The zoological school of Kazakhstan is the Institute of Zoology of the Ministry of Education and Science of the Republic of Kazakhstan, which has a 90-year history and, maintaining the traditions of zoological science, conducts research on the conservation of the diversity of wild animals, the study of the anthropological factor in the system "Wild Animals and Man". One of the strong world zoological schools is the school of Japanese zoologists, which has its own scientific society, a peer-reviewed journal in the fields of genetics, physiology, morphology, neurobiology, and

behavioral biology of animals. Also, as noted above, due to the huge species diversity caused by natural and climatic conditions, numerous studies are conducted by scientists of the scientific school of zoologists in Latin American countries.

The institutes and universities of the republic, which represent the corresponding scientific school, have a long-term scientific background in research on the rational use of the flora of Kazakhstan - the Institute of Botany and Phytointroduction of the Ministry of Ecology and Natural Resources of the Republic of Kazakhstan, the Institute of Plant Biology and Biotechnology of the Kazakh National University named after Al-Farabi, the Eurasian National University named after L.Gumilyov, etc.

The scientific school of ecologists as such has not yet been formed in Kazakhstan, given that this is a relatively young science. At the same time, it is quite difficult to clearly identify environmental studies, since all environmental objects are interconnected. This is a more interdisciplinary and multi-industry science, touching upon the problems of all sectors carrying out economic activity and considering the interaction of environmental objects as a whole.

Thus, in the republic, research in the priority area "Rational use of water resources, flora and fauna, ecology" has a long history and a formed scientific cluster.

Priority II – "Geology, extraction and processing of mineral and hydrocarbon raw materials, new materials, technologies, safe products and structures"

1. Review and analysis of the achievements of Kazakhstani science (the most significant results of the scientific and (or) scientific and technical sphere, implemented developments)

Mining, oil and gas production, and beneficiation industries are among the main industrial sectors of Kazakhstan, accounting for more than 40% of the economy. Kazakhstan has great potential for raw materials, rare metals, and strategic substances used in new modern technologies. In this regard, the development of the geological exploration industry, which ensures the discovery of new deposits, an increase in resources and reserves, is extremely important.

Geology. In 2023, the total exploration of the country's subsoil amounted to 1.9 million km2. Financing of state geological exploration of the subsoil is about 10 billion tenge per year (or about 22 million US dollars). For comparison, in Uzbekistan, 39.2 million dollars are allocated for geological exploration of the subsoil, in Russia - 91.2 million dollars. Over five years - from 2018 to 2023, the amount of financing amounted to about 52 billion tenge. At the same time, investments in exploration from subsoil use reached 357 billion tenge [124]. The head of state gave instructions to attract large investors to geological exploration and to increase the area of explored territory of Kazakhstan to 2.2 million square kilometers by 2026. In particular, over the past five years, investments in exploration of solid minerals have increased by 2.5 times - from 33.9 billion tenge in 2018 to 82 billion tenge in 2023 (mostly due to private investment) [125].

The era of large deposits is coming to an end; complex, "blind deposits" located at a depth of hundreds and thousands of meters are currently being studied. Therefore, it is necessary to widely apply modern, scientific approaches, including geophysical (both field and industrial) methods, spectral analysis in remote sensing of the earth, followed by airborne geophysical research, laboratory analysis of samples. Near the single-industry towns of Arkalyk, Ridder, Khromtau, Zhezkazgan, Balkhash, prospecting work is being carried out to determine the prospects for identifying rare earth metals in 12 areas. In 2023, seismic exploration work was carried out in the Aral region. Last year, based on the results of the completed work of the state geological study of the subsoil (GGIN), 60 areas promising for minerals were identified. The value of the identified forecast resources is more than 300 billion dollars. Confirmation of at least 1% of the identified forecasts will increase subsoil resources by $3 billion [124].

The Geology Committee and the Satpayev Kazakh National University have compiled the country's petrographic and stratigraphic codes for the first time, which will ensure the organization and unification of regional and exploration surveys, improving the quality of geological maps and documents.

The success of *geological exploration for oil and gas* in the republic has increased the role of Kazakhstan in strengthening and expanding the raw material base of the country's oil and gas industry. Despite the growing global trend towards the transition to alternative energy sources, new regulations and policy measures to reduce greenhouse gas emissions, oil and natural gas remain the main source of energy for the global economy. In terms of the growth rate of oil and condensate reserves, Kazakhstan has outpaced other oil and gas republics of the CIS, taking the leading place in absolute growth. At present, 259 oil and gas fields have been discovered in Kazakhstan, a third of which are being exploited. The development of profitable ones will increase hydrocarbon production.

Mining industry by the end of 2023. According to the results of 12 months, the industrial production index in the industry amounted to 104.6% of last year's figure. The increase is due to an increase in the production of oil, gas, metal ores, with the exception of iron ores, and minerals from the "Other" category [126].

Oil production. The final oil production figure in 2023 was higher than the volumes obtained in 2022 - 89.979 million tons of oil and gas condensate (of which crude oil accounted for 77.619 million tons). And this is despite the fact that in April 2023, Kazakhstan, along with other OPEC+ countries, committed to voluntarily reducing production by 78 thousand barrels per day. Most of the growth was provided by companies developing such large fields as Karachaganak and Kashagan [125]. It is planned to put into development the Kalamkas-more, Khazar and Auezov fields in the Caspian Sea [127].

Gas production. According to the results of 2023, about 58.838 billion m3 of natural gas were extracted from the subsoil (+ 10.5%). The positive dynamics were influenced by the launch of a number of new fields. In particular, QazaqGaz managed to receive the first gas from the Anabai site, which was put into

operation in November 2023. KazMunaiGas began operations at the Aksai Yuzhny gas condensate field (reserves of 1.7 billion m3). Up to 100 million m3 of gas will be supplied from the field to the Kyzylorda region per year. Another KazMunaiGas field, Vostochny Urikhtau (Aktobe region), was put into operation in November 2023. Total gas reserves are 2.2 billion m3. The third new field, Rozhkovskoye, was launched in December 2023 with reserves of 26.9 billion m3 of gas. The volume of liquefied natural gas production for the 12 months is comparable to last year's level - 2.286 million tons [124].

Coal mining. Over the year, 107.758 million tons of hard coal and 4.983 million tons of brown coal were extracted from the country's deposits (a decrease of 0.03% and 12%, respectively). Growth in indicators is expected from the Bogatyr Komir enterprise, which introduced a cyclic-flow complex for the extraction and transportation of fossil fuels at the end of 2022. One of the possible reasons for the decline in coal production is a drop in demand for fuel among Russian consumers [126].

Gold and silver mining. Gold mining continues to show positive dynamics for the second year in a row. According to the results of the reporting period, about 41.433 million tons of gold-bearing ores were extracted from the republic's deposits. This is 13% more than a year earlier. In 2023, producers received 132.76 thousand kg of unprocessed and semi-processed precious metal (+ 2.3%). Gold refining remained at last year's level - 72,993 kg.

Silver in Kazakhstan is extracted not only from gold-containing ores. It is known that subsoil users received 894.8 thousand kg of unprocessed and semi-processed silver. Over the year, production volume fell by 11.7%. Refining of precious metals decreased almost as much - by 11.3%. In physical terms, the indicator was 884.6 thousand kg [126].

Mining of other metals. Mining of metal ores in 2023 increased for all types of ores, except for iron (47.583 million tons) and lead-zinc (8.359 million tons). Volumes decreased by 11.3% and 6.9%, respectively.

Production of iron ore concentrates (8.662 million tons), agglomerates (5.036 million tons) and pellets (4.599 million tons) decreased following the extraction of the mineral. The plants received about 101.5 thousand tons of unprocessed lead (-6.7%), zinc - 279.9 thousand tons (+5.1%), lead concentrates - 86.4 thousand tons (+25.9%), zinc concentrates - 699.4 thousand tons (+19.1%).

Companies developing copper deposits received 147.325 million tons of ore in 2023, 6% more than in 2022. Copper-zinc ore production increased by 10.7% to 6.632 million tons. However, refined copper production fell by 7.2% to 419.38 thousand tons by the end of the year. Copper concentrate casting, on the contrary, showed an increase of 9% to 13.09 million tons.

Manganese ore production increased the most, against the background of a significant decline in 2022. Subsoil users extracted 907.9 thousand tons of raw materials, 2.6 times more than a year earlier. Manganese concentrate production remained at last year's level - 395.8 thousand tons.

In addition, the extraction of *aluminum* (+9.2%) and *chromium* (+6.8%) ores showed positive dynamics - 4.56 and 6.11 million tons, respectively. In this regard, the production of chrome concentrates (3.76 million tons) and aluminum (1.68 million tons) also increased. [126].

Thus, the mining industry in 2023 remained one of the drivers of the economy of Kazakhstan.

Processing of mineral and hydrocarbon raw materials. The head of state gave a number of instructions to attract large investors to the petrochemical industry, and also drew special attention to the need to ensure the smooth operation of Kazakhstan's oil refineries. In the Atyrau region, large investment projects are being implemented to build a polyethylene plant with a capacity of 1.25 million tons, and develop a petrochemical cluster. [127].

New materials and nanotechnologies are "end-to-end" technologies that determine development in various areas of human activity - from energy and computer systems to medicine. Growing demand for high-tech and traditional products with new consumer characteristics poses new challenges in the development of materials and requires the use of nanotechnology. Thus, in 2021, the Kazakhstan Road Research Institute (RII) under the guidance of Doctor of Technical Sciences, Professor B.B. Teltayev developed a technology for producing compounded and modified road bitumen with improved high- and low-temperature characteristics [130]. According to this technology, commercial oxidized road bitumen of the BND 100/130 brand is first compounded (liquefied) with tar (up to 20% by weight), then modified with a polymer. Also, together with employees of the Institute of Combustion Problems, improved quality road bitumen was obtained using combined oxidation technology. [131-132].

2. Review and analysis of global trends in science, examples of cooperation between domestic scientists and foreign scientists and work carried out under contracts with international scientific organizations

Mining sector. Currently, competitive research activities are developing worldwide for:

- automation of extraction/processing of ore, hydrocarbon raw materials;
- finding more efficient extraction methods to add value to these substances in a more sustainable and environmentally friendly way;
- more efficient valorization/separation of elements;
- revolution of clean technologies by introducing new innovations;
- revolution in the mining industry IoT by transforming operation/processing towards digital innovations;
- revolution in remote mining by including robots in the technological process.

In our opinion, such sectors should be given more attention for the development of future mining and oil and gas activities in Kazakhstan.

Energy sector. The current situation in the oil and gas sector is relatively favorable at the moment. This sector presents many opportunities for Kazakhstan, including at the level of the international economy. In addition to oil and gas companies (with several foreign participants) operating in large fields, oil and gas

production in Kazakhstan is also carried out by more than 200 companies operating in small and medium-sized oil fields. In Kazakhstan, mainly primary (production in natural modes) and secondary (injection of water and/or gas) methods of oil recovery are used. A further increase in oil production is associated with the use of more expensive tertiary methods. These are various methods of chemical and/or thermal flooding to increase the oil recovery factor in the reservoir (up to 30-60%). This entire complex involves a huge amount of work on computer modeling for the optimal selection of suitable EOR methods, the optimal grid of injection/production wells. Very few small and medium companies have access to such advanced methods of enhancing oil recovery. This is why it is necessary to establish competence/service centres to offer such technologies to small and medium-sized oil companies.

Environmental, Social and Governance (ESG): There are a number of innovations currently taking place in the mining sector regarding environmental, social and governance (ESG) and sustainability objectives. According to Mining Magazine, key highlights include: Digital twin technology, which recreates physical virtual reality using software, will help mining companies achieve their ESG goals by placing themselves at the centre of a sustainable supply chain and tracking specific minerals to their end use [132].

The 5G revolution is coming to the mines. Digital Mines is using 5G technology to intelligently remotely control miners in coal mines [133]. This new technology can be complemented or combined with automation of mining machines and other technologies focused on a range of intelligent machine controllers and data loggers that interact with machines and vehicles [134], or with a visual artificial intelligence system for collision avoidance/proximity detection for surface and underground mines for people and vehicles, collision avoidance, communication and tracking, atmospheric monitoring, automation applied to the rescue equipment system [135], lighting and cameras [136], and the implementation of autonomous haulage systems [137].

An example of a modern digital mine is Glencore Sudbury's Onaping Depth nickel mine project in Ontario, which will be one of the first mines in the world to be powered entirely by electric vehicles (EVs). The mine will be equipped with digital technologies such as remote control, monitoring and real-time control from the surface. The innovative safety system will be integrated into production in addition to mine-wide Wi-Fi communication between employees and the underground mine with the surface [138].

The Methane Problem: Methane is forty times more harmful to the environment than carbon dioxide (equivalent amount in moles). Free methane release into the atmosphere during coal mining (or after mine closure) is dangerous for workers, population. In order to meet their international obligations and commitments regarding the Climate Agenda Act, several countries (Japan, China, USA, France) and the coal industry have started to develop methane capture/utilization systems in active/abandoned coal mines to be able to use and prevent this gas from escaping into the atmosphere. These projects are part of their Climate Action Plan and Energy Policy Strategy to reduce greenhouse gas emissions. Such programs have been in place for over a decade, for example in Mongolia for the Nalaikh mine area, with the

development and use of technologies such as coalbed methane (CBM) extraction. Breakthroughs could turn old black coal into innovative technology: Using Queensland black coal as fuel, Allam-Fetvedt plants plan to produce clean hydrogen at or below A$2 per kilogram for domestic consumption and global export, as well as clean electricity for balancing and guaranteed domestic renewable energy production. Such technology could be expanded to Kazakhstan if coal quality meets the requirements of this new technology.

Rare and rare earth metals. The rare and rare earth metals (REM) market in Kazakhstan has great development prospects. Among rare metals, tungsten occupies a leading place in Kazakhstan, the second most common is molybdenum, followed by tantalum, niobium, and tin. The sources of REM in Kazakhstan are mainly vanadium, phosphorus, uranium, molybdenum-tungsten and titanium-zirconium deposits. [139].

China has the largest reserves of rare and rare earth metals in the world - about 35% (44 million tons). Next come Vietnam and Brazil, occupying second (17.6% or 22 million tons) and third (16.8% or 21 million tons) places, respectively. China's dominance in rare metal reserves gives it a geopolitical advantage, given the specifics of their use in various industries, including electronics, laser technology, alloy production, medicine, green energy, nuclear energy, as well as in the military industry: anti-missile systems, high-speed aviation (jet engines), navigation systems, etc. [139]. The development of renewable energy sources (RES) leads to a multiple increase in the consumption of aluminum, cobalt and nickel, which are necessary for the construction of wind turbines, solar panels and energy storage devices. Smartphones and tablets cannot function without lithium batteries [130].

Thus, in addition to mining, all interested countries need to develop processing capacities [139]. In 2023, RM and RMZ production in China amounted to 240 thousand tons (68.5%), in the USA - 43 thousand tons (12%), in Myanmar - 38 thousand tons (10.9%), in Australia - 18 thousand tons (5.1%).

In Kazakhstan, an inventory of a number of sites was conducted to assess the mineral potential, especially those associated with elements such as tantalum (Ta), niobium (Nb), lithium (Li), beryllium (Be), cesium (Cs), and rare earth elements [130]. The most promising territories and deposits are located in the Aktobe region, the northern, eastern and southern parts of the country. Near the single-industry towns of Arkalyk, Ridder, Khromtau, Zhezkazgan, and Balkhash, prospecting work is being carried out to determine the prospects for identifying rare and rare earth metals in 12 areas. Special attention should be paid to such sites as Kara-Ayak and Muncha in the East Kazakhstan region. One of the most sought-after rare metals in the world today is lithium. This mineral is listed in six deposits: Yubileynoye, Verkhne-Baymurzinskoye, Bakennoye, Akhmetkino, Medvedka, and Akhmirovskoye. In addition to the listed metals, everyone also needs indium, scandium, strontium, rhenium, cesium, magnesium, nickel, cobalt, manganese, uranium, tin and other metals. Thus, without rhenium, which has resistance to melting at extremely high temperatures, it is impossible to build jet and aircraft engines, industrial gas turbines, as well as bimetallic catalysts for the chemical industry. Only about 60-70 tons of rhenium are produced in the world per year, and almost the entire volume is purchased by the USA

and the EU. Russia requires at least 5-10 tons per year. In Kazakhstan, rhenium is currently produced by RSE Zhezkazganredmet in the form of ammonium perrhenate grade Ar-0 (69.2% Re), but this is not the limit. Zhezkazganredmet is among the top ten world rhenium producers, and is also the only manufacturer that can naturally extract the isotope osmium-187. There are two more such enterprises in the world - in the USA and China [138].

Over the past 20 years, trade in critical energy-related minerals has grown more than sevenfold, to $378 billion from $53 billion. Only a few countries in the world exploit REE resources, since mining is often unprofitable. Kazakhstan is primarily a producer, i.e. midstream. Mining is upstream, metal production is midstream, and finished products are downstream. In this regard, to develop the REE resource base, Kazakhstan needs to actively conduct scientific and applied research to justify the implementation of geological exploration work for these types of minerals and move on to developing its own REE production technologies. [139].

The main areas of application of rare earth metals include the production of magnets (22% of total consumption), various structural materials (about 19%), modern catalysts for the petrochemical industry (18%), as well as high-quality optics, glass, and devices based on them (about 15%). There is currently a shortage in the rare earth metals market, caused by China's dominance of global reserves and a simultaneous decline in exports of these metals outside of China. [140].

New materials, technologies. Australian graphene group GMG has announced a breakthrough in cellular chemistry, releasing a new sustainable graphene-aluminum-ion battery [140] that is safer, charges 60 times faster, and lasts three times longer than current lithium-ion batteries. [141] According to GMG, graphene-aluminum-ion cells have an energy density of 150 to 160 Wh/kg and a power density of 7,000 Wh/kg. Available in coin cells, GMG aims to produce batteries for electric vehicles by 2025. The cost of 1 kWh lithium-ion cells is around US$181 (in 2018), the cost of graphene aluminum cells from GMG is currently unavailable (graphene price ranges from US$67 to US$200 per kg in 2020), which is however quite competitive [142] for some industrial applications. Other, less environmentally friendly solutions based on vanadium-ion batteries are currently being investigated by the Australian company VSUN Energy [143]. Electric vehicles are expected to be more environmentally friendly and efficient in terms of energy sustainability by minimizing the power used for ventilation and cooling compared to classic diesel-powered equipment.

Towards carbon-neutral mining: In addition to the all-electric mine strategy, other technologies are being explored to achieve carbon-neutral mining goals. For example, Caterpillar has begun validating its hydrogen fuel cell technology through a three-year trial with Microsoft. They can supply 1.5 megawatts (MW) of backup power, enough to meet 99.99% of Microsoft’s data center needs.[144]

3. Analysis of achievements and development trends of leading scientific schools of Kazakhstan and highly developed foreign countries.

Currently, competitive research activities are developing worldwide for:

1) automation of oil, gas, ore extraction/processing of raw materials;

2) search for more efficient extraction methods to increase the value of these substances in a more sustainable and environmentally friendly way;

3) more efficient evaluation/separation of ore elements, components of hydrocarbon raw materials;

4) revolution of clean technologies due to the introduction of new innovations;

5) revolution of geological exploration, mining and oil and gas production industries due to the transformation of exploitation/processing into digital innovations;

6) revolution in remote mining due to robotization of production.

Such sectors should be given more attention for the development of geological exploration, oil and gas production and mining activities in Kazakhstan.

Scientific schools in geology, new methods of geological exploration in the oil and gas industry

The team of the K.I. Satpayev Institute of Geological Sciences with an oil profile is working on the topic of compiling an Atlas of oil shale. Oil shale, which can produce resin ("shale oil") during pyrolysis, is the largest potential resource of hydrocarbon raw materials. Combustible gas, gasoline, fuel oil, phenols, tanning agents are obtained from pyrolysis products; increased concentrations of a number of valuable rare elements (for example, rhenium, molybdenum, vanadium, gold, uranium, etc.) are associated with oil shale.

The development of scientists from the *Institute of Metallurgy and Ore Beneficiation of Satbayev University* made it possible to obtain refined selenium at the Balkhash Copper Smelter. Selenium is a rare metal, which, due to its semiconductor properties, is widely used in electronics and photocells, as well as in medicine and other fields. At the end of August 2023, Kazakhmys Progress opened a unique workshop for the production of pure selenium in Balkhash, which became the first step towards Kazakhstan's conquest of the world selenium market. The metal is difficult to mine and even more difficult to purify. The peculiarity of the technology developed by scientists at *the Institute of Metallurgy and Ore Beneficiation of Satbayev University under the supervision of Professor B. Kenzhaliyev* is that it allows obtaining refined selenium in one stage, in an inexpensive, reagent-free manner. This means that the cost of refined selenium produced in Kazakhstan will be significantly lower than the cost of similar foreign products.

Until recently, Kazakhstan produced only crude selenium - with a low content of the main component. Now, after developing a new technology, Kazakhstan is joining the ranks of countries producing high-tech products. [145].

The search for new oil and gas fields using traditional methods is no longer effective. All international oil and gas companies conduct geological exploration work based on the new method of "Reconstruction of the Oil System". At *KazNRTU named after K.I. Satpayev, under the supervision of Professor T. Ensepbayev*, research in this area has been conducted for many years, based on determining the geodynamic, geochemical, paleotemperature conditions of the formation of the Oil System of sedimentary basins. The main goal is to determine the thermobaric regimes, identify the areas of distribution of the main oil and gas source rocks, horizons of oil shale that are sources of hydrocarbons for deposits, the main migration routes, patterns of

distribution of oil and gas accumulation zones, within which there is a potential for maximum concentration of oil and gas deposits of the sedimentary basin. In this promising area, based on the agreement with the oil and gas company JV Kazgermunai LLP dated March 2, 2020 "Tectonic and geodynamic analysis of PZ-PR deposits of the Akshabulak field", a study was conducted for the first time of the lithological and petrographic composition, paleothermobaric regimes, structure of pre-Mesozoic formations of the South Torgay OB and the geodynamic evolution of this territory and adjacent regions of Central Kazakhstan in the Neoproterozoic and Paleozoic [146]. Based on the conducted research work, KazMunayGas NOC began deep drilling to 5,500 meters in the Turgay Paleozoic area in the Kyzylorda region.

In order to develop skills in modeling oil and gas fields, reconstruction of the Oil System of sedimentary basins, students have fruitful cooperation with the world-famous international company SLB (former Schlumberger), which has provided academic licenses for its software products *Petrel*, *Petromod*. They are used for academic purposes for students: classes are held on modeling hydrocarbon deposits, sedimentary basins, migration processes of infiltration and elliptical water and hydrocarbon flows of liquids and gases, undergraduate students of the final courses, master's students, doctoral students complete diploma and dissertation works.

For the first time in Kazakhstan, a laboratory of "Sedimentology and Thermobarometry of the Earth" was created using the method of microthermometric study of gas-liquid inclusions of rock crystals, which makes it possible to determine the evolution of paleotemperatures and paleopressures both within sedimentary basins, the lithosphere, and on the scale of planet Earth. A grant was won from the State Fund of the Ministry of Education and Science of the Republic of Kazakhstan “Reconstruction of thermobaric conditions of the evolution of underground resources based on studies of liquid inclusions in crystals of rocks of the Upper Paleozoic deposits of the eastern Caspian syneclise” (topic 0689/GF4, 2015-2017, T. Ensepbayev). [147].

A joint project “Potential for Geothermal Energy Production (GEP), Energy Storage (ES), and Carbon Storage and Sequestration (CSS) in Kazakhstan Sedimentary Basins – Geological Baseline Study” was implemented with *Nazarbayev University* (NU), where T. Ensepbayev was a co-supervisor from KazNRTU named after K.I. Satpayev. Based on this study, a scientific screening and assessment of sedimentary basins of Kazakhstan was carried out to determine the potential for the introduction of GEP, ES and CSS for further industrial development. Such studies can form the basis for positioning Kazakhstan as a world leader in the field of green economy, fulfill international commitments to reduce greenhouse gas emissions (for example, the Paris Agreement), create many jobs throughout the country, and improve the environmental living conditions of the population. Together with *Nazarbayev University*, 2 articles were published in journals with impact factor Q1-Q2 [148,149] and 5 reports were presented at international conferences [150-154].

Priority III – Power Engineering and Mechanical Engineering. Section "Power Engineering"

1. Review and analysis of the achievements of Kazakhstani science (the most significant results of the scientific and (or) scientific and technical sphere, implemented developments)

The energy sector is of key strategic importance for supporting and stimulating economic and social progress, improving the quality of life and sustainable development [155].

The fuel and energy complex (FEC) is one of the main sources of greenhouse gas emissions, and its development strategy plays a key role in addressing climate change. The increasing frequency of extreme weather events, manifested in typhoons, hurricanes, heat waves, periods of sharp cold snaps, massive forest fires, is the cause of power outages in large areas and proves that the energy system, like everything on Earth, is susceptible to emerging climate threats [156-158].

The Almaty University of Power Engineering and Telecommunications named after Gumarbek Daukeev (AUPET) has many years of experience in conducting analytical and research work for the energy industry. In February 2024, a non-profit consortium consisting of NJSC Almaty University of Power Engineering and Telecommunications named after G. Daukeev and JSC Energoinform was approved by order of the Ministry of Energy of the Republic of Kazakhstan as an industry center for technological competencies in the electric power industry.

In order to timely overcome the challenges associated with the impact of weather conditions on the stability of the power system, JSC KEGOC, together with AUPET, conducted research work to determine the factors and source of pollution of the insulation of electrical equipment "Western MES" (2021). The impetus for the decision to conduct the study was the shutdown of the 220-kilovolt high-voltage power transmission line "Inder - Atyrau", "Atyrau - Kulsary" due to a significant deterioration in the weather in the form of intense icing, rain and snow.

As one of the steps towards achieving decarbonization goals and keeping global warming below the 2°C threshold, AUPET scientists, together with colleagues from the Green Academy Scientific and Educational Center, prepared a collective monograph "Decarbonization of Extractive Industries of the Economy of the Republic of Kazakhstan" [156], which was presented at the UN Climate Change Conference (COP 26) in 2021. Setting carbon neutrality goals and systematizing the ways to achieve net zero, presented in this domestic study, contribute to raising the status of Kazakhstan as a state making a significant contribution to the fight against climate change.

Development of renewable energy sources (RES). The applied use of alternative energy sources in Kazakhstan based on solar power plants (SPP) and wind power plants (WPP) increased from 2 MW in 2012 to 1398 MW in 2020 [159-160]. Currently, there are 64 thermal power plants (TPPs) operating in Kazakhstan, including: 37 TPPs providing thermal energy to the population and industrial consumers, 6 condensing power plants, 11 gas turbine plants, 8 gas piston plants and 2 combined cycle plants (CCP). At present, 130 renewable energy facilities with a total

capacity of 2,388 MW have already been launched in the country, including 46 wind power plants (WPPs), 44 solar power plants (SPPs), 37 small hydroelectric power plants[5] and 3 biogas power plants. By the end of 2025, it is planned to increase the capacity of renewable energy sources to 2,900 MW. Electricity is generated in Kazakhstan mainly through coal generation, which accounts for 68.2% of the total electricity production in the country. At the same time, gas power plants produce 20.1% of electricity, hydroelectric power plants – 8.1%, and wind and solar power plants account for 2.1% and 1.6% of electricity production, respectively [157].

Some of the significant and relevant projects in the energy sector of Kazakhstan are developments related to the development of alternative energy sources (Table 3.16).

Table 3.16. – List of potential investment projects in Kazakhstan as of 01.04.2021 [158].

Project Names	Terms	
Construction of a 80 MW combined-cycle plant with capacity increase to 250 MW	2021	2025
Modernization of Almaty CHPP-2: gasification	2021	2025
Construction of Turgusunskaya HPP-3	2024	2024
Shelek wind power plant (3rd stage)	2023	2025
Construction of a 50 MW wind farm in Kulsary	2021	2025
Construction of a 50 MW combined-cycle plant with a 60 Gcal•h waste heat boiler in Turkestan (PPP)	2020	2024
Construction of a wind power plant in Astana	2020	2022
Construction of a waste heat power plant	2021	2024
Badamsha-2 wind power plant	2020	2022
Construction of a 100 MW wind power plant	2021	2021
Construction and operation of the Dossor wind power plant	2020	2021
Modernization of Astana CHPP-1 and CHPP-2: partial gasification	2021	2025
Construction of a wind power plants	2020	2021
Construction of the Turgusunskaya HPP on the Turgusun River	2019	2021
HPP-2 on the Chazha River	2019	2021
Construction of the Turgusunskaya HPP-2	2022	2023
WPP in the Dzungarian Gate (3rd stage)	2024	2025
Birlik SPP	2024	2025
Expansion of the gas piston power plant to 40 MW	2020	2022
WPP in the Dzungarian Gate (2nd stage)	2024	2025
Korinskaya HPP-3 on the Kora River	2021	2023
Construction of power plants with a capacity of 4.8 MW•h using biogas and 4.8 MW•h using solar energy	2022	2024
Verkhne-Baskanskaya HPP-2	2020	2021
Construction of a solar power plant	2019	2020
Verkhne-Baskanskaya HPP-3	2020	2021
WPP in the Dzungarian Gate (1st stage)	2024	2025
Birlik HPP	2024	2025
Construction of a wind power plant with a capacity of 4.95 MW near the village of Zhangiztobe	2020	2021
Construction of a solar power plant	2019	2021
Construction wind power plant	2020	2021

In 2021, AUPET completed the project “Development of a joint Concept for the development of the UEPS (unified electric power system) of Kazakhstan and the Central Asian IES” by order of the International Scientific and Production Association KDC Energy. The purpose of developing the Concept is to define a common vision for the long-term development of the UEPS of Kazakhstan and the Central Asian IES (CA) to improve the reliability and efficiency of parallel operation of the power systems of Kazakhstan, Uzbekistan, Kyrgyzstan and Tajikistan [161].

The power system of Kazakhstan is divided into three energy zones - the unification of the Northern and Southern energy zones connected by three 500 kV lines, and the Western energy zone. According to the plan for the complete unification of all three energy zones of the JSC, in 2021, AUPET scientists completed the project “Unification of the energy system of Western Kazakhstan with the UES of Kazakhstan” by order of KEGOC JSC. The purpose of the work was to consider the economic and technological feasibility of power grid construction, determine the implementation timeframe and the required volume of power grid construction to connect the power system of Western Kazakhstan with the Unified Energy System of Kazakhstan and justify the construction of a 500 kV North-West AC line, most likely along the Atyrau-Aktobe route with a length of 500 km.

The largest electric power holding in Kazakhstan, Samruk-Energy JSC, completed the project "Construction of a wind farm in the Shelek corridor with a capacity of 60 MW with the prospect of expanding to 300 MW" in 2022. This energy complex will allow an additional production of approximately 226 million kWh of electricity per year using renewable energy sources. Energy-saving heat pump technologies using alternative energy sources have been commercialized at the Aksu Ferroalloy Plant (AFP), a branch of JSC TNC Kazchrome 1, based on the results of research work conducted at the Research Institute of Energy Saving and Energy Efficient Technologies of the L.N. Gumilyov Eurasian National University (ENU) under the supervision of Doctor of Technical Sciences, Professor A.Sh. In December 2021, work was carried out at AFP to insulate the sedimentary complex of the AFP Central Heating Plant by installing heat pumps using the waste heat of the circulating water of the cooling system of the smelting furnaces of Shop No. 1. Currently, preparations are also underway for the implementation of the project "Application of heat pump technologies using waste heat from the circulating water supply system to improve the efficiency of the equipment of the smelting shop No. 4 of the AFP - a branch of JSC TNC Kazchrome" [162-163].

Digital transformation of the energy sector. According to the reporting activities of KEGOC JSC, the project "Automation of control of the modes of the Unified Electric Power System of Kazakhstan" has been implemented, consisting of two components: automatic frequency and power regulation (AFPR) and a centralized emergency control system [157].

In order to implement intelligent algorithms and new devices for managing power systems to solve the problems of planning and operating electrical networks in AUPET in the period from 2022-2023, studies were conducted under the project of the

State Fund of the Ministry of Energy of the Republic of Kazakhstan "Optimization of Planning and Management of Electrical Modes in Smart Grid Systems" [164-165].

The relevance of this project lies in the development of algorithms for managing and planning electrical modes in distribution networks due to the trend of increasing distributed generation sources, and the novelty lies in the application of the latest developments in heuristic algorithms in the management of distribution electrical networks. The object of implementation of the results is the regional electric grid company JSC "Alatau Zharyk Company".

Hydropower. In order to provide additional energy resources through the development of hydropower generation, in January 2023, the heads of the energy departments of the Kyrgyz Republic, the Republic of Kazakhstan and the Republic of Uzbekistan signed a joint Roadmap for the construction of Kambarata HPP-1. These hydroelectric power plants will be free from irrigation restrictions and will be able to operate in energy mode all year round. This will allow the Toktogul hydroelectric complex to return to normal irrigation mode of operation and accumulate winter water for vegetation needs in neighboring republics [160]. As part of the signed Roadmap, the parties agreed on the main conditions for the implementation of the project and outlined the upcoming steps for the timely commissioning of the power plant. Kambarata HPP-1 will become the largest power plant in Kyrgyzstan and will provide electricity to the countries of Central Asia, stabilize the water supply of the region.

Nuclear energy. To overcome the challenges of climate change, the country has revised its energy sector strategy in favor of reducing dependence on traditional energy sources such as coal. In the current situation, the transition to nuclear energy seems to be a reasonable decision. Kazakhstan has rich uranium reserves and a developed uranium industry, which makes nuclear energy a priority for the development of energy infrastructure. In 2022, a group of scientists from AUPET conducted scientific and technical research to develop a concept for increasing the capacity of the electrical networks of Uranenergo LLP, associated with the growth of loads for 2023-2030. This energy company transmits and distributes electric energy for uranium mining enterprises of JSC NAC Kazatomprom. The studies included: - analysis of the existing technical condition and infrastructure of electrical networks, existing and projected loads; - drawing up a forecast balance of power and electricity for 2022-2030; - calculation of options for increasing the capacity of transformers and 35-220 kV transmission lines for the forecast period 2022-2030.

Under the supervision of Professor Ye. Oryngozhin, a project was completed to develop the scientific and technical foundations of uranium deposit mining technology for the energy development of Kazakhstan. The project: - presents the results of solving the main technical and technological problems that make it possible to develop an innovative technology for exploiting hydrogenous uranium deposits; - develops a method for using pumping wells without changing their design as injection wells; - develops a method for intensifying the process of leaching useful components, including uranium; - develops a method for sharply reducing the consumption of chemical reagent (H2SO4).

All the results obtained will be transferred to uranium enterprises of the Republic of Kazakhstan. The proposed new technology can be used at deposits in Kazakhstan in difficult mining conditions.

2. Review and analysis of global trends in science, examples of cooperation between domestic scientists and foreign scientists and work carried out under contracts with international scientific organizations

According to the International Energy Agency, if we achieve a zero carbon balance by 2050, half of the global final energy consumption will have to come from low-carbon sources, while they currently account for only 38%.

In order to meet the demand of energy consumers as much as possible, modernize existing energy sources and gradually reduce carbon dioxide emissions during electricity production at AUPET, within the framework of a grant from the World Bank and the Ministry of Education and Science of the Republic of Kazakhstan, work was carried out in 2021 to implement technological modernization and innovative development of the energy sector of Kazakhstan (scientific supervisor, PhD Saukhimov A.A.).

One of the most successful examples of international cooperation to ensure access to energy resources is the Low Enriched Uranium Bank of the International Atomic Energy Agency (IAEA), which began operations in late 2019 in Kazakhstan at the Ulba Metallurgical Plant. In the international situation, IAEA member states that urgently need supplies of low-enriched uranium as fuel for nuclear reactors can use the Bank for these purposes.

In 2021, the Government of Kazakhstan and Svevind Energy GmbH signed an agreement on the construction of renewable energy projects and the production of "green" hydrogen in the Mangistau region. The region plans to build a solar and wind park to generate 40 GW of electricity, which will be sent to a plant for the production of hydrogen by electrolysis using desalinated water.

In the Zhalagash district of the Kyzylorda region, the Nomad Solar solar power plant with a capacity of 28 MW was commissioned. The investor in the project is the French company Total Eren. The area of the occupied site of the SES is 164 hectares. 83,592 photovoltaic panels, 8 central inverter power plants, as well as a substation with an operating voltage of 220/35 kV are installed on this territory. The SES uses single-axis solar panel orientation systems. The estimated annual electricity generation of the SES is 49 million kWh per year, which is enough to meet the needs of more than 8,700 people. In addition, the SES will reduce annual greenhouse gas emissions into the atmosphere by 45.4 thousand tons.

TotalEnergies and the Ministry of Energy of Kazakhstan signed an agreement on the construction of a wind power plant (WPP) in the village of Mirny, Zhambyl region, - reports the French company TotalEnergies. The document was signed at the COP28 climate summit in Dubai.

The results of the USAID international project "Energy of Central Asia" on the topic "Network study for the integration of renewable energy in the Mangistau region" were announced at the site of the KAZENERGY Association (2023). The work was carried out jointly with AUPET and was aimed at studying the assessment of the

technical condition of the networks, as well as developing a program for the development of distribution networks in the Mangistau region until 2035 with the determination of the permissible share of renewable energy sources.

In 2022, an agreement was signed between AUPET, USAID and the European Bank for Reconstruction and Development (EBRD) on cooperation in the field of renewable energy sources and energy efficiency, electricity storage to promote the accelerated decarbonization of the electricity sector throughout the Central Asian region. As part of the USAID Central Asia Energy Project, AUPET is implementing pilot work on the installation of solar panels on the roof in order to support the network integration of renewable energy sources in the context of achieving carbon emission reduction goals.

In order to implement the Low Carbon Development Program, KazMunayGas (KMG) for the period 2022-2031 is implementing a project to introduce carbon capture and storage technologies [157]. A significant step in this direction was the signing in June 2022 of a Memorandum of Understanding between KMG and Chevron to reduce carbon emissions in Kazakhstan with a special focus on CCUS technology.

3. Analysis of achievements and development trends of leading scientific schools of Kazakhstan and highly developed foreign countries

The issues of reducing the negative impact of energy facilities on the environment are in the attention of research centers and universities of Kazakhstan, where scientific research is carried out by several groups of scientists.

On the basis of AUPET, extensive fundamental and applied research is carried out on the long-term prospects for energy development, covering issues of energy security, energy efficiency and reducing the negative impact of energy complexes on the environment.

In accordance with the concept of creating intelligent electrical networks, AUPET conducts research on the creation of digital control systems for modes, including solving operational problems: - identifying the conditions for deterioration of the indicators of the system's regime reliability, taking into account the regulated load and generation of renewable energy sources; - forecasting the network mode taking into account the management of renewable energy sources and FACTS devices that ensure the regime reliability of the network.

In the project "Intelligent system for monitoring and forecasting the regime reliability of electrical networks of oil and gas complexes, including autonomous systems with renewable energy sources" under the supervision of Ph.D., associate professor of the Department of "Electric Power Engineering" Tokhtibakiyev K.K. developed systems for monitoring and forecasting the reliability of electrical networks of the oil and gas complex (OGC), which will ensure the reliability of the electrical network with a regulated requirement for the quality of power supply.

Under the supervision of Ph.D. Almuratova N.K., the project "Research and development of an energy-efficient object-oriented electric drive for centrifugal mechanisms" is being carried out, aimed at solving the problem of energy saving. The scientific novelty of the project lies in the development of a mathematical model,

software packages, calculation results and an industrial prototype of an object-oriented, energy-efficient asynchronous electric drive for centrifugal mechanisms.

In order to solve environmental problems in the energy sector, consisting in negative consequences for the environment, the research team headed by Doctor of Engineering Sciences, Professor Dostiyarov A.M., carries out work to reduce greenhouse gas emissions. A group of scientists researches and develops new efficient, environmentally friendly burner devices for a gas turbine unit (GTU). The goal of the project is to obtain new burner devices, as well as to reduce the impact of fuel-burning devices on the environment by reducing greenhouse gases. To solve the issue of ensuring stable voltage, a group of scientists headed by Professor, PhD in Engineering Umbetkulov E.K. is working on developing a wide-range valve generator (WRG), capable of generating stable output voltage to smooth out graphs of sharply variable loads and start electric motors of comparable power. This valve generator is applicable for small wind power plants to smooth out load graphs and start electric motors of comparable power. Kazakh National Research Technical University named after K. Satpayev is rightfully the leader of innovative scientific research in the country, scientists and teachers publish articles in leading world journals, the number of inventions, patents and author's certificates is growing. The university works in close cooperation with production, creating fundamental and practical ideas that solve urgent problems of economic entities. In 2022, the university implemented the following projects in the field of energy:

- development of a pilot experimental mini-hydroelectric power station up to 200 kW of the siphon type (head Bekbayev A.B.);
- serial production of charging stations for electric vehicles with improved characteristics (head Utebayev R.S.);
- obtaining and studying modified MXene materials for use in electric energy storage devices (head Shakenov K.B.);
- studying the properties of positrons generated by runaway electrons in thermonuclear reactors with magnetic confinement (head Dzhumagulov M.N.);
- thermodynamic and radiation properties of dense degenerate plasma (head Shalenov E.O.);
- studying the influence of hydrogenation and helium embrittlement processes in materials for dispersed nuclear fuel of HTGR-type reactors (head Kenzhina I.E.);

For the period 2022-2024, a comprehensive multi-purpose program was developed to improve energy efficiency and resource conservation in the energy and mechanical engineering sectors for the industry of Kazakhstan (headed by K.K. Yelemesov). In the specialized area of "Alternative energy and technologies: renewable energy sources, nuclear and hydrogen energy, other energy sources" at the Physics and Technology Institute in 2021-2023, a project was implemented on the topic "Optimization of the structure of thin films for the manufacture of solar cells on a flexible substrate" (project manager A.S. Serikkanov).

L.N. Gumilyov Eurasian National University is one of the leading scientific schools conducting research in the energy sector. At the university, under the leadership of Academician of the International Academy of Refrigeration, Doctor of

Engineering Sciences Alimgazin A.Sh., scientific work is carried out to improve the efficiency of energy supply to various facilities in populated areas and cities of the republic using non-traditional renewable energy sources (heat of the earth, ground, geothermal waters, low-temperature waste heat of industrial processes at temperatures of 50C-400C).

Scientists from *L.N. Gumilyov Eurasian National University* are conducting a scientific project "Energy supply of rural settlements through the introduction of low-carbon heat pump technology using the heat of geothermal sources." The goal of the project is the introduction of low-carbon energy-supplying heat pump complexes (NETK) of various capacities using renewable energy sources for heat supply to social facilities and the residential sector. The scientific and technical project "Development of a remote monitoring complex for the state of structural elements of overhead power transmission lines (OHPL) during operation based on intelligent noise-resistant telemetry systems" (supervised by V.V. Yugay, 2020-2022) was implemented at the Karaganda Technical University named after Abylkas Saginov. The purpose of the work was to develop a prototype of a new generation information and measuring system based on energy-passive fiber-optic sensors for implementation at industrial enterprises of the Republic of Kazakhstan. As a result, a security document was obtained - a patent "Method of automatic remote telemetry in the electric power industry". The following scientific works are being carried out at the Kazakh Agrotechnical Research University named after Saken Seifullin (KazATIU) in the direction of "Power Engineering and Mechanical Engineering":

- "Development of a methodology and a computer program for determining additional losses of electrical energy during its transportation and distribution in an electrical network" (supervised by PhD Zhantlesova A.B.);
- "Development of an efficient power supply system for autonomous consumers based on a specially designed wind power plant" (supervised by PhD Isenov S.S.);
- "Highly efficient wind generator using a multi-rotor system" (supervised by PhD Khabdullin A.B.);
- "Research, development of a set of designs and creation of an experimental model of an automatically controlled sail wind power plant with a swinging working element" (supervised by Doctor of Engineering Sholanov K.S.);
- "Development of an experimental energy complex based on a modernized boiler plant using biofuel" (supervised by PhD Bakhtiyar B.T.).

University scientists implement projects in the field of renewable energy sources, assessing energy efficiency, operation of electrical equipment, systems for obtaining, transmitting and using electrical and thermal energy.

Priority III – "Power Engineering and Mechanical Engineering", section "Mechanical Engineering"

I. Review and analysis of the achievements of Kazakhstani science (the most significant results of the scientific and (or) scientific and technical sphere, implemented developments)

Mechanical engineering is a backbone industry of the global industry, characterized by high technology and knowledge intensity, as well as a high share of added value. It is thanks to the level of development of mechanical engineering that the economic independence and security of any state is ensured, which allows us to judge the degree of its industrialization, educational, scientific and intellectual achievements of the population of a particular country. The mechanical engineering industry accounts for about 50% of global exports of manufactured goods (in Japan - 68%, China - 56%, Germany - 55%, the USA - 53%, Canada - 35%). [166].

In Kazakhstan, the share of mechanical engineering in the structure of GDP (gross domestic product) is extremely low - less than 2%, while its share in the manufacturing industry does not exceed 10%. Only 0.8% of the total number of employed people carry out their labor activities here. [167]. At the same time, the main capacities of the industry are concentrated on meeting the needs of the extractive industries of the country. However, it cannot be said that nothing is being done in this industry.

The capacity of the Kazakhstan mechanical engineering market is quite large and continues to grow continuously. At the XI Forum of Mechanical Engineers of Kazakhstan "Mechanical Engineering - a Driver for the Development of New Technologies and Innovations" held on May 11-12, 2023, the draft Comprehensive Plan for the Development of the Mechanical Engineering Industry of the Republic of Kazakhstan was discussed, which was later approved by the Decree of the Government of the Republic of Kazakhstan dated November 7, 2023 No. 991, the implementation of which will contribute to the development of not only the mechanical engineering industry, but also the manufacturing industry of the country as a whole. [168].

As of December 1, 2023, there are 4,017 enterprises operating in mechanical engineering, of which 3,850 are small, 102 are medium, and 65 are large. Compared to the situation as of December 1, 2022, the total number of operating enterprises in the industry increased by 359 units, but this happened only due to the increase in the number of small enterprises. [169].

According to the data of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (BNS ASPIR RK), the volume of production for January-November 2023 in domestic mechanical engineering amounted to 3689.4 billion tenge, increasing in value terms by 36.7% compared to the same period in 2022 (2698.9 billion tons). The index of physical production volume in the industry reached 126.8% compared to the same period in 2022. In terms of key

sectors of mechanical engineering, in January-November 2023, the automotive industry produced 124,491 passenger cars (+37.6%), 8,201 trucks (+21.7%), 2,621 buses (an increase of 2.3 times), 1,056 trailers and semi-trailers, containers (+32%) and 540 units of special and specialized equipment (+5.7%), as well as automobile parts worth 355.4 million tenge (an increase of 2.3 times). [170].

In agricultural machinery, the output of tractors increased by 22.2% (from 4,091 to 4,998 units), combines by 28.8% (from 795 to 1,024 units), and reapers by 0.4% from 925 to 929 units. The production of parts for agricultural and forestry machinery and services in the field of manufacturing agricultural and forestry machinery also increased by 5.8% and amounted to 2.6 billion tenge. [170].

In oil and gas machinery, the production volumes of oilfield equipment increased by 1.5 times and amounted to 32.2 billion tenge. The production of oil and gas processing equipment decreased by 45.8% in value terms and amounted to 225 million tenge (no production in November). The output of pumps also decreased by 13.8% and amounted to 10,957 units. [170].

In railway engineering, the production of freight cars decreased by 1.5 times - from 511 to 352 units. The production of locomotives increased by 1.9 times - from 38 to 74 units. The production of bearings decreased by 11% and amounted to 17.9 thousand tons in January-November 2023. During the period January-November 2023, 74 passenger cars were produced, which is 19.4% more than the previous year (62 cars in January-November 2022). [170].

In mining and metallurgical engineering, the production of parts for drilling or tunneling machines or machines for excavating soil, parts of cranes increased by 15.2% and amounted to 27.1 billion tenge [170].

As follows from the presented data, in January-November 2023, almost all types of activity in the mechanical engineering industry grew, and in general, in order to maintain sustainable dynamics of the industries in 2023, the state continued to provide significant support to enterprises: from preferential financing ("Economy of Simple Things", "Business Roadmap 2025", "Preferential Lending Program") to sales assistance (preferential leasing). JSC "NWF "Samruk-Kazyna" is implementing an import substitution program and an "offtake agreement" mechanism. [169]. However, despite the measures taken and the positive dynamics, there is no sustainable realization of the potential of domestic mechanical engineering and metalworking. The production of high-tech products with market competitiveness has not yet been developed; the domestic market of the republic does not have stable positions; domestic manufacturers do not have access to new sales markets, which is why there are no objective opportunities for them to enter international supply chains and, accordingly, create goods with high added value; there is no systemic support and transparent mechanisms for financial and economic stimulation of industries. Despite the fact that in January-October 2023, the volume of exports of mechanical engineering products of the republic amounted to 3153.7 million US dollars, having increased in value terms compared to the same period in 2022 by 34% (January-October 2022 - 2354.1 million US dollars) [169], the industry remains significantly

dependent on imports: about 40% of the country's imports are mechanical engineering products (19.8 out of 50 billion US dollars in 2022). [170].

For the sustainable development of mechanical engineering, it is necessary to conduct scientific research on a systematic basis. Moreover, research should be conducted not only in higher education institutions and specialized scientific institutions, but also in system-forming enterprises of various forms of ownership: plants, factories, structural design bureaus.

Domestic research in mechanical engineering is conducted mainly in the following areas: metal-cutting machines and cutting tools; rolling and pressing equipment; design and calculation of machine and mechanism designs (mainly for oil and gas, mining and metallurgy, railway engineering). The share of implementation projects is very small. Scientific developments are conducted mainly in higher education institutions.

JSC "Kazakh National Research Technical University named after K.I. Satpayev" (KazNRTU named after K.I. Satpayev) - the leading technical university of the republic - has in its structure the Institute of Power Engineering and Mechanical Engineering named after A. Burkitbayev [171]. The Institute is headed by PhD, Professor K.K. Yelemesov, under whose supervision research is conducted in the field of: predictive monitoring and repair technologies using BIG DATA technology of technological machines and equipment in the uranium, mining and metallurgical and mechanical engineering industries, etc. Over the years, research activities were developed by leading scientists-professors M.R. Tusupbekov (issues of automation of production processes in mechanical engineering enterprises), T. Mendebaev (problems of reducing residual stresses during processing of thin-walled shells with a blade tool), S.N. Ignatov (research of force and energy indicators of the process of processing workpieces using a blade tool), V.V. Povetkin (research of burner designs for cutting natural stone and issues of optimization of gear parameters), N.Kh. Davilbekov (founder of the scientific school of rolling, research into the conditions of conformity of metal deformation in drawing gauges and on smooth rolls of rolling equipment), S.A. Mashkov (research on the development of a new processing technology and the study of the patterns of formation of the ultrafine-grained and nanosized structure of titanium and aluminum alloys and the effect of deformation on their mechanical properties, etc. E.S. Askarov (issues of development and design of new machines: a new cam-screw press, significantly superior in technical performance to existing crank presses; a new wind power plant, differing from analogues in a fundamentally new design of a fixed vertical axis; a new design of a centrifugal-gyration mill for ultra-high grinding of mineral raw materials. Based on the results of these developments, Professor E.S. Askarov manufactured prototypes that successfully passed tests [172]), B.N. Absadykov (development and research of the design of the main units of rolling mills, new discharge roller tables ensuring the production of high-quality hot and cold rolled strips, as well as a study of the patterns of distribution of the stress-strain state during strip rolling) [173]. In the educational and production laboratory PolyTechPoint KazNITU named after K.I. Satpayev, research and development work (R&D) is carried out in the field of renewable energy sources, in particular, on the development

of hybrid solar stations; together with partners, scientists are engaged in the development and pilot production of electronic devices and access blocking devices.

JSC "Karaganda Technical University named after Abylkas Saginov". Under the guidance of the head of the scientific school, Professor G.S. Zhetesova, a team of scientists O.M. Zharkevich, T.M. Buzauova, T.Yu. Nikonova, V.V. Yurchenko and others at the Department of Technological Equipment, Mechanical Engineering and Standardization of the Mechanical Engineering Faculty are working on the development of a resource-saving technology for the restoration of parts, as well as automation systems for the technological preparation of mechanical engineering production [174].

JSC "Toraighyrov University". At the Faculty of Engineering of the University, under the guidance and direct participation of leading scientists K.K. Abishev, N.S. Sembaev, A.Zh. Kasenov, Zh.K. Musina and others, scientific work is carried out in the field of mechanical engineering within the framework of fundamental and applied research. The main areas of scientific work are: development of competitive designs of resource-and-energy-saving metal-cutting tools; Ensuring the technological reliability of machine parts; development and pilot-industrial implementation of innovative technology for plasma hardening of wagon wheels, etc. [175].

NJSC "East Kazakhstan Technical University named after D. Serikbayev". Professor Dudkin M.V. is implementing a grant project "Development of a design for a universal seeding complex with increased productivity for operation in the conditions of agro-industrial production of the Republic of Kazakhstan", aimed at solving the problems of equipping agricultural enterprises of the republic with high-quality multifunctional equipment for sowing and tillage; Associate Professor Kombaev K.K., within the framework of grant financing of young scientists, has implemented the project "Increasing the wear resistance of materials in the mechanical engineering industry by electrolyte-plasma modification", designed to increase the efficiency of the process of electrolyte-plasma hardening of materials used in the mining and oil refining industries of the Republic of Kazakhstan [176].

NJSC "Kazakh National Agrarian Research University". One of the leading departments of the university engaged in the research and implementation of innovative solutions in the field of operation of motor transport and agricultural machinery is the Department of Machine Use named after I.V. Sakharov. Professor of the department P. Zhunisbekov conducts research work on improving the main design elements of agricultural machinery and equipment [177].

JSC "Academy of Logistics and Transport" conducts research activities in the transport and communications industry. Leading scientists of the academy - professors Solonenko V.G., Zhanbirov Zh.G., Zhusupov K.A. and others are engaged in grant research on the problems of optimization, design, improving the efficiency and performance characteristics of machines and equipment for the railway industry [178].

RSE on the Right of Economic Management "Institute of Mechanics and Mechanical Engineering named after U.A. Dzholdasbekov" carries out work in the field of mechanics of machines and mechanisms, methods of studying the dynamics, strength, reliability and stability of industrial machines and robots, etc. Thus, under the

supervision of Professor Tuleshov A.K., scientific research is conducted in the field of kinematics and dynamics of lever mechanisms and machine units, the dynamics and control of flow and rotor machines; Professor Dzhomartov A.A. is engaged in the dynamics of mechanisms and machines; Professor Bisembaev K. - the development of methods for studying the dynamics, stability and positioning accuracy of mobile robots with a universal lift-manipulator; Professors Ibraev S.M., Seidakhmet A.Zh. - research problems in the field of oil and gas engineering [179].

Under the scientific supervision of Academician Zh. Zh. Baygunchekov, the Digital Technologies and Robotics Center of the Al-Farabi Kazakh National University is working on developing new lifting and handling devices [180]. One of the next devices developed taking into account the modern concept of mechatronics is a prototype of an electric tricycle with a total maximum motor-wheel power of 800 watts and a load capacity of 150 kg. The capacity of the new assembled 62-volt lithium-ion battery will be 18 Ah, which will allow a distance of 50-60 km without additional recharging [181].

A number of other universities, research institutes and organizations are conducting scientific work in the field of mechanical engineering, but no noticeable achievements have been observed so far.

2. Review and analysis of global trends in science, examples of cooperation between domestic scientists and foreign scientists and work carried out under contracts with international scientific organizations

Global scientific trends in the development of mechanical engineering:

- *development of additive technologies*. These technologies open up new prospects in mechanical engineering for the creation and personalization of a wide range of goods [182].

In 1989, BMW was one of the first to use them. And in 2018, the company opened a specialized Additive Manufacturing Center in Munich and manufactures prototypes, highly complex chassis elements, and parts for classic cars that are no longer in serial production there [182].

Currently, many varieties of this technology are known, which are used in a wide range of economic sectors: from medicine to the military-space complex. The most common application in mechanical engineering is SLM technology (Selective Laser Melting - this is the most common method of 3D metal printing. Using powders of steel, titanium, aluminum or other metals, it is possible to manufacture geometrically complex products, machine parts and engines for industry [182].

Advantages of additive technologies compared to traditional production: manufacturing speed, waste-free production, no seams and joints [183].

- *development of robotics and the use of artificial intelligence*. AI in the future will help autonomous mechanisms navigate the material world and interact with people [182].

- *integration of the Industrial Internet of Things*. Further development of mechanical engineering requires the steady development of communication and sensor technologies, due to which more and more machines and equipment will be connected to the Internet. This allows collecting and analyzing large volumes of data, due to

which the possibilities for optimizing production processes will increase, failures will decrease and the efficiency of machines will improve [184].

- *high-speed processing of materials*. The intensification of production processes requires a steady increase in the speed of material processing. This is achieved by increasing the hardness of the cutting tool and the rigidity of the machine components. Modern metal-cutting machines have a spindle speed of up to 40 thousand revolutions per minute [185].

- *environmental sustainability*. Mechanical engineering is called upon to innovative approaches and the development of new technologies that contribute to improving environmental sustainability and efficiency [186].

An example of effective cooperation with foreign scientists in the field of mechanical engineering is the activities of Satbayev University. In February 2024, the University signed an Agreement with one of the most prestigious technical universities in the world, the Massachusetts Institute of Technology, which will allow the creation of innovations aimed at ensuring the scientific and technological development of the economy of Kazakhstan. An agreement was also signed on Satbayev University joining the Fab Lab Network, an international network of laboratories that uses digital technologies to unite research engineers and practitioners from all over the world [187].

In February 2024, Satbayev University and The Pennsylvania State University (Penn State, USA) signed a Cooperation Agreement, which launches a new stage of academic and scientific partnership between the two universities, which closely cooperate in the field of petroleum engineering. According to the agreement, the cooperation program between the two universities will be expanded in such areas as materials science, cybersecurity and geology [188].

In 2024, a trilateral agreement was signed to open a branch of the Hong Kong CityU University, ranked 70th in the world's best universities, on the basis of Satbayev University. The cooperation of Satbayev University with CityU is part of a large-scale program to improve the quality of higher education and scientific research in Kazakhstan. The opening of a branch of CityU University at Satbayev University provides new prospects for domestic scientists and students, and provides additional opportunities to expand the scope of artificial intelligence [189].

In 2023, a Memorandum of Cooperation was signed between Satbayev University and the Grenoble Polytechnic Institute (Grenoble Institut National Polytechnique - Université Grenoble Alpes), which was the result of a visit by representatives of French engineering and business schools to the Polytechnic during the VIII International Forum of Kazakh-French Higher Education Institutions. The Grenoble Polytechnic Institute is the largest "big school" in France, one of the most prestigious and famous universities in the country. Today, the Institute includes eight engineering and administrative schools, has national status and participates in the Minatec project, one of the largest centers for research in the field of nanotechnology in Europe [190].

In 2023, the M. Tynyshpayev School of Transport Engineering and Logistics was opened at Satbayev University. To ensure high-quality training of specialists,

Satbayev University signed a cooperation agreement with the Xi'an Railway Vocational and Technical Institute (PRC), opened a double-degree educational program for the Master's degree in Transport Technology jointly with the Silesian University of Technology (Poland), and also created a consortium with the Institute of Railway Transport (Riga, Latvia). Educational programs for training engineers for the field of automobile and railway transport are certified by international and domestic agencies for accreditation of educational programs: ASIIN (Germany), IQAA and IAAR [191].

In 2024, a Memorandum of Understanding was signed between NAO "Karaganda Technical University named after Abylkas Saginov" and the Department of Education Management and Policy, Faculty of Education of the Chinese University of Hong Kong. This will allow students and teachers of both universities to participate in dual degree programs, academic mobility, conduct joint research in the field of mechanical engineering, participate in forums and conferences [174].

In 2024, NAO "Toraighyrov University" became a member of the Kazakh-American Consortium of Universities within the framework of a partnership program funded and administered by the International Institute of Education with the support of the US Embassy in Kazakhstan, as well as the Steppe Global Education Foundation. The consortium includes universities in the United States and Kazakhstan that will participate in funded projects and programs to create sustainable partnerships in higher education, including renewable energy, environmental science, agriculture, and food security [175].

In 2024, NAO D. Serikbayev East Kazakhstan Technical University signed a Memorandum of Cooperation with Singapore Polytechnic. This collaboration will ensure the exchange of knowledge and skills between the two higher education institutions in the context of implementing sustainable development goals and carry out joint work in the field of science and higher education [176].

3.Analysis of achievements and development trends of leading scientific schools of Kazakhstan and highly developed foreign countries

In almost all developed countries, mechanical engineering is the basis of economic progress. In Kazakhstan, scientific achievements in mechanical engineering are very modest. This is due to many reasons: the absence of a number of mechanical engineering industries, both high-tech and mass-produced; low degree of localization of many in-demand mechanical engineering production facilities; low competitiveness of mechanical engineering enterprises not only in foreign markets, but also within the country; dependence of production on government support; lack of diversification of sales markets; constantly growing depreciation of fixed assets; general technical and technological backwardness of enterprises; low labor productivity.

In Kazakhstan, the main share in the GDP structure currently falls on industries with low and medium technological complexity. This does not allow achieving significant technological progress in the economy. To achieve sustainable economic development, it is necessary to move away from raw material-oriented production to production with high added value, i.e. the country needs a path of developing industries with high technological complexity. The development of mechanical

engineering is designed to ensure this focus. And here the key driver of mechanical engineering has recently become the automotive industry [192].

The republic's automotive sector provided production in value terms of 847.5 billion tenge in the first half of 2023, compared to 507.8 billion tenge in the same period of 2022. The growth in physical output in real terms reached 40.1%. For comparison: real growth in mechanical engineering as a whole according to the results of the first half of 2023 amounted to 28.8%, in the processing industry - 3.5%, and in the entire industrial sector of Kazakhstan - 3.8% [192]. Thus, Almaty Hyundai Trans Kazakhstan produced 19.5 thousand passenger cars (up 41.2%), Hyundai Trans Auto - 240 units of equipment. Semipalatinsk SemAZ shipped 1.6 thousand units of commercial vehicles (up 52%). In Kokshetau, KamAZ-Engineering produced 410 trucks. The Saransk plant QazTehna produced 362 buses. Daewoo Bus Kazakhstan has 224 units of equipment [192]. Among the most popular models (including export), the leaders are Chevrolet Cobalt (8.4 thousand units), JAC J7 (8 thousand), Hyundai Tucson (5.7 thousand), Kia Sportage (4.5 thousand), Hyundai Sonata (3.2 thousand) and Chevrolet Nexia (3 thousand) [192].

At the same time, key companies in the industry are confidently focusing on increasing industrial production indicators. For example, the largest enterprise in the Kazakhstan auto industry, Allur, together with the South Korean manufacturer Kia Corporation, is launching the construction of a new plant for the production of Kia cars in Kostanay. In addition, the Allur plant has already launched small-knockdown (CKD) production of Kia Sportage cars, and the launch of a CKD line for the production of Kia Cerato is planned [192]. However, these efforts are still insufficient, the capacities of enterprises remain relatively small, lacking systemic research inherent in maintaining the sustainability of enterprises from fundamental science directly to implementation research. Small labor markets and product sales are not unambiguous factors in the sustainable development of mechanical engineering. All this also does not stimulate the development of demand for training young engineering personnel, not contributing to an increase in the level of scientific potential of university science.

Priority IV – "Information, communication and space technologies"

1. Review and analysis of the achievements of Kazakhstani science (the most significant results of the scientific and (or) scientific and technical sphere, implemented developments)

Information and communication technologies. A number of research projects aimed at solving problems of information and communication technologies have been carried out in the country's leading scientific schools. In 2023, laboratories and research centers of universities developed and implemented new models and algorithms that will be useful for various fields of activity.

The Laboratory of Intelligent Information Systems of the *Al-Farabi Kazakh National University* specializes in the development and research of information technologies aimed at creating intelligent systems to solve urgent problems in various fields, and for 2023 has the following results:

- AP09261344 "Development of methods for automatic extraction of geospatial objects from heterogeneous sources for information support of geographic information systems": based on the research carried out, a cloud distributed infrastructure was designed and deployed for the automatic extraction of geographic information from text tables of web resources [193].
- AP13068289 "Application of Machine Learning Methods for Early Diagnosis of Cardiovascular Pathologies": in 2023, the first prototype of a hardware platform for an electronic recorder with the ability to amplify and filter heart signals, designed to record and transmit data on cardiac activity, was developed [194].

As one of the leading research units at Al-Farabi Kazakh National University, the Computer Science Laboratory has the following scientific achievements:

- AP14972710 "Development of Computational Parallel Algorithms for Numerical Modeling of the Spread of Impurities to Predict the Environmental Situation in Residential Areas": the impact and spread of several pollutants emitted by vehicles in the urban environment was modeled and the environmental status of nearby residential areas was assessed.
- AP09058525 "Development of 5G digital radio modules and microwave signal receiving stations based on SoC": a cluster router was proposed that performs fast route construction by clustering the network based on eccentricity, which ensures the autonomy of the device in case of failures.
- AP14872061 "Classification of MIMO signal noise mixture modulation types": at the end of 2024, model signals will be obtained: MPSK (Multiple Phase Shift Keying), QAM (Quadrature amplitude modulation), MFSK (Multiple frequency-shift keying) for MIMO systems, conclusions will be made about the presence of different modulations in the signal noise mixture, transmitting and receiving units will be created: generator, fractal antennas, modulators.

The research activities of the *Eurasian National University* are aimed at further development of the university as a major scientific and research center of Kazakhstan, development of scientific and scientific-pedagogical schools, formation of high-tech innovative infrastructure of the university. The following scientific projects are carried out within the framework of grant and program-targeted financing:

The implementation of the software product during the implementation of the project "Development of methods, models and technologies to improve the level of cybersecurity of cellular communication networks in the Republic of Kazakhstan" will contribute to increasing the competitiveness of cellular communications, expanding the market of cellular operators, increasing labor productivity in industries using cellular network services, which will largely contribute to increasing the intensity of industrialization and increasing the Economic Complexity Index of Kazakhstan.

Currently, *KazNRTU named after K. Satpayev* is working to transform the university into the largest research hub in the Central Asian region.

According to the results of 2023, for the first time in the history of universities in Kazakhstan, Satbayev University took a position 51-70 in the global QS World University Ranking in the field of Data Science and Artificial Intelligence. Satbayev University is the only university in Kazakhstan that has a rating in this field of

knowledge, occupying approximately the same position as Pennsylvania State University.

In 2023, a number of grant-funded research projects began, including: AP19679602 "Development of a tethered unified dual-use multicopter platform with an inverter with increased frequency switching and a high voltage conversion ratio": the development of a method for overcoming the problem of limited flight time of autonomous UAVs is considered [195]; AP19679041 "Research and application of fiber-optic strain sensors for monitoring the stress state of metal and concrete structures": the behavior of structural and building materials under high-speed deformation and destruction is studied [196]; AP09058620 "Development of Web-GIS based on integrated geodynamic monitoring data for the Kazakhmys Corporation LLC field [197].

– The Research and Innovation Center Smart City Astana develops intelligent solutions using information and communication technologies and artificial intelligence in the field of data modeling, urban studies, predictive forecasting of air quality and energy consumption for smart cities. One of the unique solutions within the framework of the PCF program "Development of intelligent information and telecommunication systems for urban infrastructure: transport, ecology, energy and data analytics in the Smart City concept" is a bio-technological filter for air purification, which is based on the use of moss as a biological filter and the development of a technological environment to maintain the life support parameters of moss [198].

The Research and Innovation Center INDUSTRY 4.0 is engaged in the implementation of information technologies in industry, large-scale automation of business processes and the use of artificial intelligence. One of the main tasks is the development of a High-PHY accelerator module for the physical layer separation Split Option 7-2x as part of the implementation of a distributed block of the 5G O-RAN base station for subsequent import substitution.

As a result of the project, Astana IT University is the only university in Kazakhstan that has a 5G O-RAN base station and a test environment that allows testing base stations for performance by loading them with traffic.

- The Big Data and Blockchain Technologies Research and Innovation Center was created to solve current research problems and develop innovations in the field of artificial intelligence, big data and blockchain technologies.

- The Agrotech Research and Innovation Center was created to implement large-scale projects in the field of digital technologies for implementation in the process of increasing crop yields, livestock breeding, and automation of production processes in the agro-industrial complex.

The project “Development of a technology for intelligent pre-processing of aerospace images for recognition and identification of various objects” is being implemented [199]. The result will be an intelligent system for pre-processing aerospace hyperspectral images.

In the field of "Information, Communication and Space Technologies" at the International University of Information Technologies, research is being conducted within the framework of grant funding for young scientists on the scientific project

"Development of methods and algorithms for machine learning for predicting cardiovascular pathologies based on echocardiography and electrocardiography" [200]. A digital educational platform is being developed for remote execution of virtual laboratory work on the study of modern microwave and ultra-high frequency radio systems using virtual reality technology.

Researchers from the *Almaty University of Power Engineering and Communications* have developed a research robot with a configurable platform designed for research work on measuring and studying environmental pollution. The robot allows you to transmit received data online to a mobile device, and can also perform research work using voice messages.

Within the framework of grant funding for the project "Development of self-regulating electric drives for spacecraft", a theoretical basis for creating compact and efficient electric drives was developed.

Currently, *the Institute of Information and Computing Technologies* is conducting scientific research with an emphasis on artificial intelligence. The completed scientific project (headed by E.N. Amirgaliev) examines the use of remote sensing and artificial intelligence technologies for zoning saline agricultural fields, determining the degree of salinity, and identifying abandoned lands. The study was conducted in the Turkestan, Almaty and Kyzylorda regions.

The Institute's research group proposed a publicly available corpus of Kazakh-language dialogues in the banking sector with markup at the intention level, and proposed a new method for augmenting text data based on a combination of reverse translation and adding noise using random replacement.

A system for automatic speech recognition in the Kazakh language has been developed, which can convert voice messages into text. The intelligent system "Kazak ASR" can be tested in Telegram. The developed system will not only recognize voice signals, but also convert them into related text.

An acoustic corpus for agglutinative languages has been developed using the Kazakh and Azerbaijani languages as an example, an expansion of the existing speech corpus for the Kazakh language, collection of speech and text information for agglutinative languages, modification of the corpus to several thousand hours, as well as an effective algorithm, methods and software for integrated recognition of agglutinative languages using the Kazakh and Azerbaijani languages as an example.

A lexical-morphological analysis (LMA) block has been developed to extract words and sentences from a text document.

A commercialization project for the "Mobile Automated Biogas Complex" has been implemented. A new design of biogas and electric power equipment has been created for the efficient processing of biological waste to produce biofertilizer, biogas and electricity.

Space technologies. Over the past 5 years, the *National Center for Space Research and Technology* within the framework of the RBP has developed 6 methods and technologies using remote sensing data in the following areas: assessment of the condition and yield of grain crops and rice crops; assessment of diseases of grain

crops; assessment of pasture productivity; forecasting and methods for assessing the consequences of fires and floods.

As for the Baiterek space rocket complex, work has been carried out to date on an additional technical survey of the buildings and structures used in the project, as well as engineering surveys. The development of design and estimate documentation for the reconstruction and modernization of facilities, working design and operational documentation, the manufacture of equipment for the Baiterek space rocket complex component parts, etc. has also begun.

2. Review and analysis of global trends in science, examples of cooperation between domestic scientists and foreign scientists and work carried out under contracts with international scientific organizations

Current trends in information technology. The year 2023 saw significant advances in artificial intelligence (AI), leading to the introduction of advanced technologies in developed countries. For example, autonomous systems are being actively developed and tested (Waymo, Tesla, and Uber, among others), which can change the potential of the transport and logistics industry, and the military industry. In medicine, AI continues to develop for the diagnosis and treatment of diseases. Financial institutions are increasingly using AI to automate processes, analyze data and predict market trends, ensure security and optimize the functioning of financial systems. Quantum computing in the United States: Companies such as Google, IBM, and Honeywell continue to develop quantum computers, offering new capabilities for information processing. These innovations have the potential to revolutionize the field of information technology, offering a significant increase in the speed and efficiency of data processing.

Communication technologies. 5G in China: China is a leader in the deployment and application of 5G technology. Companies such as Huawei and ZTE are playing a key role in the development of 5G infrastructure and equipment production. This opens up new possibilities for high-speed communications and data transfer, spurring innovation in industries including medicine, the automotive industry, and urban planning.

Space technologies. Space tourism in the US and Russia: SpaceX and Blue Origin, led by Elon Musk and Jeff Bezos respectively, are racing to make space travel affordable for the general public. SpaceX has already made significant progress with commercial satellite launches and missions to the International Space Station (ISS), while Russia’s Roscosmos is also working hard in this direction. Mega-constellations of satellites for ubiquitous Internet coverage: SpaceX with its Starlink project, OneWeb, Amazon with its Kuiper project, and others are working to create mega-constellations of satellites that will provide global Internet coverage. This opens up new opportunities for digital inclusion and technology development in places where they were previously limited.

Al-Farabi Kazakh National University has launched a new spacecraft, the first of its kind in the world. Al-Farabi has more than 60 active international agreements with higher education institutions, scientific organizations for conducting joint scientific research, exchange of scientific staff. Also, the university has scientific and

educational centers of foreign companies such as Samsung, Intel, Cisco Academy, Autodesk, etc.

Figure 3.14. International cooperation of leading scientific schools of Kazakhstan

The National Center for Space Research and Technology, in close cooperation with world centers of space science, participated in the development of many scientific projects together with scientists from Canada, the USA, France, Germany, Japan, India, Israel, South Korea and is deservedly perceived as a significant research center for space technologies (Figure 3.14).

3. Analysis of achievements and development trends of leading scientific schools of Kazakhstan and highly developed foreign countries.

The active development of digitalization reflects the desire of the Government of the Republic of Kazakhstan to improve the infrastructure in the field of information technology and create a favorable environment for the development of the IT industry. One of the key areas of this development is the training of human resources. The President of Kazakhstan put forward the task of training highly qualified IT specialists who can successfully compete in the global market. This instruction indicates the importance of developing educational programs aimed at the IT sphere, as well as increasing the number of professionals in this field.

The Ministry of Science and Higher Education is constantly working to attract IT schools to the mass training of IT specialists. If in 2022 there were 49 of them, then in 2023 the number of schools where you can study using vouchers financed by the state increased to 83.

In order to train highly qualified Kazakhstani specialists, Huawei is opening ICT academies in Kazakhstan aimed at theoretical and practical training of students studying ICT specialties based on the company's own software developments and innovative technologies. Within the framework of the Memorandum of Understanding signed with the Ministry of Science and Higher Education of the Republic of

Kazakhstan, Huawei will continue to systematically develop ICT academies to strengthen the level of digital knowledge in Kazakhstan. Currently, 25 Huawei ICT academies are successfully operating in the country, whose graduates have already become recognized specialists in the field of high technologies. In Kazakhstan, Huawei's educational project has already been supported by Al-Farabi Kazakh National University, L.N. Gumilyov Eurasian National University, Astana IT University and other universities in the country.

In 2023, the Digital Bridge International IT Forum "Digital Partnership in the New Reality" was held, and on February 2-3, the largest IT Startup Alley was held in Almaty. On 10,000 sq.m., where the best startups from all over Central Asia gathered. In panel sessions with international experts from 30 countries, more than 150 speakers from leading global IT companies discussed new strategies and trends in the field of digital technologies, exhibitions of venture funds, technology parks of Central Asia, the Middle East and South Asia, a large-scale startup battle Astana Hub Battle, a job fair, an exhibition of IT schools and much more were held [201].

The international IT forum Digital Bridge 2023 brought together more than 30 thousand participants, including delegations from 30 countries, representatives of more than 300 IT companies, 450 speakers, over 100 investors and business angels, as well as more than 150 startups. Forum topic: Artificial and Human Intelligence: The right balance [201]. The organizers are the Ministry of Digital Development, Innovation and Aerospace Industry of the Republic of Kazakhstan, the Ministry of Foreign Affairs of the Republic of Kazakhstan, the Akimat of Almaty, Tech Garden and the international technopark of IT startups Astana Hub.

In 2023, several state programs aimed at developing information and communication technologies were launched. The head of state expressed interest in digitalization and innovation in the country, and noted the strategic importance of turning Kazakhstan into an IT country. The President emphasized that there have already been significant achievements in the field of digitalization, such as inclusion among the world leaders in the e-government and fintech development index, as well as a significant increase in the export of IT services.

The new task of the Government is to achieve the volume of IT services exports to one billion dollars by 2026. To do this, it is planned to open joint ventures with large foreign IT companies and develop cooperation with leading international companies.

Particular attention is paid to the use of artificial intelligence technologies, taking into account investments in this area, which in the next few years may exceed one trillion dollars. The President emphasizes that successful development of the artificial intelligence sector can significantly increase the country's GDP.

The need to create the most attractive conditions for attracting investment in the construction of large data centers and promoting Kazakhstan's interests in the field of data storage and processing is also discussed. Venture financing should become the main source for launching innovative projects.

Priority V – "Scientific research in the field of natural sciences"

1. Review and analysis of the achievements of Kazakhstani science (the most significant results of the scientific and (or) scientific and technical sphere, implemented developments)

The main areas of natural sciences, arising from natural science, include physics, chemistry, astronomy, biology, geography, geology and ecology. Subsequently, at the junction of these sciences, such disciplines as geophysics, astrophysics, biophysics, biochemistry, physical chemistry, chemical physics, geochemistry, meteorology, climatology and soil science appeared.

This section reveals aspects of the development of domestic science in the field of physics, astronomy, chemistry, biology and geography.

Physics as a science can be divided into theoretical and experimental according to research methods. According to the content of research, it can be divided into fundamental and applied. For the harmonious development of science, all its components are necessary, since careful theoretical research is needed to plan an experiment, and significant efforts of theorists to interpret the data are also required to analyze the data obtained. Fundamental research in physics provides pure knowledge about the laws and nature of physical processes, and applied physics implements them in the form of technologies, tools and devices, which in turn are used for further research in fundamental experiments.

One of the indicators of the state of science is publication activity, which is tracked in international databases of the relevant profile (Scopus, Web of Science, etc.). In total, 3049 international-level works were published in the subject area of "Physics and Astronomy" during the period under review (compared to 2405 in 2018-2020, an increase of 27%).

Table 3-17. Publications on physics for 2021-2023.

Years	Publications in Scopus	Journal articles	Conference proceedings	Monographs
2021	1059	779	255	1
2022	1006	765	208	8
2023	984	774	174	10
2021-2023	3049	2318	637	19

Table 3.17 shows that about 60% of publications are of a fundamental nature, most of which are theoretical works, mainly carried out due to the presence of some surviving scientific schools formed during the USSR, and since they do not require large financial injections for its implementation. For information, for 2018-2020 this figure was 80%, which indicates positive trends.

Thus, the level of domestic physical science corresponds to the expected indicators, taking into account the losses of the transition period and a fairly long underfunding of science.

In the field of theoretical physics, the following results were obtained: the effect of birefringence in the magnetar magnetosphere was predicted [202]; a corrected (and expanded) Volkov-Akulov-Starobinsky supergravity model was constructed; F(R,T)-gravity was created, generalizing GTR taking into account curvature and torsion, giving a consistent description of the birth and evolution of the Universe [203].

In the field of nuclear physics and elementary particle physics, the following results were obtained: within the framework of a modified potential cluster model with classification of orbital states according to Young diagrams, it became possible to describe experimental data for total cross sections of neutron radiative capture [204].

In the field of plasma physics, the following results were obtained: the dynamic structure factor and other dynamic characteristics of a strongly coupled single-component plasma were investigated using a self-consistent version of the method of moments, radial distribution functions were calculated using molecular dynamics modeling by solving the Ornstein-Zernike integral equation in the hypernetted chain approximation, when the ion core is significant [205].

In the field of solid state physics, materials science and nanotechnology, the following results were obtained: the structure of amorphous diamond-like carbon films modified with palladium nanoparticles and synthesized on silicon (100) substrates was investigated. It has been established that palladium nanoparticles affect the formation of carbon bonds and increase the number of sp2 centers, and at concentrations of more than 1 at.%, the film structure becomes graphite-like. The results published in the most prestigious journals in their fields are presented here.

There are also quite good scientific results in areas interdisciplinary with physics. Unfortunately, over the past three years there have been no results in collaboration with leading large-scale projects in the field of physics (CERN, ITER, etc.), which is an omission, since the presence of country representatives in such projects provides great opportunities for the development of physical science in Kazakhstan and the training of highly qualified scientific personnel. Efforts on the part of the state to introduce its representatives into breakthrough international projects should be made purposefully, since they are strategically important for the development of the country as a whole.

Fundamental research in the field of astronomy and astrophysics is carried out by many domestic universities and research institutes, such as the Kazakh National University named after al-Farabi, Nazarbayev University, the Eurasian National University named after L.N. Gumilyov, etc. However, since the inception of astronomical science in Kazakhstan, the leading scientific organization for fundamental and applied research in the field of astronomy and astrophysics has been the V.G. Fesenkov Astrophysical Institute, which is responsible for three high-altitude observatories, each of which has played and continues to play a major role in obtaining world-class results in the field of near and deep space research [206-218].

The main focus of the V.G. Fesenkov Astrophysical Institute (FAPI) is obtaining new results and knowledge based on optical observations using modern/newest equipment and a unique digitalized database and the results of modeling physical, dynamic processes and phenomena in the Universe using scalable high-performance computing equipment.

Over the past three years, at one of the FAPI observation bases, the Assy-Turgen Observatory, located in the Yenbekshikazakh district of the Almaty region and which is a unique object and heritage of the Republic of Kazakhstan, a lot of work has been done to significantly modernize the infrastructure of this observatory. New communications have been installed, fiber optics have been laid along the entire perimeter of the observatory (6.9000 hectares), all conditions have been created for the installation of modern equipment at the observatory and accommodation for observers, scientific and technical personnel. This modernization has served as a significant increase in interest in cooperation on the part of foreign scientists and scientific groups.

Modern scientific research and the tasks that the scientific community currently faces, and in particular in astrophysics, are difficult to imagine without a close relationship with the development of information technology and artificial intelligence, BigData and DataMining algorithms. In this regard, to meet the institute's needs for storing, processing and analyzing observational data, as well as for numerical modeling, a petaflops-class computing cluster has been created and is actively developing at AFIF. The cluster consists of high-performance computing nodes equipped with multi-core central and graphic processors. The theoretical performance of the cluster at the end of 2023 reached 97 teraflops for CPU operations (1012 cores / 2024 threads) and 1461 teraflops for GPU operations (337,408 CUDA cores). In addition, there is a fault-tolerant data storage with a capacity of 270 terabytes. The servers in the cluster are switched via 10-gigabit communication channels and run Linux OS. Task scheduling is organized using the SLURM workload manager. Calculations and data storage on the AFIF cluster are also available to external users via an online request.

The emergence of new hypotheses, algorithms, and the development of computing tools make it possible to take a fresh look at the methodology of data analysis, including the revision of archival data. New tasks have emerged in the field of Time-domain astrophysics. In this regard, the urgent task has become the transfer of all accumulated observational material into a digital format using modern software [219]. This work was successfully completed by AFIF within the framework of the program-targeted financing of the Ministry of Higher Education of the Republic of Kazakhstan (IRN BR10965141) for the creation of the National Virtual Observatory in Kazakhstan (https://vo.fai.kz/).

In addition, FAPI has carried out a lot of work to provide information about space weather in near-Earth space with the ability to assess risks for spacecraft. An Internet portal was created as part of the program work on the creation of the National Space Situational Awareness System (IRN BR11265408) with a user-friendly interface

for obtaining information of interest on the situation in near-Earth space (https://ssa.fai.kz/).

As part of fundamental research (IRN BR20280974), FAPI scientists have obtained significant results that have been published in many foreign highly-rated journals (https://fai.kz/ru/publications).

Also, in the field of space research, it is worth noting the activities of scientists of the world-class Energy Space Laboratory, operating at Nazarbayev University and headed by Nobel Prize laureate Professor George Smoot. The laboratory currently houses cutting-edge equipment, such as a cryogenics lab that can produce the “coldest spot in Kazakhstan,” advanced detector and sensor electronics, and a dynamic data analysis program. The laboratory’s scientists have developed a control system for their flagship telescope, which is currently the fastest in Asia. Researchers are developing new generations of detectors that can identify individual particles of light – sensors that can scan for changes in light a million times faster than those currently in use. One of the laboratory’s flagship projects is an ultrafast telescope, currently operating at the Assy-Turgen Observatory in collaboration with the Fesenkov Astrophysical Institute. With a unique simultaneous three-channel detector, designed and built by Nazarbayev University engineers, the telescope’s primary goal is to study some of the fastest transient phenomena in the Universe, such as gamma-ray bursts. The laboratory conducted unique measurements of gamma-ray bursts, which were announced to the world community. The laboratory is also developing its own microwave kinetic inductance detectors. These highly sensitive superconducting quantum devices measure the energy of incident radiation in a wide range of wavelengths. To date, the laboratory's scientists have published more than 100 papers in leading international journals.

Over the past five years, Kazakhstani science, thanks to reforms, has acquired a "new lease of life". The results obtained by domestic scientists in the field of mechanics are widely used in various areas of the country's economy.

Scientists from the Research Institute of Mechanics and Mechanical Engineering named after Academician U.A. Dzholdasbekov have developed an optimal design for the drive of sucker-rod pumping units based on rectilinear-guiding converting mechanisms with a universal program for the optimal design of pumping unit designs for pumping oil [220-223]. Domestic mechanical scientists have developed and manufactured:

- a prototype of a new two-rod crank press, taking into account the design features of the main working mechanisms based on the six-link Stephenson II lever mechanism, which will allow Kazakhstan to move to a higher technological level in stamping products [224-226];

- a centrifuge based on a gyroscopic rotor with an upper elastic support with nonlinear restoring and damping characteristics [226-227];

- a unique model of a vibration protection unit, which focuses on special supports that are used to mitigate vibration and have a special surface shape [229-230];

- a group of young scientists have developed and created an adaptive gripper of a remotely controlled mobile robot for handling spherical objects for the needs of nuclear power plants and agricultural and horticultural production [231-232];

- hardware and software complex of the aerial robotic system for monitoring the quality of ores in natural occurrence, which is based on a specialized domestic analytical X-ray fluorescence-energy dispersive device (EDXRF), installed on an unmanned aerial vehicle with technical vision [233-234];

- optimal design of an adaptive walking robot, the design principle of which is based on multi-criteria synthesis. As a result, it was possible to increase the maneuverability and safety of the controlled object by using new design, circuitry and software solutions [235].

- a prototype of a cable parallel robot, which consists of a fixed rectangular frame, four winches, four hybrid stepper motors with drivers and four cables [236-237];

- a robotic complex for medical purposes, which includes 4 (four) robotic devices and 1 (one) centralized software and hardware system to combat the coronavirus pandemic based on competitive domestic developments in the field of medical robotics [238-242].

Fundamental and applied research in the field of chemistry by Kazakhstani scientists has always occupied high places among CIS scientists.

Currently, Kazakhstani chemical science has achieved significant success, which consists in the creation of environmentally friendly technologies for the production of multi-purpose substances and materials and the development of effective technologies based on them that meet global trends in chemistry [243-252]. In recent years, scientific research has developed:

- *in the field of organic-mineral fertilizers and materials*. For the period 2018-2023, brown coal deposits attracted the interest of scientists. The results of scientific and agrochemical tests allowed to register the preparation "Sodium Humate", which was included in the list of chemical and biological means of pest control, plant diseases, weeds, defoliants and plant growth regulators approved for use in agriculture of the Republic of Kazakhstan. New technologies have already been introduced in the field of processing oil-contaminated soil, which includes the processes of neutralization and processing of soil into building materials and inert materials. To date, using this technology, more than 750.0 thousand tons of oil-contaminated soil have been processed at the landfill of JSC "Ozenmunaygaz" (Mangistau region), samples of paving slabs have been obtained and an experimental section of the road has been built.

- *in the field of creating nanoscale catalytic systems*. In the course of research, effective catalytic systems based on heteropoly acids have been developed. Experimental studies have shown that the application of heteropoly acids to the surface of zeolite leads to a synergistic effect, increasing the activity and selectivity of the catalyst. Samples of nanostructured V-Ti-Zr-oxide catalysts with particles of their components in the nanometer range have been created, which have successfully passed tests in the partial oxidation of 4-methylpyridine. Methods for the synthesis of highly

porous carbon from coal tar using the template method and its industrial application have been developed.

- *in the field of developing new drugs*. Based on the first synthesized in the laboratory of JSC "Institute of Chemical Sciences named after A.B. Bekturov" of starting azacyclic ketones, fundamental principles and non-trivial approaches to the molecular design of original (unique) domestic systems for practical medicine and veterinary science (immunomodulators, antihistamines (antiallergic), analgesics, antiarrhythmic, antibacterial agents) have been developed. Studies on ultrasonic and microwave activation of methods for the synthesis of hetero- and organoelement compounds have made it possible to develop effective methods for obtaining valuable products with high yields.

- *in the field of modern chemistry of ion-exchange membranes and electromembrane technology for water purification*. A technology has been created for cleaning wastewater from ore enrichment plants to fishery standards or for reuse in the technological process, which contributes to compliance with environmental standards and the rational use of water resources. A technology has been developed for cleaning unbalance wastewater from the tailings pond of the processing plant of the Altai Mining and Processing Complex of Kazzinc LLC, which has made it possible to solve the problem of water pollution in the region. Methods for obtaining organomineral sorbents based on natural mineral carriers and carbon-containing minerals, including bentonites, shungites and aluminosilicates, have been developed.

- *in the field of polymer sorbents and composite materials, ion-exchange polymers, intergel systems for the development of modern methods for separating and extracting rare earth metals from concentrates and process solutions*. Modeling of the processes of activation, sorption, desorption and regeneration of ion-exchange resins was carried out on the developed laboratory setup, which is protected by the patent of the Republic of Kazakhstan for utility model No. 8523. Effective sorbents have been developed - interpolymer systems "Amberlite IR120 - AB-17-8" and "Lewatit CNP LF - AB-17-8" - based on the effect of remote interaction for the effective sorption of ions of rare earth metals europium, scandium, cerium from solutions.

The development of geographical science in Kazakhstan is characterized by multi-aspect directions, including solutions to theoretical and scientific-applied problems, aimed at developing conceptual foundations, fundamental approaches and methodology of scientific knowledge of the mechanism of interaction of natural and economic subsystems, allowing to develop a strategy for sustainable nature management.

The main areas of activity of the Institute of Geography and Water Security of the Ministry of Education and Science of the Republic of Kazakhstan (hereinafter - IGWSS, Institute) are carried out in four blocks in demand by the state and society: assessment and forecast of water resources, hazardous natural exogenous processes, natural resource potential of Kazakhstan; digitalization, atlas web mapping.

- *on the block of water problems*. A methodology for short-term forecast of ice thickness increase for the Northern Caspian has been developed and put into production [253]. The rivers and lakes of Kazakhstan have been classified, river runoff

resources have been assessed, and various water resource scenarios have been proposed for the period up to 2050 in the context of climate and anthropogenic changes [254-255]. Hydrological foundations for preserving the wetland ecosystem and increasing the resource potential of the Ile River delta, and recommendations for preserving (rehabilitating) water bodies in the Syr Darya delta have been proposed [256-260]. Major studies are being conducted to develop a draft Agreement on Water Sharing between the Republic of Kazakhstan and the People's Republic of China, and to coordinate flood runoff in the basins of transboundary rivers between the Republic of Kazakhstan and the Russian Federation.

- *on the block of dangerous natural processes*. Catalogs of glacial lakes with a risk of outbursts in the Ile and Zhetysu Alatau, and a method for predicting avalanche danger based on artificial intelligence have been compiled [261-266].

- *on the block of assessing natural resource potential*. An assessment of the current state of landscape systems was carried out, a methodology for assessing the agro-resource potential of landscapes was developed, and the landscape-agroecological state of agricultural regions of Kazakhstan was assessed [267-268]. An economic assessment of water resources in the Ile, Ertis, and Syr Darya river basins was carried out, the redistribution of available volumes of water resources was substantiated, and the price of water resources in these objects was identified [269-271]. A new paradigm for tourism development in the Republic of Kazakhstan was created based on the development of theoretical, methodological, and applied support for the development of the national tourism industry [273-275].

- *on the block of geospatial analysis and web presentation of data.* A geospatial web application was created to support research into the spatio-temporal features of climate change in Kazakhstan [276-277].

In recent years, the staff of the IGWS of MSHE of RK received 10 copyright certificates and 7 implementation certificates.

2. Review and analysis of global trends in science, examples of cooperation between domestic scientists and foreign scientists and work carried out under contracts with international scientific organizations

Currently, *fundamental physics* is searching for the so-called "new physics". Advanced theoretical models: string theory, which evolved into M-theory, its alternative in the form of loop quantum gravity, as well as many less popular models have proven to be virtually untestable, since the effects they predict lie far beyond the capabilities of experimental physics. Also relevant topics on the agenda of modern fundamental physics are holographic duality, supersymmetry violation, the nature of dark matter and dark energy, the relationship between energy and information, etc. A large number of multidimensional alternative theories are being developed, candidates for the role of dark matter particles are proposed, scenarios for the birth and evolution of the Universe, models of extreme astrophysical processes (supernova, hypernova, kilonova explosions, the formation and evaporation of black holes, etc.) are being developed.

In the field of applied physics, on the contrary, there is a boom in the development of new materials with amazing properties, ultra-high technologies: the

era of **quantum technologies** has arrived. Quantum dots, quantum computing devices, quantum communications, quantum cryptography, photonics and spintronics: this industry is literally making a technological revolution, comparable to the transition to the era of electrical technologies. The theoretical basis of quantum technologies is quantum mechanics, and the coming decades will be the era of applied quantum theory. In this regard, practically nothing is being done in Kazakhstan. Superconductivity, strong magnetic fields, atomic clocks, ultra-precise accelerator technology, lasers, soft matter, ultra-cold physics - the foundations for the development of quantum technologies, are practically absent from the landscape of Kazakhstan's physical science and education. It is necessary to take care of the lag in this area at the state level. Kazakhstani science still has time to catch the last car of the leading train of quantum technologies. A long-term, well-thought-out strategy for creating a scientific infrastructure and training personnel capable of ensuring a breakthrough in research and development is needed.

Although applied physics exists in the country (about 40 percent of publications), it has no outlet for production, so without stimulating factors in the form of good financing and demand by industry, it is in an uncertain position. This situation is aggravated by the fact that it is impossible to develop it without an innovative industrial infrastructure, which Kazakhstan does not have. Fortunately, the world is experiencing a transition period to the industrial formation of Industry 4.0, so Kazakhstan has the opportunity to create an industrial infrastructure of a new formation from scratch and provide a basis for creating an economy of the sixth technological order.

Fundamental theoretical physics in our country is at a good level. This is evidenced by a large number of articles in this area, and in top journals. As for specific projects, we can note the cooperation with the Joint Institute for Nuclear Research (JINR) - an international intergovernmental scientific research organization in the science city of Dubna) on the basis of a quadripartite agreement with the Kazakh National University named after Al-Farabi, the Eurasian National University named after L.N. Gumilyov and the Institute of Nuclear Physics, within the framework of which a range of work is carried out from training young scientists to joint research in the field of experimental and theoretical nuclear physics, elementary particle physics and high-energy physics.

It is also worth mentioning the projects of the National Nuclear Center of the Republic of Kazakhstan with the Japan Atomic Power Company (JAPC) and the Japan Atomic Energy Agency (JAEA) on the EAGLE project to conduct out-of-reactor and in-reactor experiments to justify the design of the active zone of a promising fast-neutron reactor with sodium coolant. Cooperation with the European Organization for Nuclear Research (CERN) has great prospects; preparations for it have been underway for several years after the signing of an agreement with the Ministry of Energy of the Republic of Kazakhstan in 2019.

In the space industry, the world community is paying increasingly close attention to the problem of debris in near-Earth space, including within the framework of the initiatives of the UN Committee on the Peaceful Uses of Outer Space.

Kazakhstan has also begun large-scale work in this direction. Over the past almost three years, the Astrophysical Institute named after V.G. Fesenkov (AFIF) created the basis of the space awareness system (Space Situational Awareness, SSA), where, in parallel with the space weather segment (Space Weather, SW), one of the important objects of the space surveillance and tracking segment (SST) was successfully manufactured and put into operation at the Assy-Turgen Plateau Observatory (ATO) - a wide-angle optical system with a 40-cm aperture (SHOS-40).

It is important to note that in the process of creating the Space Awareness System (within the framework of the PCP of the RCDIAP RK (IRN BR11265408), Kazakhstan, represented by the V.G. Fesenkov Astrophysical Institute, was elected as a member of the International Asteroid Warning Network (IAWN), created under the auspices of the UN (https://iawn.net/about/members.shtml). And in the course of creating the Virtual Observatory (within the framework of the PCF of the RK MNVO (IRN BR10965141)) one of the important results was the inclusion of Kazakhstan in the International Virtual Observatory Alliance (IVOA) (decision of the IVOA Executive Committee https://ivoa.net/about/member-organizations.html).

For Kazakhstan, the creation and development of the space surveillance and tracking (SST) segment is an important tool for ensuring the safety of its KazEoSat and KazSat satellite constellations operating in low and geostationary orbits. The system will allow on a regular basis monitor potential threats of collisions between orbital bodies based on early prediction of their positions, and inform interested parties (including foreign partners) about possible risks of collisions.

The development of the space surveillance and tracking/monitoring system (SST) of near-Earth space is the first stage in the overall strategy of AFIF to deploy a global scalable network of telescopes.

To date, memorandums and cooperation agreements have been signed with the Polish Space Agency, ArianGroup (France), the Keldysh Institute of Applied Mathematics (Moscow, Russia), and the Comenius University (Bratislava, Slovakia) for the further development of the space industry of Kazakhstan.

As part of international cooperation, the V.G. Fesenkov was invited as a partner to the research team of the DART (Double Asteroid Redirection Test, https://dart.jhuapl.edu/) project of NASA – the first ever test of humankind to deflect the asteroid Dimorphos – a satellite orbiting the double asteroid system known as Didymos (https://science.nasa.gov/planetary-defense-dart/), and then, after the completion of the DART mission, to the project to study the first test of an asteroid deflection, conducting the first study of the double asteroid system HERA (https://www.esa.int/Space_Safety/Hera). As a result, the article “Signs of Emissions of Alkali Metals Na I, Li I, and K I During first minutes after DART probe crash on Dimorphos” (https://dx.doi.org/10.3847/2515-5172/ac9d33) was published [277].

Young scientists from the Institute of Mechanics and Mechanical Engineering named after Academician U.A. Dzholdasbekov together with colleagues from RWTH Aachen University (Germany) developed a nonlinear mathematical model of oscillations of an infinite cylindrical shell as a limiting case of a nanotube and obtained its asymptotic solution. The results of the conducted research can be successfully

applied in the mechanics of materials, electronics, biophysics, as well as in the creation of nanotechnology products with certain functional properties. Scientists from IMMash in close cooperation with scientists from Turkey are conducting scientific work devoted to the study of complex structures of lever mechanisms with wide functional capabilities, which are integral components of various machines and automation systems.

The Institute maintains close international ties with many foreign universities and organizations, including the London State Research University "Brunel University" (United Kingdom), Kaunas University of Technology (Lithuania), Centre for Mathematical Research (Spain), Institute of Computational Mathematics and Mathematical Geophysics SB RAS (Russia), Karlsruhe Institute of Technology (Germany), University of Cassino and South Latium (Italy), Kiel University (United Kingdom), Serbian Academy of Science and Arts, Institute of Mathematics (Serbia), Kocaeli University (Turkey), Hamburg University of Technology (Germany), University of Nice (France), Penza State University (Russia), Bauman Moscow State Technical University; Federal State Budgetary Institution of Science A.A. Blagonravov Institute of Mechanical Engineering of the Russian Academy of Science (IMASH RAS); AGH University of Science and Technology (Poland).

The main areas of cooperation and prospects for the development of international scientific relations in the chemical industry include:

- nanotechnology and the creation of sustainable materials;
- exchange of methods for the implementation of sustainable production technologies, such as low-waste environmentally friendly technologies for the creation of export-oriented and import-substituting products, fertilizers, plant growth stimulants and organic compositions;
- joint research in biotechnology to develop new methods for diagnosing and treating diseases, creating innovative medical products;
- cooperation in the development of alternative energy sources, including new technologies for wind and solar energy, geothermal and hydrogeneration.

Global trends in drug production show that the pharmaceutical market is filled with generics - reproductions of original drugs whose patent protection has expired. Generics are cheaper than originals due to the lack of capital expenditures on the development, research and advertising of new drugs. In organic chemistry, there is a shortage of new leading structures that can be optimized to therapeutically useful drugs. Demand for original drugs is predicted to increase, especially in the face of microbial resistance.

In Kazakhstan, almost all the medicines used are imported. The main problem is the high import orientation and insufficient use of the potential for the development of the domestic pharmaceutical industry. Research in Kazakhstan is often suspended at the preclinical testing stage due to the risk and lack of industry readiness for further development. To close this cycle, government funding of the intermediate phase is necessary, as is done in other countries. For example, in the United States, after the fall of the NASDAQ stock index in 2002, the state began to finance further technologization of knowledge through the Road Map, NIH and other programs.

On average, a Western innovation company spends 10-15% of its annual turnover on research. Singapore invests about $13.2 billion in scientific research from 2016 to 2020. Kazakhstan needs to create scientific research centers, which will allow it to take important positions in the international distribution of labor. This requires government support for the creation of research centers, as, for example, in China. It is necessary to consolidate the research of synthetic chemists, pharmacologists, biologists and physicians, and also to have a base for conducting all stages of preclinical and clinical trials.

Global trends in science *in the geographical field* are aimed at the development of high technologies. Thus, in 2023-2024, the Central Asian Regional Glaciological Center, together with UNESCO and other scientific centers, organized a series of events in which more than 130 specialists from Central Asia, Germany, Great Britain, Switzerland, Austria, India, Nepal and other countries took part.

In order to establish links for international cooperation between the Institute of Geography and Water Security (IGWSS) and the Potsdam Institute for Climate Impact Research, a Memorandum of Cooperation was signed on the project "Assessment of modern and predicted hydrological changes for typical natural and man-made conditions of the river basins of Kazakhstan (on the example of the Buktyrma, Yesil, Zhabai rivers) based on hydrological modeling." Metadata and maps on the natural conditions, resource potential of the Caspian Sea and its coastal part, created as a result of the international program of the European Community "Caspian Sea Environmental and Industrial Data&Information Service (Caspinfo)", were included in the world database for the study and use of ocean and sea resources. Based on the results of the project, Google Maps Demonstrator and the CASPINFO Portal were developed and implemented.

In 2023-2024, the terms of reference were developed for the UNESCO and GLOFCA Adaptation Fund project "Reducing the vulnerability of the population in the Central Asian region to glacial lake outburst in the context of climate change".

Together with Reading University (UK) and scientists from Kyrgyzstan, Uzbekistan and Tajikistan, 2 grant projects were implemented in 2021-2023, in 2023-2024, with the support of GIZ, 2 trainings were prepared and conducted on the use of space images for cataloging and calculating the mass balance of glaciers.

Al-Farabi Kazakh National University Al-Farabi, together with the IWBG, in 2021-2024, the European Union ERASMUS program is being implemented on the basis of these organizations: New courses in Geospatial Engineering for the adaptation of coastal ecosystems to climate change.

3. Analysis of achievements and development trends of leading scientific schools of Kazakhstan and highly developed foreign countries

There are a number of outstanding scientific schools in the *Kazakh National University named after Al-Farabi* (the founders are academicians Abdildin M.M., Baimbetov F.B., Sarsembinov Sh.Sh., Kozhamkulov T.A., Takibaev N.Zh., professors Isataev S.I., Zhusupov M.A., Kosov N.D., Kolomeets E.V., Baktybaev K.B., Taurbaev T.I., Yushkov A.V., Drobyshev A.S., Messerle V.E.), originating from the schools of outstanding famous scientists of the USSR, which made it the flagship of fundamental

physical science in the previous 30 years of independence. Currently, there are two institutes (SRIETP and NANOLOT) successfully operating here, as well as several active groups in the field of theoretical physics and astrophysics (Dzhunushaliev V., Abishev M., Boshkaev K., Aldabergenov E.), plasma physics (Ramazanov T., Davletov A., Arkhipov Yu., Dzhumagulova K.), nuclear physics, cosmic ray physics and high energy physics (Kozhamkulov T., Takibaev N., Zhusupov M., Burkova N., Chikhrai E., Saduev N.), thermal physics and cryophysics (Messerle V., Askarova A., Bolegenova S., Aldiyarov A.), nanotechnology, materials science, solid state physics (Prikhodko O., Ilyin A., Abdullin Kh., Zharkeshev I.) and nonlinear physics (Zhanabaev Z.).

At Nazarbayev University, the majority of articles are generated by invited foreign scientists working at the Department of Physics, the Center for Energy and New Materials Science with the Laboratory of Physics and Materials Science, and the Nazarbayev University Research and Innovation System with the Energetic Cosmos Laboratory. The University has many modern, well-equipped research laboratories. Here we can note the group on space physics, astrophysics and cosmology in the laboratory of energetic space under the leadership of the Nobel laureate J. Smoot (Linde E., Abdykamalov E., Malafarina D.), the group on nonlinear optics, laser physics, solid state and materials science (Bakenov Zh., Desyatnikov A., Utegulov Zh.), as well as scientists of the scientific group (Baigarin K., Tikhonov A.) working with the pulsed high-current ion accelerator INURA (Innovative Nazarbayev University's Research Accelerator), which was put into operation in 2018. A good modern facility like INURA is a growth point for sustainable, highly qualified scientific groups. A good example of this was the creation of the INP branch at the L.N. Gumilyov with the heavy ion accelerator DC-60, which generates almost half of ENU's publications on physics.

L.N. Gumilyov ENU. The success of this relatively young university in the field of physics is due to the invitation of representatives of leading scientific schools, promising scientists mainly from the Al-Farabi Kazakh National University, the Buketov KarSU and other scientific centers. Here we can note the groups of R. Myrzakulov in astrophysics and mathematical physics, A.K. Aryngazin in theoretical physics, K.K. Kadyrzhanov in nuclear physics, K. Baktybekov, T. Inerbaev and M. Zdorovets in condensed matter physics, nanotechnology, materials science and radiation physics of solids.

The Institute of Nuclear Physics and *the National Nuclear Center* are the main bases of nuclear science in Kazakhstan. The presence of several reactors and accelerators, the recently opened Data Center and the Center for Nuclear Medicine make them growth points for experimental nuclear physics, nuclear medicine and radiation materials science in our country. Under the leadership of Director General Sakhiev S.K., who also heads the group on theoretical nuclear physics, the Institute of Nuclear Physics successfully develops the Kazakhstan School on Physical and Technological Problems of Nuclear Energy, founder, laureate of the State Prize for Science and Technology of the Republic of Kazakhstan, prof., Doctor of Physics and Mathematics G.A. Batyrbekov; the Kazakhstan School on Radiation Physics of Solids

and Radiation Materials Science, founder, laureate of the State Prize for Science and Technology of the Republic of Kazakhstan, prof., Doctor of Physics and Mathematics O.P. Maksimkin; Kazakhstan School of Experimental Nuclear Physics, founder - laureate of the State Prize for Science and Technology of the Republic of Kazakhstan, prof., D.Sc. (Physics and Mathematics) A. Duisebayev; Kazakhstan School of Experimental Nuclear Astrophysics, founder - head - prof., D.Sc. (Physics and Mathematics) N. Burtebayev.

It is also necessary to note the schools in the National Nuclear Center associated with the materials science tokamak KTM, the IGR and IVG.1M reactors. These are scientific schools in the field of conversion of nuclear energy into optical radiation energy (Batyrbekov E.G.), in the field of condensed matter physics and radiation materials science (Skakov M.), in the field of nuclear energy safety research (Vurim A.D.), in the field of controlled thermonuclear fusion technology research (Tazhibaeva I.L.), in radioecology (Lukashenko S.N.), in methods of control over nuclear tests and modern monitoring systems (Mikhailova N.N.).

The Kazakh National Research Technical University named after K.I. Satpayev has a rich tradition of applied research in physics. The Physicotechnical Institute, which recently became part of the university, operates within its framework, where, along with research in solar energy, work is carried out in materials science, space physics, and high-energy physics. The schools of Kumekov S., Mustafin A., Boos E., Mukashev B., Sadykov T., Lebedev I. can be noted.

Karaganda State University named after E.A. Buketov traditionally has strong schools in solid state and materials science (Kuketaev T.A., Ibraev N., Saulebekov A.O.), technical physics and thermal physics (Kusainova K.K.). The groups in theoretical physics (Aryngazin K.) and nanotechnology work well. The Kazakh journal "Eurasian Physical Technical Journal" included in Scopus is published here.

Also among the scientific centers that make a significant contribution to the development of Kazakhstan's physical science, it is necessary to note the V.G. Fesenkov Astrophysical Institute, whose scientists participate in leading international collaborations, publishing their works in leading astronomical journals. The V.G. Fesenkov Astrophysical Institute is the leading scientific organization in Kazakhstan in fundamental research in the field of astronomy and astrophysics. Founded in 1950, the V.G. Fesenkov Astrophysical Institute Fesenkov Astrophysical Institute was the center of astronomy development in Kazakhstan at all stages of its development. The first research scientists of the Institute, Vilkovskiy E.Ya. (on the study of active galactic nuclei), Omarov T.B. (on the study of stellar dynamics), Chechin L.M. (on Cosmology), left behind scientific schools.

Representatives of the schools of Physics of Planets and Satellites (Teifel V.G.), Numerical Methods in Astrophysics (Omarov Ch.T.), on the study of objects of deep and near space (Serebryanskiy A.V.), on relativistic astrophysics (Aimuratov E.K.) work at the Institute. Active development of research in the field of astronomy and astrophysics allowed the Astrophysical Institute named after V.G. Fesenkov to become a member of the International Astronomical Union.

Kazakhstani science in the field of mechanics also has strong schools. Research is conducted in four areas: geomechanics and mechanics of deformable bodies, development of methods for calculating underground structures; development of machine mechanisms, mechatronic and robotic systems; hydromechanics and numerical methods for studying non-Newtonian fluids; flight dynamics of spacecraft and satellites.

The Institute of Mechanics and Mechanical Engineering named after Academician U.A. Dzholdasbekov is a leading state scientific organization in the field of mechanics, mechanical engineering and robotics. Since 2023, the Institute has been developing methods of mechanics, research into heat transfer of non-Newtonian fluids, non-stationary thermomechanical states of solids, patterns of deformation of rocks and building materials, modeling of mining, mechanics of machines and robots using machine learning and digital technologies.

The research covers mathematical models and computer technologies in the mechanics of deformable solids and structures (Alekseeva L.A., Kudaykulov A., Zakiryanova G.K., Baimakhan R. et al.), the study of the temperature field of highways in various climatic conditions (Teltayev B.B., Iskakbayev A.), modeling of dynamic systems in vibration protection problems (Khadzhieva L.A., Bisembayev K. et al.), the development of methods and programs for virtual modeling of lever mechanisms, research into the dynamics and control systems of UAVs, rotary machines and parallel robots (Moldabaykov M.M., Tuleshov A.K., Ibrayev S.M., Iskakov Zh., Dzhomartov A., Seidakhmet A., Dzhamalov N.K. et al.).

Among the leading schools in the chemical industry, one can note the A.B. Bekturov and the International Scientific and Production Holding "Phytochemistry" in Karaganda. The Institute of Chemical Sciences named after A.B. Bekturov specializes in the development of the chemistry of biologically active substances for medicine, which often do not find practical implementation. The main problems include low funding, lack of innovative infrastructure, personnel shortages and weak business interest. However, the Institute has the potential to commercialize its developments. The state drug policy should ensure the strategic availability of drugs through the creation of new drugs developed and manufactured in Kazakhstan.

The International Holding "Phytochemistry" is actively developing chemical and pharmacological research, from fundamental research to the implementation of technologies in production. It develops competitive pharmaceutical products with high Kazakhstani content based on fundamental research in chemistry and molecular biology.

Priority VI – "Life and Health Sciences"

1. Review and analysis of the achievements of Kazakhstani science (the most significant results of the scientific and (or) scientific and technical sphere, implemented developments)

Research in the field of gerontology. Scientists believe that the threat of global

demographic growth has passed [278], and at present the global problem is not rapid population growth, but its aging, which requires a significant amount of medical, social and economic measures. The solution to these measures involves institutional and political reforms and the introduction of technological innovations based on scientific research [279].

The increase in life expectancy along with the decline in birth rates leads to the aging of the world population. According to the United Nations, by 2021 the number of people over 65 years of age in the world was 9.6% of the total population, and by 2050 it is expected to increase to 16.5%. At the same time, according to the World Health Organization, the COVID-19 pandemic has had little impact on the demographic situation in the world, despite approximately 15 million direct and indirect deaths associated with COVID-19 and an almost two-year decline in life expectancy worldwide during the first two years of the pandemic [280].

Kazakhstan is at a relatively early stage of demographic aging of the population. According to the UN, the proportion of elderly people in the country will constantly grow, and by 2050 will exceed 3 million people, and the share of the total population will be 11.9%. At the same time, the indicator of Kazakhstan (in 2023 - 9.44%) is the highest among the 5 Central Asian republics (Tajikistan - 4.18%; Turkmenistan - 6.55%; Uzbekistan - 6.88%; Kyrgyzstan - 6.60%) [281]. According to the UN, by 2050 Kazakhstan will remain the leader in this criterion in Central Asia, despite the fact that the growth rate will be lower than in other Central Asian countries [282]. Despite the observed increase in life expectancy at birth worldwide and in Kazakhstan (2019: 73.3 years in the world; 74 years in Kazakhstan) (Fig. 3.15), healthy life expectancy lags behind (2019: 63.7 years in the world; 65 years in Kazakhstan) [283-284].

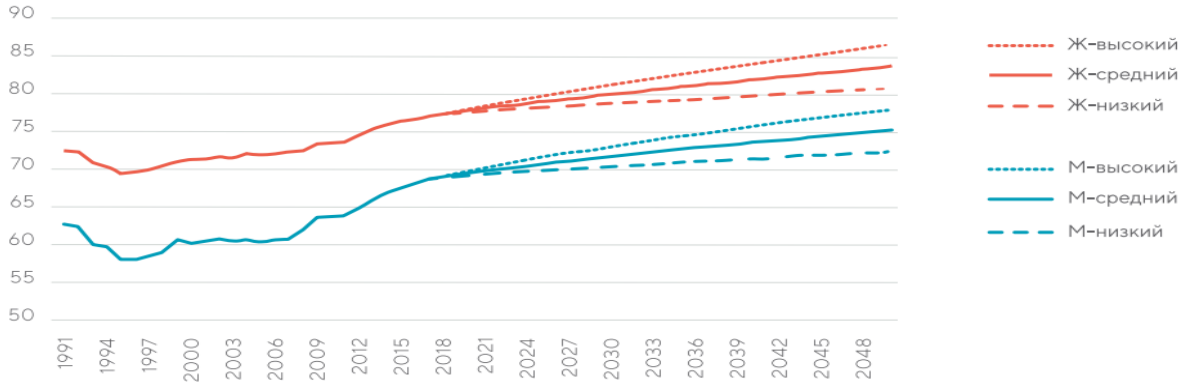


Figure 3.15 – Scenarios for changes in life expectancy at birth in Kazakhstan. Source: https://kazakhstan.unfpa.org/sites/default/files/pub-pdf/UNFPA_FullReport_Rus_Final.pdf [7].

In this regard, the United Nations General Assembly declared the period from 2021 to 2030 the "Decade of Healthy Ageing", covering four areas of activity: long-term care, combating age-related changes, age-friendly environments and integrated care [285].

This requires strengthening systemic approaches and international cooperation in conducting national scientific research in all these areas of activity to develop regional and national policies on ageing in Kazakhstan. In this context, today Kazakhstan identifies the following scientific challenges for itself:

Scientific challenge 1. Research for the formation of policies implemented by state and public institutions, and the ecosystem of healthy ageing.

The Active Ageing Index (AAI) is used worldwide as a tool for monitoring policies and measures to support active ageing [286]. This index was calculated for Kazakhstan for the first time in 2020 as part of the research work "Assessment of the socio-economic situation and needs of the elderly in Kazakhstan" and amounted to 38.4% for both sexes (40.7% for men and 36.9% for women). This shows that in the Republic of Kazakhstan, the potential for active longevity is underutilized by 61.6% compared to the ideal maximum (100%). When compared with other countries, Kazakhstan was in 9th place out of 29 countries in the active ageing index, despite 84% of elderly people not showing social activity [287]. The AAI was determined by 4 indicators: employment; participation in society; independent, healthy and safe life; favorable environment for active longevity (Table 3.18). Kazakhstan's high position in the indicator "favorable environment for active longevity" is ensured by a high level of education. The strengths included a strong reliance on social contacts and intra-family types of social activity (caring for grandchildren and elderly relatives requiring care), a high level of physical activity, and good psychological well-being. The weaknesses of active ageing in Kazakhstan were: low life expectancy at older ages, low extra-family social activity, the degree of material deprivation, and gender differences in the potential for active ageing [288].

Table 3.18. – Value and ranking of the active ageing index for the Republic of Kazakhstan (2020). Source: UNECE. Active Ageing Index. Analytical Report. UN, 2019. Geneva. URL: https://www.unece.org/fileadmin/DAM/pau/age/Active_Ageing_Index/ECE-WG-33.pdf. [287/10].

No.	Country	Active Longevity Index	Domains			
			Employment	Participation in the life of society	Independent, Healthy and Safe Living	A Favorable Environment for Active Longevity
1	Sweden	47,2	45,4	26,0	79,2	71,2
2	Denmark	43,0	40,6	21,7	78,4	66,5
3	Netherlands	42,7	36,3	26,6	77,3	64,7
4	United Kingdom	41,3	39,3	20,7	75,3	63,9
5	Finland	40,8	35,7	22,6	77,6	63,1
6	Germany	39,6	39,4	15,9	74,9	63,6
7	Ireland	39,1	35,4	18,8	75,0	63,2
8	France	38,6	26,9	26,2	75,4	62,2
9	**Kazakhstan**	**38,4**	**32,8**	**21,0**	**66,2**	**64,5**
10	Estonia	37,9	44,5	14,3	66,5	53,2
11	Belgium	37,7	23,8	27,0	73,3	62,8
12	Czech Republic	36,5	34,2	16,2	71,4	58,7

13	Austria	35,8	27,2	18,8	77,7	60,0
14	Cyprus	35,7	30,8	19,4	71,5	54,9
15	Malta	35,4	25,6	20,9	70,6	60,5
16	Latvia	35,3	37,9	17,8	57,7	50,2
17	Luxembourg	35,2	20,2	23,8	74,2	62,2
18	Italy	33,8	28,0	17,3	68,0	55,9
19	Spain	33,7	25,7	16,2	71,6	59,7
20	Portugal	33,5	33,4	11,9	67,7	54,2

These research results provided the initial data for the development of the National Action Plan for Improving the Situation of Senior Citizens "Active Ageing" for the period 2021-2025. The purpose of the National Plan is to formulate a strategy, composition and sequence of coordinated actions of all parties involved to improve the lives of senior citizens, improve the quality of life, independence and autonomy in old age, increase the healthy life expectancy of the population, maintain and strengthen health, improve the social and psychological well-being of senior citizens, expand opportunities in old age to participate in various spheres of society, in the socio-economic development of the country [289].

Thus, creating certain problems for governments and society, gerontology throughout the world is identified as a priority area from a scientific point of view. The United Nations Programme on Research on Ageing identifies a number of research areas [290] that can form the basis for policy decisions taken in response to ongoing ageing at both the population and individual levels [291]: research to formulate policies implemented by state and public institutions, to form an ecosystem of healthy ageing with the participation of older people in society and their integration into society; biomedical research to understand the basic mechanisms of ageing and longevity factors that are of fundamental importance for realizing the potential of healthy human ageing and preventing age-associated diseases; innovative technologies to improve the diagnosis and treatment of diseases in geriatric practice; research aimed at creating gerontological care services and long-term care for the elderly and the introduction of technology in this area.

Scientific challenge 2. Research for the creation of gerontological care and long-term care services for the elderly and the introduction of technology in this area. The foundations of the gerontological service in the healthcare sector of Kazakhstan have been laid. For this purpose, the "Standard for the organization of geriatric and gerontological care in the Republic of Kazakhstan" was approved (Order of the Ministry of Health of the Republic of Kazakhstan 55 dated 06/23/2021 in accordance with paragraph 32) of Article 7 of the Code of the Republic of Kazakhstan dated 07/07/2020 "On public health and the healthcare system", establishing the requirements and procedures for the processes of organizing the provision of geriatric and gerontological care to patients of older age groups with signs of premature aging in outpatient, inpatient, inpatient settings and at home; the specialty "geriatrics" is included in the nomenclature of medical and pharmaceutical specialties of the country. In order to strengthen gerontological care at the PHC level, the National Plan "Active

Longevity" until 2025" provides for mandatory implementation of "Opening of geriatric rooms at polyclinics" (in task 5 "Improving the health care system", paragraph 14). In this regard, starting in 2022, geriatric rooms in PHC will be opened in all cities of Kazakhstan to provide primary specialized care in the profile of "geriatrics". However, despite the achieved results, the function of the geriatric room in many polyclinics is reduced to simply submitting quarterly reports to the city health department on the coverage of the elderly population with dispensary examinations, promotions, organization of an active longevity school, etc. The main reasons for such formal work: 1) to date, uniform requirements and procedures for the work of geriatric rooms in PHC have not been established; 2) there is no approved unified methodology and no tools for conducting a comprehensive geriatric assessment (specified in the Standard for the Organization of Geriatric and Gerontological Care), non-standardized various questionnaires and tests are used; 3) there are no integrated programs for improving the qualifications of the Multidisciplinary Team of PHC specialists (medical and social workers, psychologists) for organizing long-term home care in gerontological practice; 4) modern gerontotechnologies and digital technologies have not been introduced into the practice of geriatric offices.

Meanwhile, the best international practice of demographically aging countries has shown that one of the main tasks of the geriatric PHC office is to provide specialized geriatric care to patients based on a comprehensive geriatric assessment of the patient's health, as well as prevention and interdisciplinary management of a patient with senile asthenia. Frailty syndrome is a key geriatric syndrome that predicts a high risk of death and other adverse outcomes in older people. At the same time, the main attention should be paid to the timely and proactive detection of frailty in elderly patients by therapists, general practitioners and their referral to a geriatric office.

In Kazakhstan, there is no state system of comprehensive long-term care that meets the needs of the population in need and is accessible to all citizens. The main reasons are: long-term care for patients is not sufficiently implemented as a political task in healthcare, and home care services are not fully integrated into the system of medical and social security of the population.

The organization of the long-term care system as a unified medical and social assistance to the elderly population as a whole is not envisaged. According to open sources, according to the Department of Employment and Social Programs of the Akimat of the city of Almaty, among 12.5% of elderly people living in the metropolis, only 1.3% of those in need are served at home by social services. According to research data, for the period 2016-2021, among outpatients in need of long-term medical, social and palliative care, 73.7% are elderly and 25.3% are old. Of all elderly people in need of long-term care, 86.3% chose "home care", while 2.3% of respondents chose "institutional care" (state medical and social institutions for the elderly and disabled or private nursing homes). The described current situation is the basis for the implementation of scientific research and the effective implementation of the National Plan "Active Ageing".

Scientific Challenge 3. Biomedical Research. Aging, from a scientific point of view, is a series of processes that include direct DNA damage, accumulation of

cellular waste, metabolic errors and imperfect repair, and the body's response to these processes, which leads to the known signs of aging and the development of age-related diseases [292]. Aging is defined by various categories and how they interact with each other is explained, stimulating the development of age-related changes and diseases [293]. Knowledge of these foundations and mechanisms of aging gives researchers an idea of how they can directly intervene in these aging processes to prevent age-related diseases [294].

In the period from 2021-2023, the scientific and technical program “National Program for the Implementation of Personalized and Preventive Medicine in the Republic of Kazakhstan” was implemented on the basis of the S. Asfendiyarov Kazakh National Medical University. The goal of the program was to develop management solutions aimed at preventing the development of diseases in the population of the Republic of Kazakhstan, taking into account local characteristics. Based on the project results, recommendations were developed for decision-making to optimize the work of primary health care; data were obtained on the real picture of the impact of industrial regions of hazard class I, motor transport and water supply systems on the health of the population of each specific city and district center of the Republic of Kazakhstan; valuable information was obtained on the genetic predisposition of the population of Kazakhstan to different courses of COVID-19, as well as on the genetic characteristics of the coronavirus strains circulating in Kazakhstan; key genetic markers associated with the development of significant diseases in individuals of the Kazakh ethnic group were identified, a reference database of genomic variants of the Kazakh population was created; draft amendments to clinical protocols regulating the tactics of using selected drugs, taking into account the genetic characteristics of the patient were developed; strains of M. tuberculosis that are most resistant to current treatment methods were identified; a technology was introduced that increases the effectiveness of treatment of acute leukemia in children; a technology of personalized cell transplant with high regenerative potential was developed; the "Biobank for the Main Social and Non-Communicable Diseases of the Population of the Republic of Kazakhstan" was created on the basis of the scientific laboratory "Center for Collective Use" of the Research Institute of Fundamental and Applied Medicine named after B. Atchabarov.

In 2023, scientists from the Karaganda Medical University conducted research to assess health and disease risk factors, obtained a genetic assessment of more than 2,000 patients and accumulated a database for analyzing the relationship between genetic markers and the development of pathologies of various origins. Genetic and serum markers were identified that make it possible to assess the risk of developing colorectal cancer; the most effective treatment regimens for chemotherapy of colorectal cancer were determined; indicators of the effectiveness of preventive measures were developed.

As part of the national program for the implementation of personalized and preventive medicine in the Republic of Kazakhstan (2021-2023), a study was conducted at the National Center for Biotechnology to create a technology for obtaining autologous genetically modified T-lymphocytes expressing chimeric antigen receptors (CAR-T), and it was recommended to use CAR-T lymphocytes for adaptive

immunotherapy of patients with leukemia. CAR-T technology is planned to be introduced in the Republic of Kazakhstan in 2024 in the format of a "hospital exception", the concept of which means that the cellular drug (CAR-T) will be used to treat patients before the registration procedure is completed. Kazakhstan may become the first country in Central Asia to begin treating oncohematological diseases with genetically modified cells.

Currently, the whole world is studying the disruption of the human intestinal microbiome as a cause and consequence of aging, since it is known to change with age. Modern studies also show that the intestinal microbiota is capable of exerting its effect not only locally, but can also influence key functions of the body, such as the cardiovascular system, central nervous system, endocrine system. There is scientific evidence of long-term dysbacteriosis of the intestinal microbiome in COVID-19 and its association with fecal excretion of the SARS-CoV-2 virus and the severity of the disease [295].

The Medical University of Karaganda conducted *a study to assess the phenomenon of bacterial translocation*. Within the framework of this project, more than 1000 patients with various disorders that contribute to the translocation of microflora from the intestine (impaired patency, increased intra-abdominal pressure, inflammatory bowel lesions) were examined. It was revealed that the phenomenon of bacterial translocation can be a key factor in the development of sepsis in surgical patients, even without the presence of a source of infection. A method for directly assessing the presence and degree of bacterial translocation in patients has been developed. A system for assessing the risks of inflammatory complications in patients based on the determination of intestinal translocation biomarkers has been developed. The results formed the basis for the development of a personalized approach to the treatment of patients with multiorgan dysfunction.

In this direction, Nazarbayev University and the Gerontology Center of the Hospital of the Medical Center of the Presidential Administration of the Republic of Kazakhstan are conducting a scientific study on the species structure of intestinal microbiota in insulin resistance in the Kazakh population. For the first time in this direction, scientists from the Kazakh National Medical University named after In 2023, S. Asfendiyarov conducted a study of the intestinal microbiome using modern sequencing platforms with the participation of elderly people and the effect of freeze-dried mare's milk on the main indicators of the microbiome and the state of lymphocyte cell membranes and immune status, including those who have had Covid-19.

Scientific challenge 4. MedTech and artificial intelligence. Without the support of applied research and the introduction of innovative technologies into practice, it is impossible to improve the problem of health care in modern conditions. In terms of competitiveness compared to other countries, Kazakhstan is at the initial stage of MedTech development and the use of artificial intelligence (AI) [296]. To promote AI, since 2023, the Science Foundation has been holding an industry MedTech reactor for the commercialization of technologies for the results of scientific and technical activities based on the Kazakh National Medical University named after S.

Asfendiyarov, the total amount of attracted investments is more than 500 million tenge.

Today, the healthcare industry of Kazakhstan is focusing on two innovative AI developments:

- in the diagnosis of oncological diseases, in particular breast cancer and lung cancer using AI;

- in the field of neuroradiology, the Cerebra software for automated diagnosis of ischemic and hemorrhagic stroke was selected to participate in the world's largest medical technology accelerator MedTech Innovator.

Since 2023, scientists from the Al-Farabi Kazakh National University have been conducting a study entitled "Development of markers and a diagnostic algorithm for the detection and prevention of early cardiovascular aging." The purpose of the study is to identify risk markers for early involutional changes in the cardiovascular system and the development of age-associated cardiovascular diseases based on the study of biochemical, immune and cytopathic indicators of older individuals. To analyze these indicators, scientists have developed machine learning algorithms to automate the process of identifying the main factors influencing the aging process. In the future, scientists plan to develop a program based on artificial intelligence that will take into account the main biomarkers and the risk of cardiovascular diseases in a particular patient. This area of research by scientists is promising, since the use of AI will allow for an in-depth study of the complex relationships between various aspects of premature aging and the identification of sensitive biomarkers, on the basis of which measures to prevent premature aging of the body will be proposed.

Scientific challenge 5. Remote medicine. Several domestic digital solutions for remote provision of medical services and monitoring of citizens' health are being implemented in Kazakhstan:

SmartECG software (CMC Technologies) - remote interpretation of cardiology examination results, which operates in 15 regions of the country;

EyeLab hardware and software complex (EyeLab) - remote processing of fundus images and automatic analysis of the obtained result, implemented in 7 regions (the cities of Astana and Almaty, Zhambyl, Akmola, Karaganda, North Kazakhstan regions and Zhetysu region);

HES-7 health diagnostic system for mobile diagnostics of residents of remote villages - "paramedic backpack" (Konsung Technology LLP);

system for remote monitoring of citizens' health using wearable devices (Sapa Telemedicine Center);

hardware and software complex for undergoing medical examination "SMARTSCAN" (TOO "Arasan Deu Group");

remote health monitoring system "Home Diagnostics" (TOO "Home Diagnostics") - an integrated hardware and software complex designed to record body sounds, perform otoscopy, pulse oximetry and ensure effective communication between patients and doctors;

program "Med 365" (TOO "Med 365") - a system for automating medical examinations, a hardware and software complex;

MedReview software (KazDevelopment company) - generating remote reports on radiation diagnostic services (X-ray/mammography/CT/MRI).

2. Review and analysis of global trends in science, examples of cooperation between domestic scientists and foreign scientists and work carried out under contracts with international scientific organizations

The medical research industry aims to advance human health and combat diseases, but faces significant challenges from high costs and lengthy research processes to their reproducibility in practice. Artificial intelligence, more accurate diagnostics, and accelerated molecular development are key actions to advance medical research to improve global health. The integration of these innovations solves the industry's pressing problems and paves the way for more efficient, accurate, inclusive, and patient-centered healthcare.

The medical research trends of the modern global community include medical technologies based on artificial intelligence, remote medical care (virtual hospitals and telemedicine), nanomedicine (immunization), development of new drugs, improved data analytics for prediction and decision making, translational research, immersive technologies, molecular analytics, etc. [297]. Synergies between biomedical science and a wide range of technological disciplines, including genetics, biotechnology, artificial intelligence are the main driving force, and lead to the development of molecular and cellular biology, which underlie personalized medicine.

Artificial Intelligence. Among the global trends in medical technology (MedTech), artificial intelligence (AI) and machine learning (ML) are a priority. According to the forecast of MarketsandMarkets, the AI services market for healthcare will grow from 14.6 billion in 2023 to 102.7 billion by 2028 [298]. According to AI in Healthcare Statistics (2023), around 40% of healthcare areas worldwide regularly use AI and ML. The range of AI use in healthcare is expanding every year, and is now considered a promising solution in cancer diagnostics, drug development, personalized treatment plans, and risk assessment [299]. In 2023, the popular areas of healthcare for AI development include radiology (75%), cardiology (up to 11%), hematology (up to 4%), neurology (up to 3%), etc. [300]. The StartUs Insights Discovery Platform report highlights such AI trends for 2023 as a platform for analyzing acoustic data of respiration and the heart (MedaPlus, Germany), a solution for triaging strokes (Hevi A, Turkey), software for early diagnosis of cancer (Sierra Medica, UK), etc. [301].

In the context of the rapid introduction of AI in healthcare in 2023, the WHO presented principles for regulating AI technologies in healthcare, contributing to the formation of best practices [302].

In terms of competitiveness compared to other countries, Kazakhstan is at the initial stage of MedTech development and the use of AI [296]. Factors such as the level of innovative development of the country (81st place out of 132 countries in the Global Innovation Index, 3rd place among the countries of Central and South Asia) [303], a rapidly developing startup ecosystem (74th place in the Global Startup Ecosystem Index) [304], state support for technological developments (for example, subsidies through a project to stimulate productive innovations), and an actively

developing scientific environment allow Kazakhstan to promote AI products in practical healthcare [305].

In gerontology, AI has begun to be widely used to predict frailty, a key syndrome that allows predicting a high risk of death and other adverse outcomes in older people. In particular, studies have shown that AI improves the prediction of frailty, surpassing traditional models [306-311], and the effectiveness of AI for screening frailty has been demonstrated compared to traditional methods [312].

Clinical trials. Cancer is growing at a significant rate worldwide, accounting for up to 25% of the global clinical trials market. The cardiovascular diseases segment is growing by an average of 7-10%, the growing prevalence and increased demand for cost-effective drugs worldwide have led to investments in science in this area. According to WHO, about 40% of clinical trials of non-communicable diseases were conducted worldwide, with infectious diseases accounting for 60% of all studies. The observational studies market in autoimmune/inflammatory diseases was the second largest, with more than 7,000 interventional studies presented on the Clinicaltrails.gov website.

The clinical trials market in Kazakhstan has been actively developing in recent years: the number of studies has increased almost 3 times over 10 years (2013 - 5; 2023 - 17), and their share is 0.85% per 1 million population (2023) [313/36]. However, compared to the countries of the EAEU and Europe, the observed growth of the clinical research market in Kazakhstan is insignificant, despite the ongoing reforms - optimization of regulatory standards, reduction in the terms of licensing processes, refusal to accredit the clinical research base. The main share (2/3) falls on bioequivalence studies of drugs, as well as phase III clinical trials. Up to 50% of studies are carried out at the expense of foreign manufacturers of drugs and medical. In 2023, the main areas of drug research were gastroenterology, immunology, ophthalmology, psychiatry. In order to develop the clinical research market in Kazakhstan, the Ministry of Health of the Republic of Kazakhstan in 2022 created the Center for the Development of Clinical Research, the purpose of which is to support and develop international and local clinical research, as well as the formation of new methodologies for finding evidence in the healthcare system. The Center is implementing the project of program-targeted financing "Development of new approaches to the organization and conduct of clinical trials in the Republic of Kazakhstan. Creation of a unified system for coordinating clinical trials" (2023-2024), within the framework of which, since 2023, work has been carried out to optimize the regulatory framework, develop the National Registry for Biomedical Research (automation of business processes for managing clinical trials (from registration to reporting) on a "single window" principle with the participation of all stakeholders), form a National Strategy for the Development of Clinical Trials in Kazakhstan for the next 3 years, etc.

The first Clinical Center for Bioequivalence has been created in Kazakhstan, on the basis of which it is planned to conduct clinical and biopharmaceutical parts, providing manufacturers with an opportunity to have a full range of services for bioequivalence and therapeutic equivalence studies.

Clinical trials in the field of aging are conducted in the following areas [314]: targeting senescent cells and removing these cells using genetic or pharmacological drugs (so-called senolytics); inhibition of the mTOR protein, including rapamycin. mTOR inhibition results in improved mitochondrial function, dermatological improvements in skin, and overall improved immune function in older adults, possibly through reduced immunosenescence; study of NAD+ and NADH – the oxidized and reduced forms of the metabolite nicotinamide adenosine dinucleotide (NAD). NAD+ is an important indicator of intracellular energy; exercise-based reduction of systemic and muscle inflammation.

Remote healthcare (virtual hospitals and telemedicine). The global remote patient monitoring market will grow steadily and will amount to more than USD 290.59 billion by 2028, with a CAGR of 14.6% [315]. The top 10 fastest growing telemedicine services are: teledentistry, teleradiology, psychiatric telemedicine, teledermatology, telepathology, telecardiology, pediatric telemedicine, ophthalmology telemedicine. Such technologies in 2023 include, for example, the expansion of the services of the American Well Corporation (USA) digital clinical program to include a cardiometabolic program, Teladoc Health Inc. uses telemedicine to solve problems with prediabetes and weight control programs, etc. [316]. Several domestic digital solutions for remote provision of medical services and monitoring of citizens' health are being implemented in Kazakhstan:

- SmartECG software (CMC Technologies) - remote interpretation of cardiology examination results, which operates in 15 regions of the country;
- EyeLab hardware and software complex (EyeLab) - remote processing of fundus images and automatic analysis of the obtained result, implemented in 7 regions (the cities of Astana and Almaty, Zhambyl, Akmola, Karaganda, North Kazakhstan regions and Zhetysu region);
- the HES-7 health diagnostic system for mobile diagnostics of residents of remote villages - "paramedic backpack" (Konsung Technology LLP);
- a system for remote monitoring of citizens' health using wearable devices (Sapa Telemedicine Center);
- hardware and software complex for undergoing medical examination "SMARTSCAN" (TOO "Arasan Deu Group");
- remote health monitoring system "Home Diagnostics" (TOO "Home Diagnostics") - an integrated hardware and software complex designed to record body sounds, perform otoscopy, pulse oximetry and ensure effective communication between patients and doctors;
- the program "Med 365" (TOO "Med 365") - a system for automating medical examinations, a hardware and software complex;
- MedReview software (KazDevelopment company) - generating remote reports on radiation diagnostic services (X-ray/mammography/CT/MRI).

Biotechnology in medicine and nanomedicine. The global nanomedicine market is valued at US$227.64 billion in 2023 and is expected to reach US$422.38 billion by 2028 [317], with more than 50% of the nanomedicine products under development targeted at drug delivery applications [318]. Around 500 clinical trials are focused on

therapeutics and diagnostics using nanomedicines. Nanomedicine has made significant advances in cancer treatment (approximately 40% of clinical trials in this field), and nanotechnology-based therapies represent a $70 billion market opportunity. Current clinical research in nanomedicine covers a wide range of nanomedicine types and includes lipid-based nanoparticles, protein-based nanoparticles, polymeric nanoparticles, virus-like particles, micelles. Genetic engineering has become a subject of great interest and investment in recent years - CRISPR-Cas9 technology, which allows making precise changes to the genome of organisms. Biotechnological developments that shaped the biotechnological industry in the global market in 2023 include a vaccine against Alzheimer's disease (UB-311, synthetic active immunotherapy based on peptides), mRNA-based vaccines against various diseases, protein engineering, repurposing of existing drugs for new therapeutic purposes, etc. [319]. As part of the national program for the implementation of personalized and preventive medicine in the Republic of Kazakhstan (2021-2023), the State Enterprise on the Right of Economic Management "National Center for Biotechnology" conducted a study to create a technology for obtaining autologous genetically modified T-lymphocytes expressing chimeric antigen receptors (CAR-T), and to use CAR-T-lymphocytes for adaptive immunotherapy of patients with leukemia. CAR-T technology is planned to be implemented in Kazakhstan in 2024 in the format of a “hospital exception”, the concept of which means that the cell drug (CAR-T) will be used to treat patients before the registration procedure is completed. Kazakhstan may become the first country in Central Asia to begin treating oncohematological diseases with genetically modified cells.

According to forecasts, the number of dementia cases in the world is expected to triple by 2050, affecting more than 150 million people [320]. And neurodegenerative diseases will be the leading cause of death, overtaking cancer [321]. The problem of dementia requires the introduction of MedTech into the lives of people living with relatives suffering from dementia. Robots can help with this by reducing depression and anxiety, giving joy from positive emotional experiences and improving their social interaction through communication [322].

One of the priority areas for the industry is neuroscience - a relatively new area for Kazakhstan. The Brain Institute was established at the Al-Farabi Kazakh National University to conduct fundamental and applied research in the field of cognitive, clinical and molecular neurosciences [323]. Also, the Educational and Scientific Center for Neurology and Applied Neurosciences operates at the S. Asfendiyarov Kazakh National Medical University to actively expand the research potential at the Science and Technology Park in accordance with the main global trends in the development of higher education. In order to integrate into the international scientific community, joint research projects are being carried out with leading international universities: University of California, Los Angeles, with the "Neurovascular Imaging Research Core", Director, Professor David S. Liebeskind; Auckland University of Technology, with the "National Institute for Stroke and Applied Neurosciences", Director, Professor Valery Feigin. In 2023, the study "Development of a program for molecular cytogenetic studies and creation of a biobank of tumors of the central

nervous system" implemented by JSC "National Center for Neurosurgery" was completed. The study is aimed at improving the diagnostics of pathologies of the nervous system, digitalization of pathomorphological and molecular genetic studies for the implementation of personalized medicine in the Republic of Kazakhstan and the creation of a centralized (unified) biobank of pathologies of the nervous system for conducting scientific research aimed at developing neuroscience, improving the quality and increasing the life expectancy of neurosurgical patients. In order to develop industrial biotechnology, bioengineering and biomedicine, Kazakhstani researchers actively collaborate with leading scientists of the international medical community from 27 countries (USA, European countries, CIS, China).

3. Analysis of achievements and development trends of leading scientific schools of Kazakhstan and highly developed foreign countries

Without the support of applied research and the introduction of innovative technologies into practice, it is impossible to improve the problem of health care in modern conditions. In 2023, JSC Science Fund organized a dialogue platform for the integration of science and business "MedTech-reactor of technology commercialization" on the basis of the Kazakh National Medical University named after S. Asfendiyarov - pitches of completed scientific projects that search for business partners to co-finance the most promising scientific and technical projects. The total amount of attracted investments amounted to more than 500 million tenge. The industry reactor reviewed about 50 medical projects covering various aspects of medical practice and scientific research, from pharmaceuticals to digital technologies in healthcare, such as the Intelligent Audiologist mobile application, KZM-01 telecardiograph, ECG patches for continuous telemedicine heart monitoring, etc. [324/47]. Following the MedTech Reactor, negotiations with business partners are underway on 8 projects, and agreements on joint activities between business enterprises and scientific organizations have been reached on 4 projects. In 2023, the Kazakh National Medical University named after S. Asfendiyarov and the National Agency for Innovation Development "QazInnovation" conducted joint business incubations worth 33 million tenge.

A Science and Technology Park was opened on the basis of the Kazakh National Medical University named after S. Asfendiyarov. The Science and Technology Park has conditions for the functioning of the following divisions:

• Business incubator for the preparation of innovative projects, startups, participation in international events, the implementation of ideas and potential of students, residents, master's students, doctoral students, young scientists and university specialists.

• Department of pilot industrial production for testing the technology for the production of medicines (the first serial samples) in accordance with international GMP standards in order to conduct further clinical trials of medicines.

• Life sciences laboratory for the development of the educational process and scientific research in the field of Life Sciences at the level of world standards, which will ultimately lead to improved quality of diagnostics and treatment of a wide range of diseases.

• Scientific and practical laboratory in cosmetology for the training of competitive personnel with professional competencies in the field of cosmetology.

• DATA-center - a repository representing an institutional electronic archive for long-term storage, accumulation and provision of long-term and reliable access to the results of scientific research and related intellectual products.

In order to achieve the goal set by the Head of State in the Address to the people of Kazakhstan to the medical community to increase the share of domestic manufacturers in the market of medicines and medical devices to 50% by 2025, in 2023 one of three Medical and Pharmaceutical Clusters from a group of innovative companies was created in Shymkent, which will be engaged in the development of dosage forms, their introduction into industrial production.

Thus, global trends in the development of life and health sciences show the need to integrate biomedical science and technological disciplines, including artificial intelligence, to solve a wide range of problems. With the development of biotechnology, it will be possible to create human organs and tissues. With the development of genetic engineering, in particular, CRISPR-Cas9 technology, it becomes possible to make point changes to the genome of organisms. With the development of bio- and microchip technology, it became possible to identify various diseases and their causes. All these scientific trends require a multidisciplinary and integrative approach to the development of the "Life and Health Sciences" direction.

Priority VII – "Research in Science and Education"

1.Review and analysis of the achievements of Kazakhstani science (the most significant results of the scientific and (or) scientific and technical sphere, implemented developments)

The dynamics of development of pedagogical science in the 21st century is accelerating. This is due to both the real sector of pre-school, school, technical and vocational, university and postgraduate education, and the expansion of the virtual space and the virtual world of man, the emergence of new opportunities for personal training. Personal development continues throughout life, and a person's life in two realities (real + virtual) creates new opportunities for its improvement. The narrative of the education crisis has about 60 years of history, starting in 1968 - with the publication of the book by the founder of the Club of Rome A. Peccei "Human Qualities" and the head of the UNESCO International Institute for Educational Planning F. Coombs "The Education Crisis in the Modern World: Systems Analysis". As is known, back in the 60s of the twentieth century F. Coombs called on countries to allocate 2% of the budget for research in the field of education.

Currently, according to the UN Secretary General A. Guterres, the education crisis has acquired new dimensions. The conclusion of the UN Conference of

Government Leaders and Education Ministers “Education Transformation Summit” on September 16-19, 2022 (New York, USA) states that “...education faces a dramatic triple crisis: a crisis of equity and inclusion, as millions of people are out of school; a crisis of quality, as many of those who are in school are not even learning the basics; and a crisis of relevance, as many education systems are not equipping new generations with the values, knowledge, and skills they need to thrive in today's complex world” (UN, 2023; Akhmed, 2023) [325].

Analyzing the reports of the National Scientific Council in the field of “Research in Education and Science” of the Republic of Kazakhstan for 2021-2023, one can state both an increase in the number of scientific researches, observe the growth dynamics, and the funding allocated by the state for their implementation. In 2022, 4 large PCF programs (2022-2024), 48 research applications for grants for 2022-2024, and 20 applications from young scientists (in 3 competitions) were approved for funding. In 2023, 10 new PCF programs for 2023-2026, 74 research applications for the 2023-2026 competition, and 16 projects for the young scientists grant competition (in 2 competitions) were approved for funding [326-329].

According to the data of the Scientific Center of the State Scientific and Technical Evaluation in Science in Figures (2023) [329], in 2022, 3 PCFs were implemented under the priority "Research in Education and Science", as a result of which 145 publications were published, including 9 in the Scopus database, 2 in the Web of Science [329]. In fact, the average PCF indicators were 48 publications, of which 3 were in the Scopus database. On the one hand, the total number of publications turned out to be the highest by priority, but the publication indicators in the Scopus database are average, i.e. the fourth in importance among other priorities (higher indicators are for EN, ICCT, E&M).

In 2022, 111 completed and ongoing projects were completed, which resulted in 288 scientific publications, including 103 foreign ones (average values are 2.6 and 0.9 per project, respectively). Implementation acts had 12 projects, with a total number of implementations - 25 [329].

In 2023, 27 PFI and 5 PCF projects in this area were completed. Semantic analysis (SEO analysis) of the implemented completed projects of 2023 showed the advantage of topics on digital and distance learning, as well as teaching the Kazakh language. While the semantic analysis of the ongoing 166 R&D projects (2022-2024) in this area clearly shows both the diversification and diversity of the direction and topics of research in the field of education, and the results obtained. Key trends: in addition to the digital focus (24), development of language competencies (14), including Kazakh (8) and English (6), innovative areas are clearly visible: research and development of functional literacy (6), inclusive education (7), creation of methodological systems (9), prevalence of technological (19) and environmental approaches (15) in research as opposed to connectivist (1). It should be noted that within the framework of the digitalization direction, the trend of gamification (4) of educational technologies is evident. Separately, we highlight research on blockchain technologies in education, creation of a “digital twin” of students, development of

massive online open courses; sports education in Kazakhstan and formation of a healthy lifestyle in children; greening of education through the formula “green school - green college - green university”.

Key achievements in education research based on completed studies in 2023.

According to the project AP09057871-OT-23 "Virtual foresight laboratory as a means of developing metacompetences in the humanities" (headed by E.K. Nauryzbaeva), a virtual foresight laboratory was created as a communicative tool for an innovative form of social partnership between humanitarian professional education and education customers. The use of the laboratory is aimed at developing metacompetences in students, taking into account future professional and qualification changes dictated by the labor market [330]. Based on the results of the project, an article was published in the Scopus database (Q2, 63% percentile), a monograph and a textbook.

According to the project AP09259370-OT-23 "Development of a technological platform for virtual learning based on artificial intelligence approaches" (headed by N.N. Kerimbaev), the technical capabilities of the virtual distance learning system and the virtual educational environment e-Learning were supplemented, in particular, virtual assistant programs, virtual and augmented reality technologies, mobile applications were developed, an interface for intelligent control of human-computer interaction in training was developed, a technological platform for a virtual educational environment within e-Learning was implemented [331]. Based on the research results, 3 articles were published in the Scopus DB conference materials (2021-2022) and 2 articles in Scopus DB journals (2022 - Q3 percentile 56%, 2023 - Q1 percentile 95%), of which 1 is included in the WoS DB. A monograph was published (2023), in 2021, author's certificate No. 16051 dated January 19, 2021 was received. The results of the project have been implemented in the educational process (3 acts of implementation).

The results of the project on the development of creativity of children and students AP09259731-OT-23 "Didactic potential of domestic painting in the implementation of the program of spiritual revival of the nation" (headed by I. Smanov) are interesting. Scientists and teachers have developed a model for training teachers based on familiarization with domestic painting, a methodology for developing the spiritual sphere of a child has been developed, and the author's program for the gymnasium course "Domestic history through the prism of painting" has been tested [332]. An article has been published in the Scopus database (Q4 - percentile 8).

The project AP09259839-OT-23 "Organization of the system of psychological profiling and correction of suicidal behavior of adolescents" [333] is distinguished by the relevance of the problem statement and the attempt to solve it. Research scientists under the leadership of T. Boleev developed a model of preventive activities of a school psychologist on suicide among students, proposed a teenager's map related to profiling, published a teaching aid "Psychological profiling and correction of suicidal behavior of adolescents" and a textbook "Suicidology".

The issues of quality of education and management of the education system are raised in the following studies on secondary and higher education.

According to the project AP09261436-OT-23 "Model of per capita financing in public and private schools of Kazakhstan and issues of sufficiency, equality and accountability" (headed by R. Kasha). The authors of the project state that “when comparing the responses of principals of schools with per capita funding and schools with line-item budgets, the analysis showed that schools with per capita funding (PF) had significantly higher (more positive) response values than their colleagues without PF for the following three survey items: (1) maintaining existing infrastructure ($d = 0.48$, $p < 0.001$); (2) ensuring the availability of the necessary support personnel at school ($d = 0.47$, $p < 0.001$); (3) ensuring teachers’ access to modern and functioning ICT ($d = 0.34$, $p < 0.05$) [334]. On the other hand, no significant differences were found for the remaining four survey items [334]. The article was published in the Scopus database (Q1 – 83% percentile).

The project AP09260789-OT-23 "Problems of 'diploma mills' in the higher education system of Kazakhstan" (headed by A.N. Ospanova) summarizes the problems of universities: low quality of the educational environment; ineffective quality management of higher education; weak organization of practice-oriented educational programs; low controllability of diploma mills in Kazakhstan; bureaucracy in universities; meritocracy as an imperative in the higher education system. Recommendations for their solution are offered: "refusal of the services of diploma mills (private enterprises, special institutes) that guarantee high-quality preparation of theses, research articles and issuance of diplomas "on request"; large-scale digitization of graduates' data; “to develop principles of accountability, impartiality and transparency in universities in terms of the fair distribution of grants within the framework of state procurement and private donations (patronage) in order to create a fair competitive environment, which could have a positive impact on the development of high-quality higher education in Kazakhstan” [335].

A separate area of this sphere is related to science studies, therefore let us consider brief results of the project AP09259979-OT-23 «Institutional status of science in modern Kazakhstani society: assessment of problems of representativeness and development of priority directions of a new paradigm of development of prestige of science» (headed by Taubayev A.A.) [336]. A survey of stakeholders was conducted — representatives of mass media as conductors of popularization of scientific achievements. According to the results: 78.1% of respondents understand importance of science for Kazakhstani society, 53.2% consider status of Kazakhstani science in the world to be low, 68.4% define prestige of doing science as average, 52.4% recognize effectiveness of role of mass media in changing the current situation, 82.4% recognize low percentage of mass media publications of information about development and achievements of Kazakhstani science, 79.2% are little informed about them; 43.1% attribute the current situation to the lack of interest among the population in this kind of information, 39.4% to the lack of interesting facts suitable for coverage, 27.5% to the lack of initiative on the part of scientists themselves; 69.3% believe that this information niche is practically empty, but quite promising if there is interest on the part of scientists and the state. The study summarizes the institutional factors influencing the development of theoretical and applied science in the country:

crisis of fundamental science; low level of interaction between educational and research institutions; low motivation of scientists and young scientists to develop the theoretical field of domestic science; lack of external social motivation; pronounced emphasis on importing popular theoretical constructs and research problems abroad; high bureaucratic relevance of science; high level of mobility of scientific interests in the range of state priorities and international trends of the international field of science; the peripheral status of the academic community (i.e. in the situation of the existing monopoly of European (mostly English) and American universities on the "production" of new theoretical models, scientists play the role of an empirical base and consumers of ready-made theoretical constructs); the problem of the legitimacy of the international status of science and scientists, in particular the dependence on the Hirsch index in foreign databases; weak interest in the works of domestic scientists; replication and plagiarism; resistance of the scientific elite to the scientometric assessment of the results of scientific activity; English as the leading language in the international community; the relevance of research interests to socio-economic and political demands, etc. [336]. The authors of the project offer recommendations for promoting the prestige and status of Kazakhstani science, in particular the creation of the "Bilim" society as a structure for raising the level of knowledge of society and influencing public consciousness, the active use of social networks in advertising domestic scientific achievements; the creation of a specialized popular science TV program; the development of scientific journalism; popularization of scientific exhibitions and museums, etc. [336] Based on the results of the study, articles were published in the Scopus database (Q3 - 44% percentile).

The following significant scientific results were obtained in the interim reports of 2023. We focus on the results of projects to maintain the physical and mental health of schoolchildren.

According to the project AP19677800-KC-23 "Monitoring the physical health of children and adolescents: modification of national measurement tools" (headed by Otaraly S.), it was revealed that the development of fitness tests in the world is proceeding in two directions: the development of health-related tests and skills-related fitness tests [337]. It is planned to adapt advanced methods and introduce them into Kazakhstani school practice.

According to the project AP14869833-KC-23 "Strengthening the psychological health of Kazakhstani schoolchildren as a factor in reducing the risks of cyberbullying in the process of online socialization" (headed by G.M. Rakisheva), a methodology for assessing the impact of cyberbullying markers on the level of human psychological health was developed; an initial survey of students was conducted with the consent of their parents; a virtual psychological laboratory was developed (v 1.0, free Django framework in Python), which includes an administrative and user part, and the functionality for creating user accounts was developed - expert, psychologist, student, parent [338]. In 2023, copyright certificate No. 33327 dated 03/06/2023 was received.

According to the project AP19174913-KC-23 "Implementation of the research-based learning model for future teachers in the regional university of the republic" (headed by Ermekbaeva G.G.), a training model has been developed that includes two

approaches: RLT - research-led teaching and RBT - research-based teaching on the part of the teacher; as well as RBL - the role of the student [340]. The role of the teacher includes assistance, moderation, guidance, tutoring and mentoring of students' activities.

The project on developing the theoretical foundations of the educational SMART environment can be called a breakthrough. According to the project AP19679833-KC-23 “Connectivist model of foreign language educational SMART environment in the context of Kazakhstan: justification of necessity, analysis of availability and development strategy” (headed by Shelestova T.Yu.), an algorithm for designing this environment was developed by creating a network space for interaction between the student and the teacher-facilitator, who is proficient in connectivism-oriented technologies. Each of the SMART components (self-, media-, art-, re- and trans-) is important in this context: self- self-determination and initiative of students, taking into account their psychological characteristics, proactivity of activities, media-use of media technologies - online forums, WhatsApp chats for feedback with the teacher, art- use of creative teaching and research methods, re- active participation and feedback and trans- cross-border unification of disciplines in the network SMART space [341].

According to the project AP14871422-KC-23 "Development of a model for implementing educational tourism in the system of teaching higher education students: theory, methods, practice" (headed by D.G. Mamraeva), an assessment of the state of the educational tourism market was carried out, a survey of tour operators and travel agencies of Kazakhstan was conducted (with regional differentiation: Astana, Almaty, Shymkent, Karaganda, Mangistau and Turkestan regions) to study the specifics of consumption and provision of educational tourism services; it was found that medical specialties, pedagogical sciences, "business, management and law", "engineering, manufacturing and construction industries" are in demand among foreign students; a matrix of supply of educational tourism products was developed. 57.2% of the surveyed travel agents believe that over the past 5 years, educational tourism; a greater number of educational tours are purchased in the summer (41.3%), in the fall (23.8%), in the spring (19%), in the winter only 15.9% of sales; The most popular countries for outbound educational tourism are Italy, Spain, France, the Czech Republic, the USA, Great Britain and South Korea, while Canada, Poland, China, Singapore and Russia are less popular [342]. 2 articles have been published in the Scopus database (Q2 – 58% percentile).

Connectivism, digitalization and the use of artificial intelligence are changing the coordinate system of modern education. The modern digital generation of children is updating new theories and technologies of teaching, upbringing and development in pedagogy. The issue of spiritual and moral education and upbringing deserves special attention. In pedagogy, different names for modern pedagogy are being developed – cyberpedagogy, digital pedagogy and digital didactics. They require a new philosophical platform or concept, which is discussed by UN and UNESCO experts. The transformation from classical pedagogy and formal education to the heutagogy and pyragogy of the digital generation, education 3.0 and 4.0, non-formal and informal

education is going deeper. It is necessary to reveal the laws of learning throughout a person's life (not only classical pedagogy for children, andragogy).

2. Review and analysis of global trends in science, examples of cooperation between domestic scientists and foreign scientists and work carried out under contracts with international scientific organizations.

A look into the future up to 2050 in the report of the International Commission on the Futures of Education of UNESCO (2023) [343] highlights the role of the education system in shaping a common world and a shared future. After the COVID-19 pandemic, in the era of escalating military actions in the world, education and science are assigned a special role in creating conditions for the survival of humanity, the ecology of the natural and social environment, and respect for human rights.

It proposes a rethinking of pedagogical approaches and the development of an updated "pedagogy of cooperation and solidarity". The new definition of the goals of education is associated with the implementation of the right *to lifelong education*, uniting people on the basis of "collective efforts and the provision of knowledge, scientific progress and innovation to create *a sustainable future for all*, based *on social, economic and environmental justice*" [343].

The main theses of the report include not only the development of a pedagogy of cooperation and solidarity, but also an emphasis in the curricula on *environmental, intercultural and interdisciplinary learning* for students' access to knowledge and the ability to produce it through the ability to think critically and apply knowledge; *teaching as a collective activity of teachers* in knowledge production and social transformation; strengthening the role of *schools as protected educational facilities and support for social integration, equality, individual and collective well-being; expanding educational opportunities throughout a person's life*.

Achievements of neuroscience are actively promoted in the education system, influencing the learning process. It is emphasized that the development of biotechnology and neuroscience is capable of implementing human engineering in a previously unthinkable way [343].

In general, the analysis of publications of the UN global studies in the field of education, science and culture (UNESCO) shows the following trends: - the search for a relational concept of modern education as opposed to atomistic and individualistic; - issues of gender education and STEM education among girls; - development of conscious reading literacy of children (children understand the meaning of what they read) and digital intelligence of students; - development of recommendations for the use of artificial intelligence by schoolchildren in education; - implementation of a strategy for the health and well-being of children in the education system; - the use of statistics in closing the "blind spots" in the quality of children's education and Big Data for forecasting the development of education, etc.

The concept of paradigmatic relationality in pedagogy will help to understand the connections between different points of view and worldviews [350]. It reveals that relationality recognizes the property of dynamism, change and differentiation through constant immersion and interaction with the wider world; connections between the

human and non-human worlds; understanding that the learning process is inseparable from society. In society, the central social goal is justice and harmony.

Modern pedagogy is associated not with the consumption of information, but with research and co-creation of the teacher and students, living relationships in the world "here and now". "Recognizing relationality in educational practices, processes and methods means rethinking social harmony in such a way as to destroy the fragmentation of disunity, hierarchies, times and places in the search for deeper solidarity and interconnectedness" [350]. UNESCO invites scientists, analysts, and practitioners for dialogue and reflection on the Futures of Education initiative. In 2022, UNESCO published the Strategy for Education for Health and Well-being [344], which implements the UN Sustainable Development Goals. The implementation of such a strategy is possible through interdisciplinary research in the field of education and the transformation of the activities of psychological services in the country's schools. Expected results of the document: (1) students receive sustainable support from school health systems that promote students' physical and mental health and well-being; (2) students receive high-quality gender-transformative CSE (comprehensive sexuality education), including HIV, life skills, families and rights; (3) students have a safe inclusive learning environment free from all forms of violence, bullying, stigma and discrimination [344]. It should be noted that some research areas have already been reflected in national studies and initiatives. However, a comprehensive systemic general approach is required.

Analysis of development and research trends in the field of education by various research centers, global print media, and digital industry giants also allows us to highlight the following trends in research and development in education:

- inclusive education for every student;
- blended learning, gamification, and augmented reality in education, the use of artificial intelligence in education, i.e. the use of immersive technologies - virtual reality (VR), augmented reality (AR), mixed reality (MR) for the learning process, deep understanding, and creative learning;
- social-emotional learning (SEL) to improve students' psychological well-being and academic success, develop life skills, increase self-awareness, communication skills, and make responsible decisions;
- microlearning as the use of video resources, interactive games, quizzes for deep memorization and updating knowledge on subjects;
- data analytics, expanding the role of statistics in decision-making in the field of education, monitoring the quality of education, etc.

Digitalization has led to new opportunities for analytics of people's learning, data visualization and data mining both for the community, organization, country, and individually for the learner himself for informed decision-making and making choices and influencing the success of learning outcomes.

The listed trends (directions) of research and development are actively implemented in the international scientific cooperation of Kazakhstani scientists and teachers with foreign colleagues. Large international projects in the field of education Erasmus+ are being implemented, carried out by a consortium of universities in

Kazakhstan. For example, in the field of medical education, the grant 20212-2024. 618860-EPP-1-2020-1-EL-EPPKA2-CBHE-JP "Professionalization of Bachelor's and Master's Degrees for Strategic Risk and Quality Management in Healthcare Services within the Framework of Open Distance Education in Russia, Kazakhstan, Azerbaijan and Laos" (project coordinators: Khikmetov A.K., Kalmataeva Zh.A. et al.) [345].

Another project ERASMUS-EDU-2023-CBHE-STRAND-1 "Land management, Environment & SoLId-WastE: inside education and business in Central Asia" LESLIE. Project coordinators: Doctor of Physical and Mathematical Sciences, Professor Bolegenova S.A. and Shortanbaeva Zh.K., co-implementers of which are 14 partner organizations from 3 EU countries (Spain, Italy, Cyprus) and 2 Central Asian countries (Kazakhstan and Uzbekistan). Timeframe for implementation – 2023-2026.

Expected results: creation of a Sustainable Land Management Hub in Kazakhstan and Uzbekistan, uniting higher education institutions (HEIs); joint development and implementation of a micro-qualification program in Sustainable Land Management (SLM); creation of a set of didactic tools in digital format that can be integrated as supporting material into the SLM BSc and MSc ONLINE educational programs; integration of educational materials into a single SLM online repository (Toolbox); development of a pilot incubator for future learning, including the use of new educational technologies using the STEHEAM approach to promote and disseminate SLM for university students in 2030.

Management (SLM) will be implemented in Central Asian universities (Kazakhstan and Uzbekistan), updating their current academic offering at the bachelor's and master's levels, while ensuring that the needs of regulators and industries are met in line with the latest and most rigorous international standards [346]. As can be seen from the expected results, the direction of blended learning, microlearning, and digitalization of education is being implemented.

Let us dwell separately on the foreign trend of studying the NEET generation, which can be interpolated to the Kazakhstani reality. NEET is a generation of young people who do not have an education, work and training, which becomes a problem for the quality of life of both these people themselves and society, i.e. an increase in their number reduces the human and social capital of the country, affects the level of education of the state. The NEET population in the EU countries is young people aged 15 to 34, in the OECD - 15-29 years old, in Japan and South Korea - 15-34 years old. Research by foreign scientists shows that the key factors determining whether a young person will become NEET are individual, family and educational characteristics (gender, education, age, parents' work, parents' education). In rural areas, the determining factor is disability and immigrant origin. Young people from disadvantaged families, such as divorced or unemployed parents, are more likely to become the NEET generation, married women and migrant women are also more likely to become NEET, compared to men [347]. The formation of the NEET generation is becoming a pressing scientific problem of interdisciplinary research - economic, social, psychological and pedagogical, political science, requires the attention of Kazakhstani scientists.

3. Analysis of achievements and development trends of leading scientific schools of Kazakhstan and highly developed foreign countries.

In Kazakhstan, since 2010, the training of scientific personnel has been transformed into PhD doctoral studies. In the 2022/2023 academic year, 923 doctoral students studied in pedagogical sciences, of which 296 people were accepted to the 1st year. 221 doctoral students graduated in the 2022/2023 academic year, of which 74 people defended their dissertations, which amounted to 33.5% [329, p. 50] - the highest percentage compared to other branches of science in Kazakhstan.

Kazakhstani pedagogical science is known for its scientific and pedagogical schools, descended from the first Kazakhstani scientists and teachers: S. Balaubayev, T.T. Tazhibayev, A.I. Sembayeva, R. Lemberg, N.D. Khmel, A.P. Seytesheva, V.V. Egorova and others.

Based on the defense of doctoral PhD dissertations in 2023, the following scientific schools in the field of pedagogy and education can be distinguished, which continue the traditions of the above-mentioned scientists and educators: G.Zh. Menlibekova (L.Gumilyov Eurasian National University); L.A. Shkutina (E.Buketov Karaganda University); N.B. Zhienbaeva and N.N. Khan (Abai Kazakh National Pedagogical University); A.S. Magauova (Al-Farabi Kazakh National University), etc.

The study of scientific schools of foreign scientists demonstrates the directions of international research, which involve both doctoral students of the country where the leading universities are located and foreign applicants studying at these universities. Professor Dietrich Benner from Humboldt University of Berlin (Germany) [348-349] with his scientific school examines the issues of didactics, ethical and moral competencies, upbringing and education, as well as non-affirmative action in pedagogy. Director of the Center for Teacher and Pedagogical Research at the Institute of Education at UCL (UK), Professor Caroline Daly [350] with doctoral students examines the role of digital technologies in professional training, school factors of mentoring in education that influence the development of teachers. Professor Amado Padilla from Stanford University (USA) [351] with doctoral students studies the acculturation of students, the academic success of immigrant adolescents, the connections between bicultural competence and racial identity with motivation to learn, and other issues of equality in education.

Priority VIII – "Research in the field of social and human sciences"

1. Review and analysis of the achievements of Kazakhstani science (the most significant results of the scientific and (or) scientific and technical sphere, implemented developments).

In 2023, Kazakhstan demonstrates significant achievements in the field of social sciences and humanities, emphasizing the importance of the country's intellectual and cultural development. In recent years, social sciences and humanities have demonstrated several key trends that reflect both the global challenges of our time and the specific interests of the academic community in Kazakhstan:

1. Interdisciplinary approach. The desire to integrate knowledge from various fields, such as psychology, sociology, economics and cultural studies, allows for a deeper analysis of social phenomena and the development of comprehensive solutions to modern problems.

2. Digitalization of research. The introduction of digital technologies such as big data and artificial intelligence into research methods in the social sciences makes it possible to analyze large volumes of data to obtain new knowledge about social processes and human behavior.

3. Focus on the impact of global challenges on Kazakhstan. Research in the social sciences is increasingly focused on addressing global issues in the context of their impact on the situation in Kazakhstan, including climate change, migration, inequality and sustainable development.

4. Cultural diversity and inclusion. The importance of taking into account cultural diversity and promoting inclusion is becoming a central theme in social research. This includes the study of minority rights and opportunities, gender studies, and social justice analysis.

5. Ethical and methodological issues. Social research is increasingly faced with the need to reflect on the ethical aspects of its work, especially in light of the use of personal data and increasing requirements for confidentiality and consent to participate in research.

These trends shape the modern face of the social sciences and humanities in Kazakhstan and determine the directions of future research.

From 2021 to 2023, a number of significant research projects were implemented within the framework of the strategy for the development of social sciences and humanities. All projects implemented during this period focused on priority areas related to the study of ideological and ideological foundations, socio-cultural processes, and socio-political technologies.

Section "Research in the Humanities"

Philosophical research. In 2023, Kazakh scientists conducted philosophical research in various areas, covering the history of Kazakh and world philosophy; the study of Kazakh society in the context of global political and digital transformations; the study of mass consciousness in the context of ideological processes and risks. An important place is occupied by religious studies conducted at the intersection of history, philosophy, and the problem of external influences on the confessional situation in the Republic of Kazakhstan. Geopolitical processes and the problem of the threat of religious extremism give special emphasis to the importance of studying the key problems of Islam and religion as a special social institution. In 2023, the Institute of Philosophy, Political Science and Religious Studies of the KN MNVO RK successfully completed the scientific program "Social modernization of Kazakhstani society: ideological and ideological foundations, conceptual models, socio-cultural processes, socio-political technologies", which was implemented under the guidance of Doctor of Philosophy, Professor Sagikyzy A. in the priority area of "Research in the field of social and humanitarian sciences". In addition, the implementation of such grant research projects as "Processes of religiozization in Kazakhstan: specifics,

trends, impact on the development of society and human capital" under the guidance of Burova E.E., "Secular and religious values in modern Kazakhstan: interaction and influence on the policy of the Republic of Kazakhstan in the field of religion" under the guidance of Kosichenko A.G. and "Religious aspects of traditions and innovations in Kazakhstan: past, present and prospects" under the guidance of Satershinov B.M. was completed. Based on the results of the projects, an interdisciplinary analysis of the influence of religiosity on Kazakhstani society was carried out, which made it possible to analyze the role of religion in the processes of socio-cultural changes in Kazakhstan. Particular attention was paid to supporting young scientists. The project "The Impact of Digitalization on the Political Culture of Kazakhstani Youth" under the leadership of N.I. Aitymbetov highlighted how digital technologies influence the political preferences of young people.

History of Kazakh philosophy. The study of Kazakh philosophy is carried out within the framework of the study of ideological and theoretical-methodological problems of Kazakh culture. Studies have been conducted on the philosophical dialogue between the East and the West through the prism of the activities of historical figures, one of the most significant of which is al-Farabi. The correlation between the spiritual heritage of historical figures of the Turkic world and Western philosophy allows us to understand the mutual enrichment of the intellectual sphere and leads to the idea of mutual understanding and agreement in the modern Kazakh socio-cultural context [352]. In the series "Personalities of the Great Steppe", published within the framework of the state program "Gylymi Kazyna", a collection of articles was published dedicated to the poet and thinker, collector of Kazakh folklore Mashyur Zhusip Kopeyev, his life and work, analysis of his philosophical views [353]. Social philosophy. An important area of domestic philosophy is the study of issues of social modernization of Kazakhstani society in its various aspects, such as public policy, the relationship between secular and religious values, and the formation of human capital. Such work is carried out by Kazakhstani scientists Seidumanov S.T., Sagikyzy A.S. and others. The works of Kazakhstani scientists raise methodological problems of studying social development, including issues of the relationship between global trends and national specifics [354-356].

Religious studies. No less important in the context of the multi-confessional nature of Kazakhstani society are scientific studies of the religious situation. In 2021-2023, the Institute of Philosophy of Social and Political Sciences conducted systemic studies on such issues as: processes of religiozization in Kazakhstan: specifics, trends, impact on the development of society and human capital; secular and religious values in modern Kazakhstan: interaction and influence on the policy of the Republic of Kazakhstan in the field of religion; religious aspects of traditions and innovations in Kazakhstan: past, present and prospects [357-359].

Islamic studies. In the context of the fact that the republic is a secular state, which pursues a balanced policy of forming a single nation based on the principle of citizenship, as President K.K. Tokayev has repeatedly stated, scientific research in the field of Islam, which is professed by the majority of citizens, is important [360]. Leading researcher of the Institute of Philosophy, Political Science and Religious

Studies Altaykyzy A. in 2022-2024 is researching the topic "The phenomenon of "halal" and the formation of environmental consciousness in secular states: a comparative analysis". The purpose of the study is to reveal the meaning of the phenomenon of "halal" in the interdisciplinary discourse of multicultural secular Kazakhstan, its spiritual, moral, environmental and rational meaning [361].

The staff of the Institute of Historical Research of Kazakhstan Sikhimbayeva D.A., Seytakhmetova N.L., Toktarbekova L.N., Turganbayeva Zh.Zh. are also engaged in a whole range of problems covering: Islamization in the context of nation-building in Kazakhstan, integration and disintegration trends; Islamic tolerance in the context of interfaith dialogue in Kazakhstani society; gender equality in Islam: Islamic feminism and traditionalism; Islamic identity in the realities of Kazakhstan: problems of interfaith dialogue and consolidation.

Historical research. The main priority of the historical science of Kazakhstan in 2023 was the further development of the concept of history in the framework of the preparation of an academic 7-volume work. The publication being prepared should exclude conceptually outdated approaches to national history, introduce new archival materials and historiographic sources into scientific circulation, which will significantly change the concept of historical consciousness.

Domestic scientists under the leadership of Azhigali S.E. the study of the methodology of field ethnoarchaeological (ethnoarchitectural) studies of monuments of the steppe zone of Kazakhstan and in the diaspora area was continued. As part of this work, a card and electronic card index on monument studies and methods of studying monuments of Kazakhstan is being formed, a corresponding bank of photocopies of text and illustrative materials has been created.

The study of D.A. Kunayev's contribution to the socio-economic development of Kazakhstan and the preservation of the territorial integrity of the republic is planned for 2022-2024. A complete scientific reconstruction of the life and work of the famous statesman D.A. Kunayev is being carried out, based on the involvement of archival, written and folklore sources.

Archaeological research. Work continues on identifying and preserving monuments of historical and cultural heritage, comparative analysis of cultural concepts of the material culture of Kazakhstan and Central Asia. All this makes it possible not only to emphasize the uniqueness of the archaeological heritage of Kazakhstan, but also to substantiate the inclusion of this heritage in the global historical and cultural process, in particular the Turkic area of material and spiritual cultures. Domestic scientists conducted archaeological research of the ancient and medieval Almaty; study of pottery in Southern Kazakhstan and adjacent territories (Uzbekistan, Kyrgyzstan and Tajikistan); study of the archaeological complex of Kokentau and the monuments of historical and cultural heritage included in it.

Oriental studies. The Institute of Oriental Studies named after R.B. Suleimenov is engaged in the study of regional and transnational identity, which is a Turkic-Sogdian spiritual symbiosis. Within the framework of Islamic civilization, a unique model of interaction between cultures has developed, the study of which at the present stage is an important factor in foreign policy interaction in the Central Asian region.

An important area is the study of foreign archives containing valuable documentary, cartographic and other information. The following projects are dedicated to this: "Historical and Cultural Heritage of Kazakhstan and Central Asia in Foreign Archives" (2022-2024) and "Ancient and Medieval History, Culture, and International Relations of the Turkic World and Kazakhstan Based on Sources and Archives of the Vatican and Other European Countries" (2023-2025). Of great importance is the study of the current regional situation in Central Asia, which, due to the geopolitical crisis, has taken on a new meaning and development. The direction of these geopolitical communications that deserves attention is the ties between Central Asia and China, as the largest Asian player in the international arena.

Section "Research in the field of social sciences"

Economic research. In 2023, the Institute of Economics of the KN MNVO RK completed the implementation of the scientific program “Study of factors, features and dynamics of demographic processes, migration, urbanization in Kazakhstan, development of digital maps and forecasts” under the supervision of Doctor of Economics Alzhanova F.G. [362]. Based on the results of the implementation of the scientific program for the period 2021-2023, groups of regions with different activity of demographic processes were identified, a demographic development forecast for Kazakhstan and its regions until 2050 was compiled. Recommendations were developed for the adaptation and integration of migrants into the local community of the recipient regions, which is an important condition for the territorial mobility of the population and the reduction of socio-economic risks associated with migration.

Under the supervision of Panzabekova A.Zh. In the Institute of Economics, within the framework of the project "Socio-cultural factors of corruption and the concept of forming an anti-corruption culture in Kazakhstani society", theoretical and methodological approaches to the analysis of corruption in Kazakhstan were studied with an emphasis on socio-cultural factors. The Concept of anti-corruption culture was developed, which provides for measures to strengthen social institutions and promote value orientations in society.

An important event was the publication of the books by academician Orazaly Sabden "Kazakhstannyn sara zholy", "World, Turkic civilization and the future of Kazakhstan". It is necessary to note the work on improving the qualifications of research staff and young scientists. In particular, three employees of the Institute were awarded a PhD degree, two employees were awarded the title of associate professor. The Council of Young Scientists of the Institute held methodological seminars in Zertteulab and Oi-club, where researchers reported and discussed the problems of the crypto industry, the use of blockchain technology in the economy, environmental factors of the Aral Sea and oncological diseases, searching for journals in the international bibliometric systems Scopus and Web of Science, structuring dissertations.

Also, courses were held for employees on studying the IBM SPSS Statistics statistical data analysis program. As part of the study "Digital Transformation of Service Enterprises in Kazakhstan" under the supervision of K. Kirdasinova at L.N. Gumilyov Eurasian National University, a methodological approach to assessing the

readiness of enterprises for digital transformation was developed, conditions and factors of influence were studied, including the COVID-19 pandemic. Three forecast scenarios for development until 2030 and a new business model "Digital Platform "Services" aimed at enterprises with different potential for transformation are proposed. New mechanisms for stimulating digital transformation are also proposed, which includes an economic and mathematical model and the development of an ecosystem to support enterprises.

At the Institute of Economic Research, under the supervision of B.D. Khusainov, an analysis of the determinants of the quality of economic growth was conducted using a Bayesian econometric model adapted to the conditions of Kazakhstan. The study covered the analysis of the dynamics and quality of economic growth, identifying the key factors in the development of the national economy in different periods. The scientific novelty of the work lies in the development of a methodology for quantitatively assessing the quality of economic growth and formulating practical proposals for future development.

Political science research. At Al-Farabi Kazakh National University, under the supervision of Doctor of Political Sciences, Professor G.O. Nasimova, a project was implemented on the topic "Protest Potential in Kazakhstan: Features, Factors and Trends". The project analyzed the protest potential in Kazakhstan, including socio-economic and political factors influencing the level of protest activity of the population. The study covers an assessment of the social well-being of citizens, trust in the media and the political situation, as well as identifying regional features of protests and forecasting their dynamics. The work provides a methodology for assessing protest activity and a socio-demographic portrait of citizens prone to protests, which helps to understand current and future trends in protest behavior in the country. Also, at the Al-Farabi Kazakh National University, under the leadership of F. T. Kukeeva, within the framework of the project "The Impact of Power Transit on the Foreign Policy of the Republic of Kazakhstan: New Opportunities and New Challenges", the impact of power transit on Kazakhstan's foreign policy was studied, taking into account historical, economic and political conditions. The work analyzes the criteria for choosing foreign policy models and mechanisms for their implementation during the transit period, comparing them with examples of other Central Asian states.

At the Institute of Philosophy, Political Science and Religious Studies of the KN MNVO RK, under the leadership of Kadyrzhanov R.K., the project "Cultural Foundations of National Construction in Kazakhstan" was implemented. The research group analyzed the cultural foundations of national construction in Kazakhstan. The study revealed the influence of cultural and linguistic heterogeneity on the development of the state, especially through the opposition "Kazakhs-Kazakhstanis". Linguistic and ethnic identities, practices and politics of historical memory were considered, as well as an assessment of the influence of education and information systems on cultural homogenization, identifying the prospects for integrating the Kazakh language into the cultural life of various groups of the population.

At Toraigyrov University, under the leadership of Anesova A.Zh., research was completed on the project "The Problem of Forming a Value-Based National Picture of

the World in the Context of Modernization of Society and the State (Based on Kazakhstan's Everyday Political Discourse)"; the influence of text and personal factors on the creation of Internet comments on political texts in Kazakhstan was analyzed. Based on text-derivatological analysis, text-generation strategies were identified, including the use of keywords, emotionality and associativity. The results helped to reconstruct the national picture of the world through mythologemes, specific vocabulary and traditional expressions, giving the comments a unique national flavor.

2. Review and analysis of global trends in science, examples of cooperation between domestic scientists and foreign scientists and work carried out under contracts with international scientific organizations

Today, the social sciences and humanities are going through a period of significant changes caused by both internal disciplinary dynamics and external social, technological and political factors. These changes lead to the emergence of new research areas and methods.

One of the central trends is the interdisciplinary approach. Researchers are increasingly moving beyond the traditional boundaries of disciplines to more fully answer complex questions facing society. For example, economics is intertwined with psychology in the field of behavioral economics, and historical research uses big data methods to analyze historical processes.

Another significant aspect is the increasing focus on global studies. In the era of globalization, the social sciences and humanities are increasingly asking questions related to the interaction of different cultures, economies and political systems. This leads to a deeper understanding of the processes taking place in different parts of the world and to the analysis of global problems such as climate change, migration, international conflicts and the world economy.

Inclusivity and multiculturalism are two more key topics in modern social sciences. Research is becoming more inclusive, paying attention to minority voices and exploring issues of social justice. This includes gender analysis, human rights research, and policies for marginalized groups.

Technological innovations are also having a huge impact on the social sciences and humanities. The use of artificial intelligence and machine learning in big data analysis opens up new possibilities for understanding complex social processes and behavioral patterns. Digital humanities, which uses algorithmic analysis of texts, images, and data, is becoming an important tool in the hands of researchers.

Research ethics is becoming an important aspect of modern academic activity. Increased attention to ethical issues is associated with an understanding of the potential impact of research on society. Issues of data privacy, consent to participate in research, and the impact on vulnerable groups are becoming central to academic debates.

At the same time, rising geopolitical tensions are expected to stimulate demand for research in the social sciences and humanities in the near future. Geopolitical tensions are caused by conflicts arising from a variety of factors, including territorial disputes, ideological differences, competition for resources, economic interests, historical issues, and power struggles. This situation will increase the demand for scientific knowledge and expertise in political risk assessment, international relations,

conflict resolution, cultural and historical context analysis, and human rights protection.

Public funding and policy have become a key trend shaping the social sciences and humanities market landscape and, in part, shaping the research agenda in this field. For example, in 2021, the European Commission launched Horizon Europe, a major seven-year, €95.5 billion ($116.5 billion) research and innovation funding programme from 2021 to 2027. The programme aims to address global challenges, including climate change and sustainable development, and promote competitiveness and growth in Europe.

These trends reflect profound changes in the social sciences and humanities, which continue to evolve and adapt to a changing world.

In 2023, the Institute of Philosophy, Political Science and Religious Studies signed a memorandum with Shenzhen University (PRC), within the framework of which it is planned to implement joint scientific research, including within the framework of projects on digitalization and development of the Asia-Europe transport corridor. It was decided to create a joint "Silk Road Center" to monitor Kazakh-Chinese relations.

At the initiative of the International Kazakh-Turkish University named after Khoja Ahmed Yasawi, significant events were held in 2023 to develop cooperation between Turkic-speaking countries in the fields of science, education, culture and sports. In particular, on September 20-23, 2023, with the support of the Ministry of Science and Higher Education of the Republic of Kazakhstan and the Akimat of the Turkestan Region, the VII World Congress of Mathematicians of the Turkic World was held, organized by the Turkic World Mathematical Society (TWMS) and the International Mathematical University of Technology named after H.A. Yasawi. The Congress brought together more than 500 mathematicians from 20 countries. At the plenary session, 405 reports were presented by world-famous scientists from Turkey, Azerbaijan, Turkmenistan, Uzbekistan, Kyrgyzstan, Russia and Kazakhstan on 10 scientific areas of mathematics. On October 17-20, 2023, the traditional X Turkological Congress on the theme "Modern Turkology: Scientific Paradigms and Interdisciplinary Nature" was held. 168 representatives from Azerbaijan, Bosnia and Herzegovina, Iran, Kazakhstan, Kyrgyzstan, Uzbekistan, Russia, Turkmenistan, Turkey, Chile took part in the congress. On November 23-24, 2023, the I International Congress of Biology of the Turkic World was held on the initiative of the Ministry of Higher Education of the Republic of Kazakhstan. More than 150 scientists from 24 countries took part in the congress: Turkey, Kyrgyzstan, Uzbekistan, Greece, Japan, India, etc.

AlmaU signed a memorandum with Erzincan Binali Yildirim University (Turkey) on cooperation and assistance in the academic and administrative fields in order to increase educational activity and improve the quality of educational programs at all levels. AlmaU School of Politics and Law participates in the work of the Central Asian Research Center for Regulation of Artificial Intelligence (CARCAIR), studying the issues of legal regulation of artificial intelligence technology.

The Center for Sociological Research and Social Engineering of Al-Farabi KazNU together with the Hong Kong Polytechnic University (PolyU) are implementing a project to study the needs of children, youth and their families living in poverty in Kazakhstan. This project contributes to achieving the Sustainable Development Goal #1 "End poverty in all its forms everywhere". The project manager on behalf of Al-Farabi KazNU is Doctor of Sociology, Professor G.S. Abdiraimova, and on behalf of PolyU - Associate Professor of Applied Social Sciences Ku Hock Boon. The project contributes to the development of recommendations for improving social policy in Kazakhstan and Central Asian countries. As part of the project, students of Al-Farabi KazNU undergo practical training at three social service centers in Almaty: Rehabilitation Center "Association of Parents of Disabled Children", Public Foundation "Center for Social and Psychological Rehabilitation and Adaptation for Women and Children "Rodnik" and Children's Home "Ark".

Since February 2023, the Center for Internationalization of Education of the Kazakh National Women's Pedagogical University has been developing joint educational programs for master's and doctoral studies with the universities of the University of Cambridge, University of Sussex, Department of Physics, The Cavendish Laboratory, Michigan State University. Also, national educational programs 7M01104 - "Research in Education" and 7M01103 - "Management and Leadership in Education" were developed jointly with the University of Applied Sciences and Nazarbayev University. Also, within the framework of cooperation with the University of Sussex, a scientific seminar-training "Development of Research Skills in the Field of International Education" was held from July 17 to 25, 2023 with the participation of the faculty and doctoral students of the university. On the platform of the Kazakh National Women's Pedagogical University, together with the University of Niğde Omer Halisdemir, the "Niğde Technopark Center" was opened. The center's employees are implementing the project "Teaching the Kazakh language through digital resources based on the national brand." The center's activities are aimed at expanding the possibilities for commercializing the results of scientific work, for which acceleration programs are being implemented for the faculty and students of the Kazakh National Women's Pedagogical University.

3. Analysis of achievements and development trends of leading scientific schools of Kazakhstan and highly developed foreign countries

The scientific division of the IT giant Google Research focused on developments related to the development of artificial intelligence in 2023. Work on optimizing algorithms and improving language models was strengthened by the Search Generative Experience (SGE) technology, which uses large language models (LLM) to rethink how to organize information and how to help people navigate it, creating a more flexible conversational interaction model for our core search product. This work expanded the capabilities of search engines, primarily focused on information retrieval, into something much more - capable of searching, synthesizing, creatively generating and continuing previous searches - while continuing to serve as a point of connection between users and the web content they are looking for [363].

In 2023, significant archaeological discoveries were made. For example, researchers from Oxford discovered the footprints of two adults and a child, left in the prehistoric era, near the White Sands site in New Mexico (USA). Analysis of quartz grains and pollen showed that they made this journey between 21,000 and 23,000 years ago – thousands of years before humans were thought to have reached America. This has prompted a reconsideration of the idea that humans first arrived in America 16,000 to 14,000 years ago, crossing a land bridge between Siberia and Alaska. The new dates mean that humans were already living in New Mexico at the height of the last ice age. If the dates of the footprints are correct, this discovery will become a new well-known fact [364]. An important area of global science is the study of human cognitive abilities. Scientists from the Department of Psychology at the University of California conducted an analysis of behavioral representational similarity, which showed how episodic learning is influenced by and changes semantic memory. The authors of the study show that episodic learning systematically shapes semantic space depending on how learners interact with the material and the strength of prior associations [365].

In 2023, the Institute of Philosophy, Political Science and Religious Studies successfully completed a research program dedicated to the social modernization of Kazakhstani society, under the supervision of Professor Sagikyzy A. The program included an analysis of ideological foundations, conceptual models and socio-cultural processes, as well as the development of socio-political technologies. At the same time, grant projects studying religious trends and their impact on society were completed, under the supervision of Burova E.E., Kosichenko A.G. and Satershinov B.M. These studies helped to better understand the role of religion in socio-cultural changes in Kazakhstan. Attention was also paid to supporting young scientists, in particular, to studying the impact of digitalization on the political culture of young people.

In 2023, the main priority of the historical science of Kazakhstan was the preparation of a 7-volume work on the history of the country, the purpose of which is to update the concept of national history, introduce new archival data and historiographic sources. Scientists under the leadership of Azhigali S.E. conducted ethnoarchaeological research of the steppe zones and the diaspora, creating card indexes and a bank of photocopies for the study of monuments. Archaeological work is aimed at demonstrating the historical and cultural connection of the Turkic and Kazakh cultures, as well as preserving and analyzing the cultural heritage of Kazakhstan and Central Asia. Foreign archives are also being studied, which are important for understanding the historical and cultural heritage of the region. Significant results have been achieved in the field of so-called university science, with important projects being implemented in both national and regional universities. In 2023, at the L.N. Gumilyov Eurasian National University, under the leadership of K.A. Kirdasinova, a study on the topic "Digital transformation of service enterprises in Kazakhstan" was successfully completed. The project developed a methodological approach to assessing the readiness of enterprises for digital transformation, and

studied the influencing conditions and factors, including the impact of the COVID-19 pandemic.

Significant political science research was completed at Al-Farabi Kazakh National University. Under the leadership of Doctor of Political Science, Professor G.O. Nasimova, a project was implemented analyzing the protest potential in Kazakhstan. The study covered an assessment of the social well-being of citizens, trust in the media and the political situation, identifying regional features of the protests and predicting their dynamics. Also, under the leadership of F.T. Kukeeva, a project was completed examining the impact of the transit of power on Kazakhstan's foreign policy, where historical, economic and political conditions were analyzed and recommendations were proposed for the development of an effective foreign policy strategy.

At Toraigyrov University, under the supervision of A. Zh. Anesova, a study on the topic of "The Problem of Forming a National Worldview of Values in the Context of Modernization of Society and the State" was successfully completed. The study analyzed the influence of text and personal factors on the creation of online comments on political texts in Kazakhstan. Based on text-derivatological analysis, text generation strategies were identified, which helped to reconstruct the national worldview through mythologemes, specific vocabulary and traditional expressions, giving the comments a unique national flavor.

Priority IX – "Sustainable development of the agro-industrial complex and safety of agricultural products

1. Review and analysis of the achievements of Kazakhstani science (the most significant results of the scientific and (or) scientific and technical sphere, implemented developments)

The following significant results were obtained for the programs and projects completed in 2023.

Development of intensive livestock farming. State support has intensified the development of beef cattle breeding, ensured its intensification, and the formation of a production base. Increased interest in beef cattle breeding in recent years has increased the number of specialized beef cattle, however, the growth rate is insufficient. Therefore, in the coming years, the development of the domestic beef cattle breeding industry is one of the strategic directions. Improving the genetic potential of cattle, specialized meat breeds of domestic selection should ensure an increase in the production of domestic breeding products every year by 5%.

On beef cattle breeding. Within the framework of NTP *BR10764981 "Development of technologies for effective management of the selection process for the preservation and improvement of genetic resources in beef cattle breeding" 2021-2023. (performer - NJSC "West Kazakhstan Agrarian and Technical University named after Zhangir Khan")* scientifically and economically sound breeding programs for improving the economically useful traits of the Kazakh white-headed, Auliekol,

Hereford, Aberdeen Angus, Kalmyk breeds have been developed, which allow preserving the existing gene pool while observing the recommended measures.

New breeding lines of the Kazakh white-headed cattle breed have been created and tested: Kunduza 9481 Pilot 17433 Samuryk 100195791, Podarok 75/045, for which patents for breeding achievements have been received. In addition, the results of scientific research have been published in an international journal with Q2.

Within the framework of the scientific project AP09259133 "*Study of the microbiome of the gastrointestinal tract of cattle in order to reduce greenhouse gas emissions" (implemented by the Kazakh Research Institute of Animal Husbandry and Forage Production)*, when comparing beef cattle breeds (Kazakh white-headed, Aberdeen Angus, Hereford) in the republic as a whole, the lowest concentration of archaea in the intestinal contents was found in the Kazakh white-headed breed. At the same time, animals of the Kazakh white-headed breed have a certain advantage over other breeds in terms of the content of bacteria in the intestinal contents.

On dairy cattle breeding. Within the framework of the NTP for 2021-2023. The research on the development of technologies for keeping, feeding, growing and reproduction in dairy cattle breeding based on the use of adapted resource-energy-saving and digital technologies for various natural and climatic zones of Kazakhstan has been completed under the research project of the Ministry of Agriculture of the Republic of Kazakhstan BR10764965 "*Development of technologies for keeping, feeding, growing and reproduction in dairy cattle breeding based on the use of adapted resource-energy-saving and digital technologies for various natural and climatic zones of Kazakhstan" (executor - NAO "KATRU named after S. Seifullin"*). Automatic equipment for stress-free determination of the live weight of heifers using RFID technology has been created, a system for reading data from RFID tags has been implemented to identify specific animals during weighing. The scales are calibrated taking into account standards and requirements for measurement accuracy. Based on the results of scientific research, 2 articles have been published in international journals since Q3.

On poultry farming. As part of applied scientific research in the field of agro-industrial complex 2021-2023. under the scientific and technical program BR10765039 "*Development of technologies for effective management of the selection process in poultry farming" (executor - NAO "West Kazakhstan Agrarian and Technical University named after Zhangir Khan*"), a two-line cross "Ansar" was created with a reduced fat content in the carcass, a high rate of live weight gain of young animals at the age of 7 weeks - 3.249 kg, with feed costs per 1 kg of live weight gain of 2.8 kg, with the yield of ducklings from a parent pair for 40 weeks of productivity at the level of 142 heads.

Patents were received for the invention "Method for obtaining a composite mineral feed additive for poultry" and breeding achievements: Cross of ducks "Ansar"; "Paternal line A1"; "Maternal line of ducks A2".

On horse breeding. Within the framework of the scientific project AP14870614 "Genetic marking of productive qualities of the Kazakh horse of the Jabe type based on SNP genotyping with broad genome coverage" 2022-2024 (implemented by the

West Kazakhstan Agrarian and Technical University named after Zhangir Khan), the genetic diversity of horses of the Kazakh breed of the Jabe type was studied. The results obtained showed the absence of a pronounced genetic structure at the population level. The entire studied sample of Jabe horses represents a more or less homogeneous gene pool with a moderate level of individual variability [366].

Patents have been received for breeding achievements: the Doskuren 83-85 [367] and Zamantory 69-84 [368] stud lines of the Kushum breed, the Zhanibek intra-breed type of the Kushum breed [369], the Adai riding intra-breed type of the Kazakh horse [370], the Rattory-60 stud line of the Adai type of the Kazakh breed [371], the Bugabay kiik konyr-98 [372] and Manap sur-93 [373] stud lines of the Adai offspring of the Kazakh horse, the Mangystau intra-breed productive type of the Adai offspring of the Kazakh horse [374]. An article has been published in the international journal Q1.

Within the framework of the scientific project *AP14869181 "Research of the ecogenomics of the microbiome of the Kazakh horse breed using the NGS sequencing method" 2022-2024 (implemented by the Kazakh National Agrarian Research University)*. High-throughput metagenomic sequencing of 16S rRNA was carried out on DNA isolated from freshly excreted feces and nasopharyngeal swabs taken from horses from different regions of Kazakhstan [375-376].

In the camel breeding field. Within the framework of the event "Conducting genotyping of different species of camels and creating an information database of genetic resources of camels in Kazakhstan", a bioinformatics analysis was carried out in order to compare SNP genotyping data for camels of the Bactrian species of the Kazakh breed, dromedaries of the Arvana breed and hybrids. A principal component analysis (PCA) was conducted, which showed that the studied two-humped and one-humped camels are clearly separated from each other. [377].

Ensuring veterinary safety. Within the framework of the scientific and technological program "*Study the epizootological characteristics of the country's territory for especially dangerous diseases and develop veterinary and sanitary measures to improve their effectiveness" 2021-2023. (executor - Kazakh Research Veterinary Institute LLP)* the epizootological characteristics of the country's territory over the past 10 years for especially dangerous animal diseases were determined, the current epizootic situation was studied (anthrax, foot-and-mouth disease, lumpy skin disease, rabies, pasteurellosis, leptospirosis, listeriosis, infectious rhinotracheitis and viral diarrhea, emphysematous carbuncle, camel plague, highly pathogenic avian influenza, equine rhinopneumonia, tuberculosis, glanders in horses, etc.) and parasitic diseases, including those dangerous to humans (echinococcosis of carnivores, canine taeniasis, opisthorchiasis in fish).

Zoning and regionalization of the territory of the Republic of Kazakhstan were carried out according to the degree of intensity of the epizootic situation for the above diseases.

As a result of the implementation of the scientific and technological program *"Developing and proposing for production means and methods for diagnostics, disease prevention, therapy of infected animals and disinfection of soil anthrax foci"*

2021-2023 (executor - Kazakh Scientific Research Veterinary Institute LLP), 8 vaccines have been developed for the prevention of especially dangerous animal diseases (foot-and-mouth disease, camel pox, equine lymphangitis, animal necrobacteriosis, equine rhinopneumonia, equine influenza, equine myt, Rhodococcus equine); 13 diagnosticums (for the diagnosis of bird influenza, bovine leukemia, brucellosis, Newcastle disease, infectious bovine keratoconjunctivitis, anthrax, equine helicobacteriosis, Rhodococcus equine, equine myt, INAN, equine and camel trypanosomiasis, equine influenza); 2 medicinal products (against streptococcosis, necrobacteriosis of animals); methods and schemes for disinfection and elimination of soil anthrax foci.

Under the commercialization project "*Organization of production of highly effective anthelmintic drugs and implementation of scientifically based measures for the devastation of zoonotic and most pathogenic invasions among domestic and wild animals in natural biocenoses" (executor - Kazakh Research Veterinary Institute LLP*), for the first time in the Republic of Kazakhstan, industrial production of various antiparasitic drugs has been established, which are widely used in veterinary practice.

A Dossier on foot-and-mouth disease and plague of small ruminants and a self-declaration on HPAI have been compiled to obtain the status of well-being of the territory of the Republic of Kazakhstan.

For the period 2021-2023, 8 veterinary drugs of the Republic of Kazakhstan were registered in the State Register.

The results obtained within the framework of the scientific and technical program BR10764944 "Development of methods for analytical control and monitoring of food safety" (executor - NAO "KATIU named after S. Seifullin", manager - Bulashev A.K.): for the first time, environmental monitoring of the safety and quality of fish in the reservoirs of Central, Northern Kazakhstan and the West Kazakhstan region was carried out and new methods for veterinary and sanitary assessment of fish and fish products were proposed.

In 2023, scientists published 5 articles in highly cited international journals in Q1 and Q2 journals, received 5 patents.

Intensive farming and crop production

increasing the productivity of pastures. Within the framework of the NTP BR10764915 "Development of new technologies for the restoration and rational use of pastures (use of pasture resources)" (implemented by the NAO "West Kazakhstan Agrarian and Technical University named after Zhangir Khan"), studies have been completed, as a result of which results were obtained on the restoration and rational use of pastures in various natural and climatic zones of the Republic of Kazakhstan. The economic effect of the program is aimed at increasing production profitability by 15-20%. Improvements to degraded areas will increase pasture productivity by 25%. As a result of the introduction of new technologies, the productivity of hayfields will increase by 50%, pastures - up to 30%. The expected content of digestible protein in green fodder is at least 60-65 g / kg of feed, in the grain of forage crops - 110-120 g / kg of feed; exchange energy in green fodder 6.7-8.5 MJ, in grain of forage crops 10.50-11.5 MJ. The research results were implemented in hayfields and pastures of

various natural and climatic zones of the Republic of Kazakhstan on an area of 1,483 hectares.

In 2023, the research results were published in articles in 5 cited international journals Q1 and Q2, 5 patents were received.

In the field of farming systems and modern technologies for cultivating agricultural crops

Within the framework of NTP BR10764908 "*Develop a farming system for cultivating agricultural crops (grain, legumes, oilseeds and industrial crops) using elements of cultivation technology, differentiated nutrition, plant protection products and equipment for profitable production based on a comparative study of various cultivation technologies for the regions of Kazakhstan" (executor - LLP "KazNII of Agriculture and Plant Growing"*), a technological system for growing safflower, oil flax, spring barley based on the intensification of soil cultivation and sowing systems, the use of mineral fertilizers, plant growth and development stimulants, a pea-oat mixture for rainfed conditions of the southeast of Kazakhstan has been developed.

Within the framework of the scientific and technological program "*Development and implementation of soybean cultivation technology using biologization means, ensuring increased yields and environmentally friendly products" (implemented by the Kazakh National Agrarian Research University*), the annual use of biofertilizers and biopreparations ensured an increase in total humus by 0.03-0.04%, mobile forms of NO3, P2O5 and K2O by 4.5-11.2; 7.8-11.5 and 3.5-12.6 mg/kg, respectively. In these same variants, compared to the control, an increase in the total number of bacteria (11.2×10 21.6×106 CFU/g of soil) and mycelial fungi (2.2×103 to 16.5×103 CFU/g of soil) was noted. The highest soybean yield was obtained when treated with HansePlant - 40.6 c/ha, slightly lower than 39.5 and 38.7 c/ha (BioEcoGum and Agroflorin).

To develop resource-saving technologies for cultivating promising leguminous crops under the scientific and technological program "*Develop and implement energy-saving varietal technology for cultivating promising varieties of leguminous crops (chickpeas, lentils, peas) in drylands of the southeast of Kazakhstan" (executor - NAO "Kazakh National Agrarian Research University*"), agrobiological features of growth and development of promising leguminous crops, such as peas, chickpeas and lentils and their new varieties, were studied, optimal parameters of the main elements of varietal technology (row spacing, seeding rate, use of a complete scheme of liquid microfertilizers) and their impact on grain yield were determined.

As a result of research under NTP BR10764908 "*Develop a farming system for cultivating agricultural crops (grain, leguminous, oilseed and industrial crops) using elements of cultivation technology, differentiated nutrition, plant protection products and equipment for profitable production based on a comparative study of various cultivation technologies for the regions of Kazakhstan" (executor - A.I. Barayev Scientific and Production Center of Grain Farming LLC*), scientific foundations have been developed for the intensification of farming systems for the agro-ecological, soil and hydromodular zones of the country, control of erosion processes, minimization of mechanical tillage, diversification and intensification of the structure of crops, plant nutrition, etc.

According to NTP BR10865093 "*Development and scientific substantiation of technical and technological parameters for the adaptation of space sensing and precision farming technologies to current production tasks of agricultural entities and the formation of a reference database necessary for this" (executor - A.I. Barayev Scientific and Production Center for Grain Farming LLC*), a model for managing the production of crop products has been developed in the form of an information and reference program based on available software using fertility models, biocenosis productivity management modules, GIS technologies, and plant development monitoring for the Akmola, Kostanay, and North Kazakhstan regions.

Within the framework of the NTP BR10865099 "*Construction of a decision-making system for the production of the main types of agricultural crops based on the adaptation of the DSSAT model of growth and development of agricultural crops, an integrated management system for livestock production based on Smart technologies with the formation of an information base of scientific and technical documentation on agro-technologies for entities of the agro-industrial complex in order to create Smart systems in agriculture" (executor - NAO "Kazakh Agrotechnical Research University named after S. Seifullin*"), for the first time in Kazakhstan, the adaptation of the DSSAT CSM simulation model was carried out to simulate the production process of agricultural crops (spring wheat, spring triticale, oilseed flax, peas, fodder millet, sunflower hybrid) in the conditions of Northern and Central Kazakhstan. Within the framework of this Program, a package of ready-made technical documentation with open access (Open API) for individual types of agricultural technologies and the livestock sector was formed. In the field of selection of agricultural crops.

As a result of scientific research at the *Kazakh Research Institute of Agriculture and Plant Growing LLP* (2 scientific and technical programs for breeding and seed production of oilseeds, cereals (soybeans, sunflower, flax, rapeseed), leguminous crops, as well as 1 project for breeding grain crops (winter, facultative and spring wheat, triticale, barley, oats, corn, sorghum) under the budget program 267 of the Ministry of Agriculture of the Republic of Kazakhstan and 9 projects under the budget program 217 of the Ministry of Health of the Republic of Kazakhstan) for 2021-2023, according to the full scheme of the breeding process using genetic diversity, traditional and molecular genetic breeding methods, 17 new stress-resistant varieties and hybrids of agricultural crops were created and submitted for state variety testing over a three-year period: winter rapeseed pervenets Semirechye; winter wheat variety Amanat for irrigated lands, winter wheat variety Dulati for rainfed purposes, soybean variety Milka, soybean variety Saule, sugar beet hybrid Abulkhair; winter wheat variety Khan Tengri, winter barley variety Zhasorken, winter soft wheat variety KIZ-90, winter soft wheat variety Adilet, chickpea variety Alpamys, pea variety Asylai, bean variety Asyl, soybean variety Amalia, soybean variety Kostana, safflower variety Gloria, corn hybrid KazNIIZIR-90 SV. During the same period, 11 varieties and hybrids of agricultural crops bred by KazNIIZIR LLP were recommended for use in production [378].

According to the project AP09259636 "*Study of genetic resistance of promising varieties and rootstocks of apple to a dangerous disease - fire blight using SNP*

markers" (executor - NAO "Kazakh National Agrarian Research University") as a result of molecular identification of the causative agent of fire blight by the PCR method based on genomic DNA, it was established that out of 8 samples of bacterial cultures, three cultures (varieties Aport, Sinap Almatinsky, Pinova) were identified as phytopathogenic bacteria Erwinia amylovora. A molecular genetic method for identifying SNP markers of apple resistance to fire blight has been developed.

During the implementation of the project AP09058208 *"Screening of cultivated and wild forms of the gene pool of grain legumes for resistance to diseases to find the source material for selection" (executor - NJSC "Kazakh National Agrarian Research University*"), the identification of genes of resistance to a complex of diseases was carried out using molecular markers and the selection of carriers of resistance was carried out, DNA was isolated, PCR analysis was carried out using special molecular markers according to literary data. The identified carriers of genes were further studied for productivity traits.

In the field of forage production and irrigated agriculture. Within the framework of the project AP09259400 "*Selection of non-traditional crops for intensive use of irrigated lands and creation of a green conveyor depending on the bioclimatic potential of growing zones" (executor - NAO "Kazakh National Agrarian Research University*"), an assessment of the hydrothermal conditions of the southeast of Kazakhstan was carried out, calculations of the need for agricultural crops in the sum of active temperatures and the actual sums of positive, active temperatures were made, and the results of field studies showed that in the conditions of the Almaty, Zhetysu, Zhambyl and Turkestan regions, with the introduction of new resource-saving technologies, it is possible to obtain two harvests of agricultural crops per year.

In the field of organic farming. As a result of NTP BR10764907 "Development of technologies for organic agriculture for growing agricultural crops taking into account the specifics of regions, digitalization and export" (executor - LLP "Kazakh Research Institute of Agriculture and Plant Growing"), biologized crop rotation schemes were developed. Green manure crops (peas, peas + oats, vetch + oats, buckwheat, spring rape, sweet clover, winter rape) with high productivity coefficients and large biomass were selected as green fertilizers.

Within the framework of the Scientific and Technical Program "Organic production of potatoes and table root crops (carrots, beets) based on the use of adaptive-ecological varieties and biologization of crop agrotechnologies in the conditions of the southeast of Kazakhstan" (executor - NAO "Kazakh National Agrarian Research University"), studies were conducted in various vegetable and potato crop rotations to determine their role in organic production. Their positive effect on the productivity of potatoes and table root crops was established. Farms in the region are offered biologized crop rotations for organic production, since the studied types of bioorganic fertilizers improve the nutritional regime of the soil, significantly increasing the content of nutrients available to plants.

Ensuring phytosanitary safety. According to NTP BR10764991 "Creation of highly productive varieties and hybrids of oil and cereal crops based on the achievements of biotechnology, genetics, physiology, plant biochemistry for their

sustainable production in various soil and climatic zones of Kazakhstan" (executor - Kazakh Research Institute of Agriculture and Plant Growing LLP), the study of the immunological characteristics of varieties made it possible to identify resistant variety samples. Evaluation of breeding material in field conditions against the background of artificial infection with rust showed that the majority (79.2%) of soft and hard wheat lines were characterized as moderately susceptible (MS) and susceptible (S) to the pathogen. A significant difference in the reaction of foreign varieties to the local population of the Puccinia pathogen was noted. Among the tested varieties of selection: Russia, Turkey, Lithuania, Romania, Hungary, Switzerland, Czech Republic, France, Germany, Italy, Canada and the USA, genotypes were distinguished that showed resistance (R) and moderate resistance (MR) up to 5-10% to the pathogen [379].

Processing and storage of agricultural products and raw materials. In the course of the project BR10765062 *"Development of technology to ensure the preservation of the quality of agricultural raw materials and processed products in order to reduce losses during various storage methods" (executor - NAO "KATIU named after S. Seifullin*"), technologies were developed for freeze-dried honey with a long shelf life, a drink with honey, freeze-drying berries with a long shelf life, storage of grapes of domestic varieties in order to obtain organic products. Based on the research results, 1 article was published in the international journal Q2, 1 monograph was issued, 1 patent was received.

Within the framework of NTP BR10764998 *"Development of technologies using new strains of beneficial microorganisms, enzymes, nutrients and other kits in the production of special dietary food products" (executor - NAO "KATIU named after S. Seifullin*"), technologies for functional food products were developed, as well as technologies for obtaining lactobacilli and bifidobacteria for use in technologies for obtaining probiotic products and goat and sheep milk. Based on the research results, 2 articles were published in international journals Q2, 2 monographs were published, 1 patent was received.

Within the framework of the scientific and technological progress report BR10764970 *"Development of high-tech technologies for deep processing of agricultural raw materials in order to expand the range and output of finished products per unit of raw materials" (executor - Kazakh Research Institute of Processing and Food Industry LLP*), innovative methods for processing agricultural raw materials were studied and developed in order to increase the output of finished products, expand the range and reduce the proportion of waste in production, and new formulations of biologically active additives, enzymes, starters, starch, oils and other products that contribute to the development of the food industry were created. Based on the research results, 4 articles were published in international journals Q1, Q2, 2 monographs, 1 textbook were published, 13 patents for utility models and 1 patent for an invention were received.

Within the framework of NTP BR10764977 "*Development of modern technologies for the production of dietary supplements, enzymes, starters, starch, oils, etc. in order to ensure the development of the food industry" (executor - TOO "KazRDI*

of the processing and food industry"), unique recipes and technologies for the production of combined meat products using secondary and plant raw materials with high biological and performance indicators have been developed. New recipes and technologies for the production of dry feeds that provide adequate nutrition for service dogs of Kazakhstan have been presented. An innovative technology for storing chilled poultry meat and poultry products using biological methods of preservation and cold has been created.

Based on the research results, 4 articles were published in international journals Q1, Q2, 8 monographs were published, 7 patents for utility models were received.

Technical support for the modernization of the agro-industrial complex

Initiative project for 2021-2023 "*Development of an automated fertilizer application system*". Project manager - Sugirbay A. M.

The goal of the program is to increase the yield of various crops and reduce competition between seeds for nutrients by developing a seeder working body for no-till farming with an automated dosing system for sowing various seeds with simultaneous application of mineral fertilizers.

Based on the research results, 2 articles were published in international journals Q1, Q2.

1.2. Sustainable development of rural areas

In 2023, Kazakh Research Institute of Agricultural Economics and Rural Development LLP completed two projects financed by the Ministry of Agriculture of the Republic of Kazakhstan (MoA RK) and the Ministry of Science and Higher Education of the Republic of Kazakhstan (MSHE RK).

Project 1: "*Conducting analytical research and forecasting (assessment) of the development prospects of the agro-industrial complex of the Republic of Kazakhstan to improve the efficiency of the agro-industrial complex*". Main results and conclusions:

- a detailed analysis of the main sectors and sub-sectors of the agro-industrial complex by region was carried out, constraints to development, growth reserves were identified, and a development forecast was compiled until 2027.

Project 2: "*Self-employment of rural youth of Kazakhstan as creative work from formal employment to freelancing using digitalization*" (2023-2025). An analysis of global experience in the field of freelancing and self-employment was conducted, definitions of the categories of "self-employment" and "freelancing" were identified, as well as the characteristic features of the freelancer group; trends in the modernization of the economic activity of the self-employed population were studied, which confirms the importance of freelancing as a direction for diversifying labor relations, especially among young people. Based on the research results, 1 article was published in the international journal Q1.

2. Review and analysis of global trends in science, examples of cooperation between domestic scientists and foreign scientists and work carried out under a contract with international scientific organizations

According to leading analytical companies, trends such as artificial intelligence, generative AI, climate and green technologies, mobility, AR / VR / XR and other synthetic environments, robots and drones, bioengineering have the potential to

influence agriculture in the near future, while Web3 infrastructure, meta-universe and quantum technologies can affect in the long term.

According to a study conducted by the StartUs Insights Discovery platform (https://www.startus-insights.com/), based on the analysis of 3,790,000 startups and scale-ups worldwide, the following key trends were identified: Internet of Things, Robotics, Artificial Intelligence, Agricultural Drones, Precision Farming, Agricultural Biotechnology, Big Data and Analytics, Controlled Environment Agriculture, Regenerative Agriculture, Connected Technology.

Thus, the global agricultural industry is undergoing a profound transformation thanks to advances in Artificial Intelligence (AI) technologies, which are transforming and improving various aspects of agriculture: from increasing productivity and efficiency to improving sustainability and reducing waste.

The trends of recent years have led to the emergence of the concept of "Agriculture 5.0". Agriculture 5.0 is a new generation of agriculture, which is characterized by the use of advanced technologies, such as artificial intelligence (AI), the Internet of Things (IoT) and machine learning, to improve productivity, efficiency and sustainability. It is advisable to highlight the following main global technological trends by agricultural sector: crop production, livestock farming, agricultural processing and biotechnology. In many ways, the main trends and factors existing in Kazakhstan correspond to global trends, although there are certain specifics associated with the country's geographical location, geopolitical features, the state of the economy and social system. In the field of veterinary medicine, Kazakhstani scientists closely cooperate with foreign colleagues from South Korea, Georgia, Cuba, the USA, France and Germany. Annual internships for specialists and vaccine development are financed from the state budget, private companies and grants. As of 2023, more than 3,000 qualified specialists in this field work in Kazakhstan.

3. Analysis of the achievements and development trends of leading scientific schools of Kazakhstan and highly developed foreign countries

Several leading scientific schools have currently been formed in the Kazakh Scientific Research Veterinary Institute: in the field of epizootology (Academician of the National Academy of Science of the Republic of Kazakhstan Ivanov N.P.), veterinary parasitology (Abdybekova A.M.), in the field of studying infectious diseases of animals (Bizhanov A.B.).

Academician *Ivanov N.P.* was the first to develop an antigen for RDSK in identifying patients with infectious epididymitis in rams, which had no analogues in the world and in the post-Soviet space. He was also the first in the world to develop and successfully implement 12 diagnostic, prophylactic and treatment methods for bacterial infections (moraxellosis, necrobacteriosis, brucellosis, foot rot, salmonellosis, etc.) on the basis of the Agroholding "Baiserke-Agro", which ensured stable epizootic well-being of animal husbandry. Scientific developments of Academician N.P. Ivanov were highly appreciated by international scientific communities (Switzerland, France) and the Government of the country: he was awarded the State Prize of the Republic of Kazakhstan in the field of science and technology named after al-Farabi for a series of works on the topic "New innovative achievements in the development of animal

husbandry (cattle breeding, sheep breeding, horse breeding, camel breeding, veterinary medicine)". Scientifically interesting works on studying the biology of pathogens of invasive diseases, creating diagnostic and prevention methods, new means for deworming agricultural, domestic and wild animals taking into account the species composition of parasites circulating in the territory of Kazakhstan are carried out by scientists of the Kazakh Research Institute of Veterinary Medicine under the supervision of Doctor of Veterinary Sciences, Professor Abdybekova A.M. (Hirsch Index 9). The professor has developed and implemented means and methods for the prevention and therapy of echinococcosis, opisthorchiasis and other helminthiases of carnivores, studied the species composition of parasites of commercial fish in natural reservoirs of the republic. Patents for their developments are included in the Web of Science database.

Bizhanov A.B., Doctor of Veterinary Sciences, Professor, Scientific Director and responsible executor of programs for the development of measures to combat mytosis, pasteurellosis, epizootic lymphangitis of horses and plague, trichophytosis of camels. The immunobiological preparations developed by him are used throughout the territory of the Republic of Kazakhstan with a high anti-epizootic effect and have had a significant impact on the recovery of farms from infectious diseases. It should be noted that Kazakhstan has stepped onto the next stage of industrial and innovative development. According to Kazakhstani scientists, this stage is characterized by the reprogramming of the scientific system in accordance with modern economic requirements, therefore, the development of science, regulated by relevant regulatory indicators, structural, organizational, personnel, infrastructure and financial security, should lead to fundamental changes.

Priority X - "National security and defense"

1. Review and analysis of the achievements of Kazakhstani science (the most significant results of the scientific and (or) scientific and technical sphere, implemented developments).

The science in the direction of "National Security and Defense" studies the main areas of national security, namely: political, economic, military, information, social, environmental (biological). Issues of state defense capability are also interrelated with these areas. In turn, state security is a relative state of security of the individual, society and the state, ensuring the dynamic development of the country [380].

Security threats and challenges are constantly increasing and changing. Thus, a fence built between Palestine and Israel according to all modern requirements for military engineering structures cannot be a guarantee of the security of one of the parties. The events of October 7, 2023 - the Hamas attacks on Israel - are a clear example of the fragility of a frozen conflict, security and defense in general.

The Constitution of Kazakhstan determines that the state ensures the integrity, inviolability and inalienability of its territory [381]. The Law of the Republic of Kazakhstan "On National Security of the Republic of Kazakhstan" defines

18 main national interests. 20 main threats to national security have been identified that may arise as a result of natural, man-made, and, first of all, socio-political phenomena [380].

Analyzing the achievements of science in the area of "National Security and Defense" (the most significant results of the scientific and (or) scientific and technical sphere, implemented developments), first of all, it should be noted that the Military Doctrine of the Republic of Kazakhstan defines the main measures for the development of military science - as an integral part of science, namely [382]:

1) increasing the military-scientific potential in the Armed Forces, Far Eastern Federal District; 2) training military scientific personnel; 3) development of the research base; 4) continued development of disciplines dealing with military issues; 5) attracting leading specialists from other branches of science; 6) using the opportunities of public-private partnership; 7) application of military-civil integration of scientific, educational organizations and institutions.

In addition, the Military Doctrine of the Republic of Kazakhstan defines measures to attract investment and intensify innovative activities to update the scientific, technical and production-technological base of the defense industry and conduct R&D.

An analysis of the implementation of the provisions of the Military Doctrine of the Republic of Kazakhstan showed the following:

1. Increasing the military-scientific potential in the Armed Forces, Landing Troops and Navy.

Since 2021, the Defense Research Council has been established and is functioning in the Ministry of Defense of the Republic of Kazakhstan - a collegial consultative and advisory body that carries out its activities in order to make decisions on approving the volume of funding for defense research, the volume of grant and program-targeted funding for the Ministry of Defense, as well as developing recommendations for the National Scientific Council "National Security and Defense" in specialized scientific areas within the framework of announced competitions, as well as scientific, scientific and technical projects and programs [383].

At the National Defense University, the number of academic staff (hereinafter referred to as the faculty) is 62 scientists, including 6 doctors of science, 20 candidates of science, 36 doctors of philosophy PhD. There are 3 dissertation councils in the following specialties: "Military Art", "Military History", "Armament and Military Equipment" [383].

On the basis of the National Defense University (hereinafter - NDU), there is a military scientific research center, which, along with theoretical research, also creates prototypes of weapons. For example, the team of the military scientific research center (hereinafter - MSRCs) of the NDU, together with a domestic enterprise, created and is testing the unmanned vehicle "Shagala". Also, at the NDU, there is a scientific platoon, in which conscripts serve [383].

The scientific potential of the National Guard of the Republic of Kazakhstan is 19 scientists. In order to increase and qualitatively strengthen the scientific potential of the Academy of the National Guard (hereinafter - A NG), 5 officers entered the

doctoral program of the National Defense University in 2022-2023. In November 2023, based on the Memorandum between the Academy of the National Security of the Republic of Kazakhstan and the University of Public Security of the Republic of Uzbekistan (hereinafter referred to as UOB RU) dated March 10, 2023, 8 officers were admitted to the UOB RU to obtain an academic degree. In 2024, 20 candidates plan to enter the specified university. 5 officers are studying in the graduate school of the Omsk State Pedagogical University of the Russian Federation [384].

In 2023, the following persons received a degree (academic degree) at the Border Academy of the National Security Committee of the Republic of Kazakhstan (hereinafter referred to as the PA of the National Security Committee of the Republic of Kazakhstan): 4 - PhD doctors, 4 - candidates of sciences. Academic titles: 3 - professor, 5 - associate professor (associate professor) [385].

2. Implementation of training of military scientific personnel.

Since 2023, the A NG has begun training under the master's degree program in the specialty "Military training and education". Starting from the new 2024-2025 academic year, the Faculty of NG of the National Defense University is working to open new study groups studying in the state language in two qualifications: "Operational and Tactical Management of the National Guard", "Organization of Educational and Ideological Work of the National Guard" [384]. 3. Development of a research base. For 2023-2027, work is underway in the A NG to create scientific and educational laboratories. The title documents for 5 scientific and educational laboratories based on 5 departments have been prepared [384].

In 2023, two laboratories (a scientific and a scientific-technical laboratory) were created at the Border Academy of the National Security Committee of the Republic of Kazakhstan within the framework of research and development work on program-targeted and grant financing (hereinafter referred to as PTGF). They are provided with autonomous power sources (solar panels). The laboratories are intended to train specialists in the maintenance and application of innovative technical means of border protection, to conduct comprehensive, laboratory and practical classes, as well as to conduct scientific research and experiments.

A stabilizing platform was created to accommodate a van body on it. The platform is installed on the ABSh KAMAZ 43118 for operating the MPM in difficult road conditions.

As part of the improvement and development of the scientific and experimental base, the following was purchased: 3 - modern high-tech professional UAVs (helicopter type); 3 workplaces for training "UAV operators" in UAV control; 1 high-power charging station; 1 - means of visualization of object information. Two instructor officers have been trained to teach the basics of UAV control [384].

4. Continuing to develop disciplines dealing with military issues. The Department of Tactics and General Military Disciplines of the National Guard Academy has introduced the position of a teacher of UAV operation, and the programs of two new disciplines, "Unmanned Aircraft Systems" and "Operation of Unmanned Aircraft Systems", have been approved. New academic disciplines have been introduced at the NG NOU faculty: "Operational and Service (Combat) Readiness of

National Guard Formations and Units", "Religious Studies", and "Military Didactics" [384].

5. Attracting leading specialists from other branches of science.

Within the framework of memorandums and agreements, the National Guard Academy attracts leading specialists from the M. Kozybayev North Kazakhstan University and the DIGITAL URPAC Schoolchildren's Palace, a state-owned enterprise. The faculty of the Faculty of NG NOU regularly participate in classes (lectures, seminars) conducted by leading specialists from different countries (UAE, India, China, Azerbaijan, France, Italy, Turkey, etc.) and higher education institutions of the Republic of Kazakhstan on the basis of concluded agreements of NG [384].

The Border Academy of the NSC RK has attracted specialists from domestic enterprises and higher education institutions of Kazakhstan to solve the problems of scientific programs (projects) on program-targeted and grant financing [385].

6. Using the opportunities of public-private partnership. The Academy of NG organized work with the faculty in the amount of 16 people with the passage of courses on "Artificial Intelligence" and business incubation "SPRINT-2023" in the regional representative office "INHUB" of JSC "National Agency for Innovation Development "QazInnovations"" of the Republic of Kazakhstan.

Upon completion of the courses, the faculty of the Academy of NG received knowledge and skills in the commercialization of technologies, with the registration of rights to intellectual property; the project "Shanyrak" was protected, which received support from local investors in Petropavlovsk-Kazakhstan region [384].

7. Application of military-civil integration of scientific, educational organizations and institutions. The NG Academy has concluded 23 Memorandums and Agreements, including: at the international level - 1 (Public Security University of Uzbekistan); with military (special) universities of the Republic of Kazakhstan - 7, with 2 civilian organizations and 13 at the regional level in the North Kazakhstan region of the Republic of Kazakhstan [384].

For 2023, higher educational institutions of the National Security Committee of the Republic of Kazakhstan regularly participate in the examination of scientific projects conducted by JSC "NCSNT". More than 30 examinations of research applications and final reports have been carried out. Since 2016, representatives of the Border Academy have been members of the expert council of the KOKSSHE MSHE RK in the direction of national security and military affairs [385].

8. Measures to attract investment and intensify innovation activities to update the scientific, technical and production and technological base of the defense industry, and conduct R & D.

The National Guard of the Republic of Kazakhstan is working on cooperation in the framework of R & D with the involvement of the existing technological base and the potential of engineering and technical workers of two plants: JSC Petropavlovsk Heavy Machinery Plant and JSC Kirov Plant to create prototypes and implement new technological developments with subsequent commercialization and financing the development of research and development activities of the Academy of the National Guard. Work is underway with Kazakhstan Aselsan Engineering LLP on cooperation

in the field of research and development and testing (testing) of prototypes of weapons and communications, combat equipment and other military property, and equipment based on the Academy of the National Guard. The teaching staff of the Faculty of NG NOU participate in the working group in the State Center of the Republic of Kazakhstan "Development of the scientific and theoretical foundations of civil defense of the Republic of Kazakhstan taking into account new threats and challenges" IRN AR 09260477. In 2023, applications were submitted to the Ministry of Defense and Higher Education of the Republic of Kazakhstan for participation in grant financing in the direction of "Development of a draft of rules for the service and combat use of NG of the Republic of Kazakhstan taking into account new threats to state security". In 2024, "Improvement of the scientific, theoretical and applied foundations for the use of NG in the context of modern threats to the National Security of the Republic of Kazakhstan" [384]. Since 2020, the Ministry of Defense of the Republic of Kazakhstan has initiated scientific developments and rationalization work in various areas. Thus, according to the technical assignments of the Ministry of Defense, defense enterprises are conducting R & D to create promising weapons systems. These are multiple launch rocket systems, artillery fire control vehicles, NBC reconnaissance systems, Barys armored wheeled vehicles, anti-UAV systems, and others.

In order to develop scientific potential and master new types of production, the Ministry of Defense of the Republic of Kazakhstan has developed and transferred to the Ministry of Defense of the Republic of Kazakhstan a list of 110 types of military products [386].

In 2023, 4 scientific projects were carried out at the Institute of Space Engineering and Technology LLP within the framework of grant funding from the Ministry of Defense of the Republic of Kazakhstan for 2021-2023 and 2022-2024, including 2 projects with the "DSP" classification under the priority "National Security and Defense". 1) Project AP09260581 "Development of a passive radar system for airborne objects using GNSS satellite navigation signals" (implementation period 2021-2023, funding volume for 2023 - 20,663.34 thousand tenge). Results obtained: a methodology for conducting full-scale experiments on receiving and processing reflected GNSS radio signals was developed, prototypes of receiving satellite navigation equipment were manufactured, acts on the conducted full-scale experiments on receiving and processing radio signals reflected from an airborne object were signed. 2) Project 00045/GF-DSP-20 "Hardware and software complex for receiving and transmitting video streams and navigation data in real time for operational-search activities" (implementation period 2021-2023, funding volume for 2023 - 23,000.00 thousand tenge). Results obtained: an experimental sample of hardware and software complex for receiving and transmitting video streams and navigation data in real time for operational-search activities was manufactured.

At the Border Academy of the National Security Committee of the Republic of Kazakhstan, within the framework of the PCF for 2021-2023, research was conducted on the topic "Development of a prototype of a continuous-wave radar station".

Within the framework of the PCF for 2023-2024, research is being conducted on the topic "Conducting research in the field of acoustic reconnaissance with the creation

of a prototype of a shot recorder to increase the combat potential of the national security forces".

Together with the domestic manufacturer TOO SKTB "Granit", a prototype of a shot recorder has been developed. In the first half of 2024, preliminary full-scale tests of the prototype of the sound-measuring complex are planned. As a result of the tests, the characteristics laid down in the technical specifications will be verified.

In the period from 2021 to 2023, as part of the development of science, the National Guard Academy conducted the following scientific research.

In 2021, at the Center of Military Unit 5574 (Zhetygen), a PPS consisting of 20 officers conducted R&D. Based on its results, 5 teaching aids were published, incl. "Battalion tactical group in a special operation to stop the activities of illegal paramilitary (armed) formations (groups)", "Operational units in an anti-terrorist operation" (volume), "Features of tactical actions of units (forces and means)", etc. In 2022, 21 scientific studies were conducted on fundamental, applied, current problems of the activities of the NG RK and on problems of improving teaching methods [384].

In 2023, scientific research was conducted on the topic of "Improving the tactics of service and combat use of units of the National Guard of the Republic of Kazakhstan and their comprehensive support in modern conditions." In 2023, in order to improve the knowledge and skills for organizing and conducting training of personnel, as well as effective management in the performance of various service and combat tasks, unit commanders together with the PPS conducted research. Based on its results, 11 educational and methodological materials were published. The results of the research were introduced into the service and combat activities and the educational process of the National Guard of the Republic of Kazakhstan [384].

The following research was completed at the Faculty of NG NOU [384]:

in 2021 "Scientific and theoretical foundations for organizing interaction between the National Guard and the Border Service of the National Security Committee of the Republic of Kazakhstan in internal and border armed conflicts", "Improving the management activities of the deputy commander of a military unit for educational and social and legal work"; in 2022, "Improving the service and combat use of an operational brigade (regiment) in suppressing an internal armed conflict", "Experience in organizing technical support for NG units that performed service and combat tasks to maintain the legal regime in the city of Almaty in January 2022";

in 2023, "Analysis of the exercises conducted in the NG of the RK for the period 2017-2022: Conclusions and practical recommendations" the monograph "Post-Kenestik yntymaktastyk" was published. Mynbaev Sh.Zh. - NOU, Astana, 2023.

The research results have been introduced into the educational process for training master's students in academic disciplines and are actively used by master's students, doctoral students when conducting experiments of a scientific and applied nature [384].

At the same time, at present in Kazakhstan there is no mechanism related to further experimental testing, introduction into production and commercialization of military products developed by domestic specialists.

Thus, on March 1, 2023, at the initiative of the RPO "Academy of Military Sciences", a meeting was held at the Ministry of Industry and Infrastructure Development of the Republic of Kazakhstan with the participation of representatives of the security agencies and the military-industrial complex of the Republic of Kazakhstan, where the following scientific projects were considered:

1. Igbayeva T. M., Doctor of Technical Sciences, Academician of the International Academy of Science, Honorary Member of the Academy of Military Sciences of the Republic of Kazakhstan, Professor of the Department of Life Safety of KazNTU named after K.I. Satpayev to conduct further research to experimentally confirm the existence of the effect of a multiple increase in the detonation velocity and / or the rate of outflow of gaseous explosion products in the axial direction for a charge composed of figured checkers at a training ground. An increase in the velocity of explosion products by 7.49 times was experimentally achieved. 2. Kobulbaeva E.B., the first project is the AO V-30MK assault rifle, modernized with a classic layout and the ASO V-30K balanced, Patent No. 34679. The assault rifle is designed in a classic layout. The second project is the KSM-M rifle. The third project is the 82 automatic turret grenade launcher (ABG 82).

Currently, the future of these inventions remains open.

Thus, there are problematic issues regarding joint work and interaction between authorized bodies responsible for the development of science in the direction of "National Security and Defense" and scientific organizations, regardless of their form of ownership, whose activities are related to ensuring the security and defense of the country.

2 Review and analysis of global trends in science, examples of cooperation between domestic scientists and foreign scientists and work performed under contracts with international scientific organizations.

Russia. The Military Scientific Complex of the Armed Forces of the Russian Federation (hereinafter referred to as the MSC of the RF Armed Forces) is divided into two components. The first is university science, including scientific divisions of more than 30 military universities. They specialize in conducting operational and tactical research in the interests of developing military art. The second component is "institute" science, concentrated in more than 20 research institutes and centers [387].

The main tasks of the MSC of the RF Armed Forces are to identify issues that require a scientific approach, direct scientific resources to their implementation, and create the necessary conditions for the earliest possible implementation of the results obtained in the practice of troops (forces). Their solution is carried out jointly with the military-scientific and scientific-technical committees of the military command bodies. There are 25 of them in total. Military-scientific, naval, scientific-technical committees are the "headquarters" of military science, the "drive belts" between the military command bodies and scientific structures [387].

The main areas of activity of the VNK and issues of their practical implementation: organization of scientific work, more than 350 areas of scientific research; development of a unified military-technical policy in the field of development and modernization of weapons and military equipment, and its

implementation in the formation of the state armament program and state defense order; organization and control of military-scientific support for R & D; organization of events for the development of the military-scientific complex of the RF Armed Forces; organization of the study and generalization of combat experience, military-historical work, publishing and scientific-information activities [387].

USA. American scientific agencies provide the whole world with breakthrough technologies. Financing of advanced developments in the field of national security and defense in the United States serves as a driving force for the development of science and the venture market. US government agencies finance fundamental and applied research, usually on a non-repayable basis. The annual budget for such financing in 2020 amounted to more than $150 billion. At the same time, more than a third of the funds for scientific work are allocated through the Pentagon, which is the largest sponsor of scientific research in the total amount of distributed budget funds. Other major distributors of funds and customers of scientific research in the United States include federal departments and agencies such as the Department of Health, the Department of Energy, the Department of the Interior, NASA, and the National Science Foundation [388].

Venture market. One of the foundations of the competitiveness of the American economy is its innovative focus. The demand for new technologies and openness to their application have always been integral characteristics of the US economy. The model of economic activity in the USA demonstrates a steady demand for innovations - be it solutions that contribute to the growth of efficiency of existing industries, the launch of improved consumer products and services, or the emergence of completely new markets. For several decades, the American venture investment market has been not only the largest in the world, but also the most mature and continuing to develop dynamically. Thus, today the American venture market with a volume of $ 164 billion (NVCA estimate) occupies approximately half of the global one, and the ratio of venture investments to GDP in the USA is approaching 1%, which exceeds the indicators of other large developed countries. For comparison: in Russia this figure is only 0.02% [388].

China. Chinese innovations are aimed at the synergy of brain science, artificial intelligence (hereinafter - AI) and biotechnology. The People's Liberation Army of China (PLA) has developed a range of command, control, communications, computers, intelligence, surveillance, and reconnaissance systems and has focused on expanding information operations capabilities, including cyber warfare, electronic warfare, and psychological warfare.[389] PLA strategists expect a new style of warfare to be on the horizon as the nature of conflict shifts from "informatized" to "intelligent" warfare.[389] China has established a Military Scientific Research Steering Committee, which is responsible for setting high-level priorities and strategic directions. The Science and Technology Commission has also been elevated to lead military-technological innovation and promote civil-military fusion. The Research Center oversees a series of plans, programs, and expert groups of leading scientists on priority areas that include human-machine intelligence fusion and biotechnology.[389] The PLA Academy of Military Sciences, which has traditionally been responsible for

strategy and doctrine, has been formally appointed to lead the PLA's military science enterprise. It has launched the National Institute of Defense Technology Innovation, which includes research institutes specializing not only in unmanned systems and artificial intelligence, but also in advanced interdisciplinary technologies such as biotechnology and quantum technology. The AMS leadership also has the experience and authority to advance these new directions in military innovation [389].

International scientific military cooperation in the direction of "National Security and Defense" in Kazakhstan is carried out according to cooperation plans. Priority interaction is carried out with the CSTO member states (since February 2022, after the well-known military events in Eastern Europe and the Caucasus, events have been reduced), the SCO, the CIS, NATO countries (under the Partnership for Peace Plan), bilateral military cooperation with the United States, Great Britain, Turkey, China, South Korea and others. On an ongoing basis, the training of scientific personnel of Kazakhstan in these countries (Master's and Doctoral programs) is carried out. Within the walls of the NOU, foreign military personnel are trained under the program of military Master's and Doctoral programs for representatives of South Korea, Iran, Pakistan, and the CSTO countries.

The development of the military-political situation in the world, in Central Asia, which directly affects the internal stability of the states of the region, shows that it continues to escalate and become less stable and predictable. The struggle for raw materials and spheres of influence in regions rich in natural deposits (energy carriers) is intensifying. World players continue to redistribute spheres of influence, especially in the territories where the Soviet Union once dominated, including on its immediate territory. The military conflict in Ukraine and the "hot" phase that began in the Middle East in early October 2023 are proof of this. Naturally, the opposing sides will put forward certain goals of military action - all this is an element of the information war. At the same time, the main essence does not change. These conditions require Kazakhstan to strengthen measures to ensure national security and increase the country's defense capability, including the development of science in this area. This requires financial expenditures in critical areas of research activities to prevent threats to national security defined in the country's legislative acts.

3 Analysis of the achievements and development trends of the leading scientific schools of Kazakhstan and highly developed foreign countries

In Kazakhstan, the foundation of military science has been created and is functioning - higher military educational institutions in the system of state power bodies - the National Defense University, the Border Academy of the National Security Committee of the Republic of Kazakhstan, the Academy of the National Guard, the Academy of the Ministry of Emergency Situations of the Republic of Kazakhstan, military institutes of the Ground Forces, the Air Defense Forces, Radio Electronics and Communications - are the main higher military educational institutions. Scientific organizations of the quasi-public sector, including JSC "Center for Military-Strategic Research" (fundamental military science), LLP "R&D-center" NC "Kazakhstan Engineering" (applied military science). As a RPO, the Academy of Military Sciences (as part of an association of over 70 military scientists) has been

conducting research for more than 10 years. This association was the first real attempt to strengthen the military-scientific activities of military scientists working in various state and non-state bodies, in the interests of ensuring National Security and Defense of the Republic of Kazakhstan.

The Academy of Military Sciences (hereinafter referred to as the AMS) celebrated its tenth anniversary in 2023. The members of the AMS are honored military scientists, scholars, veterans of the Armed Forces of the Republic of Kazakhstan, who have extensive service and scientific experience, including combat experience. With their participation, the military-scientific potential of Kazakhstan was created. The members of the AMS participated in the development of all military doctrines of our country, in the preparation of drafts of the basic laws of the Republic of Kazakhstan on the military activities of the state, and created scientific military terminology. They carry out military-scientific research (work) on an ongoing basis, including classified research. They head educational and scientific institutions. They are members of the Dissertation Councils of the NOU and other higher educational institutions of the Armed Forces, the Far Eastern Military and Military Physics of the Republic of Kazakhstan.

The Academy of Military Sciences in its further development can become a Competence Center. With sufficient funding and the creation of a military and scientific infrastructure, it can lead the scientific direction of “National Security and Defense” and coordinate the development of science between the bodies and organizations that are part of the Military Organization of our state and others, including international scientific organizations.

4. ANALYSIS OF THE STATE OF SCIENTIFIC POTENTIAL

(the qualitative composition of scientific organizations and higher education institutions, autonomous educational organizations engaged in science, the quality of training of domestic scientific personnel, the attraction of foreign scientists, the equipping of scientific laboratories with modern equipment for conducting scientific research)

For statistical survey of scientific and scientific-technical research and experimental development, two input indicators are used in state statistics: the number of personnel engaged in scientific research and development, and R & D costs.

Network of scientific organizations. According to state statistics, in the Republic of Kazakhstan in 2023, 425 organizations were engaged in scientific research and development. This is 11 units more than in the previous year. The number of organizations remained unchanged in the Zhetisu region, Aktobe, Pavlodar, North Kazakhstan, East Kazakhstan regions and the city of Astana. In the West Kazakhstan, Zhambyl regions and the city of Shymkent, their number decreased by 2 organizations. In the rest, the number of organizations increased (Table 4.20).

Table 4.20. – Number of organizations carrying out R&D *units*

Region	2021	2022	2023	Increase/decrease (-) relative to 2022
Republic of Kazakhstan	438	414	425	11
Abai Region	0	10	11	1
Akmola	10	10	13	3
Aktobe	15	13	13	0
Almaty	10	8	9	1
Atyrau	10	8	11	3
West Kazakhstan	9	9	7	-2
Zhambyl	9	9	7	-2
Zhetysu Region	0	2	2	0
Karaganda	38	38	39	1
Kostanay	15	14	15	1
Kyzylorda	10	7	9	2
Mangistau	7	5	6	1
Pavlodar	9	6	6	0
North Kazakhstan	8	7	7	0
Turkestan	9	8	9	1
Ulytau Region	0	1	2	1
East Kazakhstan	37	25	25	0
Astana	90	90	90	0
Almaty	139	132	134	2
Shymkent	13	12	10	-2

According to the Bureau of National Statistics of the ASP&R RK

Despite the increase in the total number of organizations conducting scientific research, there was a decrease in the state and business sectors by 4 and 8 organizations, respectively. However, organizations in the business sector continue to dominate both in terms of quantity and structure. They account for more than 40% of all organizations operating in the field of research activities (Table 4.21).

Table 4.21. – Number of organizations performing R&D, by activity sector *units*

Indicators	2021	2022	2023	Structure of organizations, in %
Total	**438**	**414**	**425**	**100**
including				
public sector	101	106	102	24,0
higher professional education sector	95	94	105	24,7
entrepreneurial sector	202	179	171	40,2
non-profit sector	40	35	47	11,1

According to the Bureau of National Statistics of the ASP&R RK

In the structure of organizations that carried out R&D, **privately owned organizations** predominate. They account for more than 66%. The share of state-owned organizations was 29%. The share of foreign-owned organizations reached 4.5% (Table 4.22).

Table 4.22. – Organizations by form of ownership *units*

Indicator	2021	2022	2023	Структура, %
Total	**438**	**414**	**425**	**100**
State	84	116	125	29,4
Private	336	285	281	66,1
Foreign	18	13	19	4,5

According to the Bureau of National Statistics of the ASP&R RK

Despite Kazakhstan's policy of transition from the active role of the state as the owner and regulator in economic sectors to healthy competition between private entities, in 2023 there was a reduction in private organizations by 4 units and a significant increase (by 9 units) in state-owned organizations.

Human resources. In 2023, the number of science workers as a whole amounted to 25,473 people. This number includes skilled and unskilled workers, secretarial and clerical staff, as well as specialists whose activities are related to R & D services.

The number of research specialists, that is, workers professionally engaged in R & D and directly involved in the creation of new knowledge, including administrative and managerial personnel (including heads of scientific organizations and departments carrying out scientific research and development), amounted to 21,534 people (Table 4.23).

Table 4.23. Number of personnel engaged in research and development by region of the country, *units*

Region	Number of personnel, total				Research specialists			
	2021	2022	2023	Increase/ decrease (-)	2021	2022	2023	Increase/ decrease (-)
Republic of Kazakhstan	21 617	22 456	25473	3 017	17 092	18 014	21534	3 520
Abai Region		1 042	1 214	172		798	951	153
Akmola	782	748	775	27	523	477	511	34
Aktobe	381	420	472	52	335	380	432	52
Almaty	697	330	404	74	501	179	217	38
Atyrau	427	111	140	29	417	104	128	24
West Kazakhstan	441	417	379	-38	430	403	366	-37
Zhambyl	393	407	405	-2	351	352	362	10
Zhetysu Region		308	333	25		305	333	28
Karaganda	1 134	1 272	1 463	191	910	980	1 141	161
Kostanay	570	484	513	29	442	411	394	-17
Kyzylorda	239	293	423	130	165	218	387	169
Mangistau	650	661	683	22	590	601	631	30
Pavlodar	447	477	551	74	363	368	390	22
North Kazakhstan	163	161	162	1	114	118	115	-3
Turkestan	245	239	353	114	209	204	310	106
Ulytau Region		2	21	19		2	13	11
East Kazakhstan	1 902	1 004	1051	47	1 355	691	735	44
Astana	3 894	4 265	4867	602	3 154	3 554	4 246	692
Almaty	8 730	9 191	9994	803	6 763	7 280	8 699	1 419
Shymkent	522	624	1270	646	470	589	1 173	584

According to the Bureau of National Statistics of the ASP&R RK

The measures taken to implement the *Concept for the Development of Higher Education and Science in the Republic of Kazakhstan for 2023-2029* to strengthen the intellectual potential of science and form a critical mass of scientists have led to a jump in the number of human resources.

The total staff has increased by more than 3 thousand people, or by 13% compared to the previous year and by 18% instead of the planned 3% compared to the base year of 2021, research specialists - by 3.5 thousand people, or by 20% compared to the previous year and by 26% compared to 2021.

But in this situation, it should be borne in mind that the number of research specialists in the total volume of research personnel is about 85%. The remaining 15% includes technical and support personnel, i.e. there are only 0.2 workers performing technical work per researcher. This suggests that in addition to their immediate responsibilities for creating new knowledge, the researcher is also forced to perform technical work. The number of researchers, taking into account the full-time equivalent (FTE) of 0.65, **is 13,997**.

For information: *According to Eurostat statistics for 2022 (or the year closest to it), in countries with the highest share of R&D expenditure in GDP, the share of research specialists in the total number of scientific personnel, taking into account FTE, ranges from 85.5% in Sweden to 49.8% in Italy. On average, this figure was 68.6%.*

Source: https://ec.europa.eu/eurostat/databrowser/product/page/rd_p_persocc$defaultview

Of the 20 regions of the Republic of Kazakhstan, only West Kazakhstan and Zhambyl regions saw a reduction in general personnel by 38 and 2 people, respectively; the number of research specialists decreased in West Kazakhstan, Kostanay and North Kazakhstan regions by 37, 17 and 3 people, respectively. In all other regions, the number of both general personnel and researchers increased significantly. At the same time, the number of technical personnel whose job responsibilities require technical knowledge and experience in one or more fields of engineering, physics, biology, social sciences or humanities, as well as other service personnel, which include qualified or unskilled specialists, secretarial and clerical personnel involved in R&D projects or directly related to such projects, decreased by 337 and 166 people, respectively.

The indicator characterizing the involvement of labor resources in scientific research and development is ***the number of researchers per 10 thousand people employed in the economy***.

In 2023, this indicator showed a certain growth.

Compared to 2022, in the republic as a whole, it increased by 3 positions and amounted to 28 people per 10 thousand employed in the economy, while the number of research specialists reached 23.7 people compared to 20.1 people in the previous year. The calculation was made based on the total number, excluding FTE.

For information: *for comparison, from the OECD Core S&T Indicators, which are a set of indicators comparing S&T data in OECD member countries and individual non-member countries, in 2021 this indicator ranged from 40.1 people per 10,000 employed in the Romanian economy to 238 people in Belgium. In Finland, this indicator was 211.7 people, in Korea - 211.6, Denmark - 203.7, Sweden - 194.6, Japan - 138.1, in the USA - 171.0, China - 76.6. This indicator in OECD countries is calculated taking into account the FTE.*

Source: OECD Data Explorer • Main Science and Technology Indicators (MSTI database)

The involvement of personnel in research activities was higher than the national average in six regions: the cities of Almaty, Astana and Shymkent and the regions of Abay, East Kazakhstan and Karaganda. In these regions, except for the East Kazakhstan region, the number of research specialists exceeded the national average (Table 4.24).

Table 4.24. – Number of personnel engaged in research and development in 2023 per 10 thousand people employed in the economy

	Personnel engaged in R&D per 10,000 people employed in the economy	Research specialists per 10 thousand people employed in the economy	Employed population*, thousand people
Republic of Kazakhstan	**28,0**	**23,7**	**9 082**
Abai Region	41,5	32,5	292
Akmola	19,0	12,6	407
Aktobe	10,9	9,9	435
Almaty	5,7	3,1	705
Atyrau	4,2	3,8	335

West Kazakhstan	11,4	11,0	333
Zhambyl	7,4	6,7	544
Zhetysu Region	10,8	10,8	309
Karaganda	27,3	21,3	536
Kostanay	11,4	8,8	450
Kyzylorda	12,8	11,7	331
Mangistau	20,3	18,7	337
Pavlodar	14,3	10,1	385
North Kazakhstan	5,9	4,2	275
Turkestan	4,4	3,9	801
Ulytau Region	2,1	1,3	101
East Kazakhstan	28,5	19,9	369
Astana	73,9	64,5	659
Almaty	95,6	83,2	1 046
Shymkent	29,3	27,1	434

Calculated based on data from the Bureau of National Statistics of the ASP&R RK
**Source of information: Key indicators of the labor market by regions of the Republic of Kazakhstan 2001-2022.*

When assessing human resources, representative indicators include full-time equivalent and the employee mobility rate.

Information: *Full-time equivalent (FTE) is an indicator that reflects the time actually spent by personnel on R&D and demonstrates the efficiency of human resource use.*

An FTE of 0.65 indicates that researchers spend only 65% of their working time, or 5.2 hours out of 8, on R&D. When recalculating their numbers for a full working day, it turns out that in 2023, 14.0 thousand people were actually engaged in research. If, according to statistics, 21.5 thousand specialists are engaged in research, then the difference is more than 7.5 thousand people.

Among 20 regions, 11 have a FTE below the national average. In the regions of Abay, Atyrau, Zhetysu, Kyzylorda, Pavlodar and Shymkent, the FTE was either less than 0.5 or slightly exceeded this figure. It turns out that in these regions, each researcher spent no more than 4 hours daily on scientific activity during the year (Table 4.25).

Table 4.25. – Full-time equivalent of research specialists

Region	2021	2022	2023
Republic of Kazakhstan	0,72	0,76	0,65
Abai Region		1,00	0,47
Akmola	0,82	0,85	0,89
Aktobe	0,54	0,59	0,61
Almaty	0,73	0,91	0,90
Atyrau	0,85	0,50	0,49
West Kazakhstan	0,41	0,43	0,43
Zhambyl	0,82	0,83	0,95
Zhetysu Region		1,00	0,50
Karaganda	0,71	0,53	0,52
Kostanay	0,49	0,47	0,40
Kyzylorda	0,83	0,72	0,47

Mangistau	1,00	1,00	1,00
Pavlodar	0,53	0,52	0,46
North Kazakhstan	0,62	0,57	0,54
Turkestan	0,89	0,94	0,95
Ulytau Region		1,00	1,00
East Kazakhstan	0,65	0,75	0,66
Astana	0,71	0,74	0,69
Almaty	0,81	0,90	0,70
Shymkent	0,38	0,40	0,51

According to the Bureau of National Statistics of the ASP&R RK

Another indicator is labor mobility (hiring, firing, or transferring to another job, etc.).

After completing higher or postgraduate education in 2023, 978 people entered the scientific field, of which 181 were PhDs, 123 were candidates of science, 28 were doctors of science, and 439 were masters. In addition, 2,888 people moved from one scientific organization to another. The majority of those hired, 2,921 people, came to the scientific field from other places not related to scientific activity. In total, 8,498 people were hired for research activities. At the same time, in 2023, the number of employees who left for various reasons amounted to 4,870 people, of which 2,803 left at their own request, 111 were downsized, and 1,956 were downsized for other reasons.

High mobility rates negatively affect the quality and effectiveness of research.

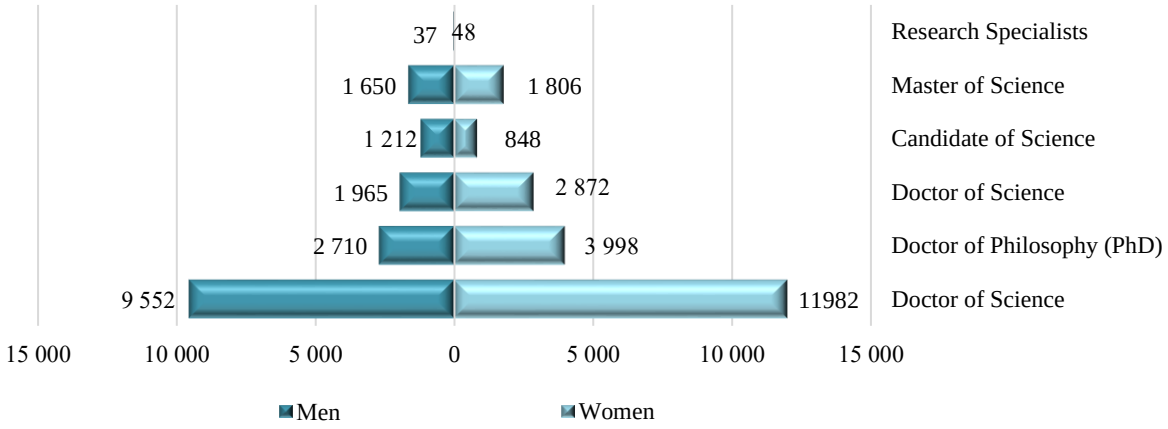
For information: *According to the UNESCO Institute for Statistics, women accounted for only about 31.5% of all researchers worldwide, measured by headcount. At the regional and subregional levels, the share of women researchers also showed significant heterogeneity. Central Asia and Latin America and the Caribbean led the way, with the highest share of women researchers at 46.5% and 44.4%, respectively. They were followed by North Africa (43.3%) and South-East Asia (41.2%). About one in three researchers was a woman in Europe, North America (35.3%) and West Asia (35.1%), above the global average, while in sub-Saharan Africa the figure was 31.4%. On the other hand, the share of women researchers lags significantly in South and East Asia, with 25.9% and 22.1%, respectively.*

Source: Spring 2024 Data Update | UNESCO UIS (unesco.org)

Kazakhstan is one of the few countries where women outnumber men and is among the top three countries in the world rankings with the leading number of women in science.

In 2023, as in previous years, more than 50% of masters, candidates of science and doctors of philosophy were women (Fig. 4.18).

People



According to the Bureau of National Statistics of the ASP&R RK

Figure 4.18. Structure of the gender composition of research specialists in 2023.

Men predominated only among doctors of science (41.2%). However, even here their number decreased by 156 people over the year.

The age composition of researchers is considered one of the basic characteristics of the effectiveness of research activities.

In 2023, the number of personnel in all age groups increased (Table 4.26). In the personnel structure, the largest percentage (29%) falls on the most productive age - 35-44 years.

It should also be taken into account that the share of women scientists in Kazakhstan in 2023 is 55.6%, of which more than 50% are of reproductive age.

Table 4.26. – Distribution of the number of employees performing scientific research and development by age

	2021	**2022**	**2023**	**Increase/ Decrease (-)**	**Personnel structure, in %**
Total, *people*	21 617	22 456	25473	3 017	100
up to 25 years	1 260	1 246	1590	344	6,2
25-34 years	5 448	5 415	5739	324	22,5
35-44 years	5 831	6 443	7397	954	29,0
45-54 years	4 023	4 173	4825	652	18,9
55-64 years	3 213	3 279	3647	368	14,3
65 years and older	1 842	1 900	2275	375	8,9

According to the Bureau of National Statistics of the ASP&R RK

In 2022, positive dynamics were noted in the number of highly qualified scientific personnel.

In the personnel structure, the largest share is made up of candidates of sciences (about 18%) and PhD doctors (11%) (Table 4.27).

Table 4.27. – Distribution of personnel by qualifications *people*

	2021	2022	2023	Increase/ Decrease (-)	Personnel structure, in %
Personnel engaged in research and development, total	21 617	22 456	25473	+3 017	100
of which research specialists	17 092	18 014	21534	+3 520	80,2
of which those with the following qualifications:					
Doctors of Science	1 652	1 743	2060	+317	7,8
Candidates of Science	3 838	3 945	4837	+892	17,6
Doctors of Philosophy, PhDs	1 952	2 460	3456	+996	11,0
Doctors in the field	55	96	85	-11	0,4

According to the Bureau of National Statistics of the ASP&R RK

The increase in the number of personnel in 2023 was mainly due to research specialists, whose number increased by 3.5 thousand people. At the same time, the number of technicians whose job responsibilities require technical knowledge and experience decreased by 337 people, and other auxiliary workers by 166 people (Table 4.28).

Meanwhile, the overall increase in the number of employees was unevenly distributed across sectors of activity. In the public sector, there was a decrease in employees by 635 people. The number increased by 2.9 thousand people in the higher professional education sector, by 639 in the non-profit sector, and by 75 people in the entrepreneurial sector.

Table 4.28. – Number of personnel engaged in research and development, by personnel category and sector of activity *people*

	2021	2022	2023	Increase/ Decrease (-)	Personnel structure, in %
Total	**21 617**	**22 456**	**25 473**	**3 017**	**100**
researchers	17 092	18 014	21 534	3 520	84,5
technicians	2 824	2 783	2 446	-337	9,6
others	1 701	1 659	1 493	-166	5,9
including by sectors of activity:					
public sector	*7 611*	*6 614*	5 979	-635	23,5
higher professional education sector	*8 157*	*10 525*	13 463	2 938	52,9
entrepreneurial sector	*3 975*	*3 255*	3 330	75	13,1
non-profit sector	*1 874*	*2 062*	2 701	639	10,6

According to the Bureau of National Statistics of the ASP&R RK

As in previous years, the largest number of researchers are involved in the natural sciences – 6.5 thousand people (30.3%). The field of engineering and technology accounts for 5.1 thousand people (23.9%), the humanities – 4.1 (18.9%), the social sciences – 2.3 (10.5%), agricultural sciences – 1.8 (8.4%) and medical sciences – 1.7 thousand people or 8.0% each (Table 4.29).

Table 4.29. Distribution of research specialists by branches of science for 2023

people

Indicators	Total	of which by branches of science					
		Natural	Engineer-ing and technology	Medical	Agricu ltural	Social	Human itarian
Research specialists	21 534	6 534	5 141	1 722	1 805	2 259	4 073
of which those with a degree							
Doctor of Science	2 060	615	346	192	158	210	539
Candidate of Science	4 837	1 352	849	432	465	582	1 157
Doctor of Philosophy PhD	3 456	1 042	848	263	217	471	615
Doctor of Science in the field	85	42	5	28	3	5	2
Master	6 708	1 979	1 686	404	589	837	1 213
Reference: *Provision of* ***highly*** *qualified scientific personnel, persons per 1000 research specialists*	610	592	478	677	565	725	735

According to the Bureau of National Statistics of the ASP&R RK

The provision of highly qualified scientific personnel per 1000 research specialists in the field of humanities as a whole amounted to 735 people, social sciences - 725, medical - 677, natural sciences - 592, agricultural - 565 and in the field of engineering developments and technologies - 478 people. It should be noted that candidates of sciences dominate over all other highly qualified scientific personnel in all branches of science.

The effectiveness of scientific research is determined not only by the content and methods of conducting and implementing its results, but also by the qualifications of the scientist, which depends both on his personal qualities and on the effectiveness of the system for training and certification of scientific personnel. The training process is of the nature of reproduction of scientific personnel, carried out according to postgraduate education programs including two levels: master's and doctoral studies

In the 2023/2024 academic year, 105 organizations trained master's students, and 75 doctoral students (Table 4.30).

Table 4.30. – Number of organizations training scientific and teaching staff

units

	2021/2022 academic year	2022/2023 academic year	2023/2024 academic year
Master's degree	102	105	105
Doctorate	74	73	75

According to the Bureau of National Statistics of the ASP&R RK

As can be seen from the statistics, the number of organizations with master's degree programs remained unchanged, while doctoral programs increased by 2 units.

Doctoral studies. An average of 1.7-1.8 thousand doctoral students are admitted to doctoral studies every year, while the average graduation rate from doctoral studies over the past five years is 1.6 thousand people. Doctoral studies are accompanied by attrition and extension of the term. Thus, in the 2023-2024 academic year, the number of people who dropped out before completing their studies was 424 people, and the number of students who underwent training beyond the established term was 104. Losses during the training period amounted to an average of 9% of the total number.

Meanwhile, as noted by competent sources, a high attrition rate can be considered as "natural selection" and is not a minus in the work of doctoral studies. At the beginning of the 2023/2024 academic year, 5966 people were registered in doctoral studies, of which 3712 people, or 62.2%, were women. The number of doctoral students accepted in the reporting year was 1686 people. The number of doctoral students graduated was 1854 people, of which 1652 people were studying under a state order. During the period of study in doctoral studies, 219 people, or 11.8%, defended their dissertations. The number of doctoral students in the specialized field is 233 people and doctoral students in philosophy (PhD) - 5733 people. (Table 4.31).

Table 4.31. – Number and graduation of doctoral students *people*

	2021	**2022**	**2023**
The number of doctoral students (at the end of the year) – total	5924	6156	5966
included:			
doctoral students according to their profile	144	135	233
doctoral students	5780	6021	5733
Doctoral student admission – total	1 720	1711	1686
included:			
doctoral students according to their profile	39	35	74
doctoral students	1981	1676	1612
Graduates of doctorates - total	2503	1536	1854
Defended a thesis from the total graduation*	642	234	219

According to the Bureau of National Statistics of the ASP&R RK

**Here and below – the number of persons who defended dissertations during the period of doctoral training (i.e. within the period of doctoral studies specified in the order of enrollment)*

In general, the dynamics of doctoral training is quite stable and is carried out in higher professional education organizations under programs aimed at training personnel for scientific, pedagogical and (or) professional activities, with the award of the degree of Doctor of Philosophy (PhD), doctor in the profile. However, the low proportion (23%) of students who defended their dissertation during the period of study is a problem of preparation in doctoral studies and requires a more careful study and appropriate decision.

The data show that the number of doctoral students compared to the previous year - 2022/2023 has decreased by 190 people.

The main contingent of students is PhD students - 96.1% (in the previous year it was 98%), and the share of doctoral students in the profile accounts for about 3.9%.

The most represented in terms of the number of students in doctoral studies in the 2023-2024 academic year are engineering, manufacturing and construction industries (1,054 people), followed by pedagogical sciences with 836 people, business, management and law - 832 people. The list of training areas is closed by veterinary science with 47 people, services - 86 people, agriculture and bioresources - 144 people. And it should be especially noted that only 125 doctoral students receive the highest scientific qualification in the training area National Security and Military Affairs (Table 4.32)

Table 4.32. – Preparation of doctoral students in the 2023/2024 academic year in the following areas

Area's name	Doctoral students accepted in the reporting year		Number of doctoral students		Doctoral students graduated in the reporting year, total	of which		
	total	of which women	total	of which women		women, total	with a dissertation defense	
							total	of which women
Educational Sciences	212	162	836	669	335	264	21	18
Arts and Humanities	177	121	622	447	207	146	14	12
Social Sciences, Journalism and Information	93	61	346	221	128	92	7	6
Business, Management and Law	218	105	832	438	186	122	48	28
Natural Sciences, Mathematics and Statistics	181	117	676	465	304	210	25	17
Information and Communication Technologies (ICT)	92	39	328	144	103	59	6	3
Engineering, manufacturing and construction industries	303	165	1 054	566	283	145	17	10
Agriculture and bioresources	35	24	144	88	59	29	2	1
Veterinary science	15	10	47	33	18	15	2	2
Health care and social security (medicine)	162	119	456	327	146	105	55	39
Services	23	16	86	56	12	7	-	-
National security and military affairs	54	7	125	32	51	9	-	-

According to the Bureau of National Statistics of the ASP&R RK
**In the Nazarbayev University report, the number of doctoral students is not distributed by specialty*

Not all graduates *graduated* with a dissertation defense *in any of the specialties*.

The number of doctoral students who defended their dissertations was higher than the national average in two specialties: business, management and law, as well as health care and social security (medicine).

An analysis of the gender composition of doctoral students shows that women significantly predominate in most specialties. A numerical advantage of men is noted only in information and communication technologies and national security and military affairs.

According to the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 3,286 master's students from the CIS countries are studying in educational institutions of the republic. In addition, 626

master's students are studying from non-CIS countries. The largest number of foreigners came from China - 333, Afghanistan - 96, Nigeria - 44, Pakistan - 6.

347 people from the CIS countries are studying for a doctorate, 184 people are from non-CIS countries. The increase in the number of foreign master's and doctoral students can be considered a positive phenomenon. In most international rankings, one of the most important criteria for assessing a university is international student and teaching mobility - the share of foreign students in relation to the total number of students at the university. In the future, foreign students may be of interest for joint scientific research.

Conclusions. Analysis of statistical data on scientific potential shows that the expansion of the network of organizations and a significant increase in the number of both general personnel and research specialists can be noted as a positive phenomenon. This *formally* demonstrates the successful implementation of the action plan for the implementation of the Concept of Science Development.

However, a detailed examination of this phenomenon shows that despite the fact that Kazakhstan presents itself as a state with a market economy, where competition and entrepreneurship are the driving factors of development, there is a transfer of organizations from private to state ownership, thereby reducing initiative activity.

Meanwhile, the national priority 8 "Building a diversified and innovative economy" of the National Development Plan of the Republic of Kazakhstan until 2025 sets the goal of reducing the role of the state as an owner and regulator in industries to healthy competition between private entities.

The main message is to revive the economy of Kazakhstan. The most important conditions for the transition to a market economy, the formation of various forms of ownership, the development of competition and entrepreneurship are denationalization and privatization of state property.

It should be noted here that 365 organizations out of 425 that submitted a report on the implementation of scientific research and development have the organizational and legal form of a limited liability partnership (LLP), a joint-stock company ("JSC") or a state enterprise on the right of economic management or operational management (state-owned enterprise), i.e. they are small or large businesses and only 60 organizations are institutions. As noted in the Entrepreneurial Code of the Republic of Kazakhstan, entrepreneurship is an independent, proactive activity aimed at obtaining net income through the use of property, production, sale of goods, performance of work, and provision of services. Entrepreneurial activity is carried out *on behalf of, at the risk and under the property liability of the entrepreneur* [390].

Therefore, for organizations engaged in scientific research, the state is obliged to externally evaluate the *results of scientific activity* and the degree of their usefulness for the state and society using various instruments, as well as to form effective external control over the effectiveness of budget expenditures on scientific projects [391].

The system of training highly qualified scientific personnel is noteworthy. Despite the fact that candidates and doctors of science have not been trained in Kazakhstan for more than 12 years, the influx of these specialists into science in Kazakhstan is very high. The number of candidates of science still exceeds all other

highly qualified scientific personnel. Their influx after graduation this year was in second place, immediately after PhD doctors, whose training is carried out in Kazakhstan. The question of why and where Kazakhstani personnel receive this level of higher scientific education also requires a more in-depth study and decision-making.

A small number of postgraduate graduates continue to enter the field of scientific research. Thus, out of 1.9 thousand people who graduated from doctoral studies in 2023, including 219 who defended their dissertations, only 190 people entered the field of scientific research. This rate of personnel renewal does not compensate for losses due to attrition due to natural causes, such as retirement, since the number of pre-retirement and retirement age personnel makes up a quarter of all employees engaged in research.

5. ANALYSIS OF FINANCING SCIENTIFIC RESEARCH AND DEVELOPMENT (*carried out from state budget funds, attracting financial resources to science from the private sector*)

According to preliminary data, the Physical Volume Index (PVI) of the Gross Domestic Product (GDP) for 2023 compared to 2022 amounted to 105.1%, and remained at the level of the operational GDP estimate. In the structure of GDP, the share of goods production is 36.3%, services - 56.4%.

Statistical data show that the volume of gross domestic product (GDP) produced for January-December 2023 (according to preliminary data) amounted to 120,561 billion tenge. Compared with the corresponding period of the previous year, it increased in real terms by 18.8% (Table 5.33).

Table 5.33. – Structure of gross domestic product.

	January-December, million tenge*	Compared to the corresponding period of the previous year		As a percentage of the total
		physical volume index	deflator	
2022				
Gross Domestic Product	**101 522 983,7**	**103,2**	**117,2**	**100**
Production of Goods	*40 335 725,5*	*103,2*	*115,5*	*39,8*
Production of Services	*53 407 849,7*	*102,6*	*115*	*52,5*
Gross Value Added	**93 743 575,2**	***102,9***	***115,2***	***92,3***
Net Taxes on Products	*7 779 408,5*	*107,9*	*148,5*	*7,7*
2023				
Gross Domestic Product	**120 561 096,4**	**105,1**	**111,4**	**100**
Production of Goods	*43 821 781,4*	*103,8*	*101,1*	*36,3*
Production of Services	*67 898 144,3*	*105,8*	*119,3*	*56,4*
Gross Value Added	**111 719 925,7**	***104,9***	***111,4***	***92,7***
Net Taxes on Products	*8 841 170,7*	*107,9*	*110,8*	*7,3*

According to the Bureau of National Statistics of the ASP&R RK

** According to preliminary data. After clarification of quarterly statistical observations in the service industries for which monthly data were missing, and supplementation with administrative data, which are also missing, the operational assessment of GDP will increase.*

GDP is mainly the sum of the value of goods in the production sector of the economy and the costs of providing services, including professional scientific and technical activities, including ***R & D costs***, i.e. *costs incurred in the search for new knowledge and its translation into new products or processes as they arise*.

The ratio of production of goods and production of services in GDP for 2022 was 36.3% and 56.4%, respectively. The main share of the production of goods in GDP is industry - 26.4%.

According to statistics compiled from reports of implementing organizations, in 2023, research and development costs amounted to 172.6 billion tenge, including 144.0 billion tenge allocated from the republican budget.

However, despite such significant investments in research activities, Kazakhstan occupies a rather low position compared to other countries of the world. Thus, according to the latest data, total global R&D spending in 2022 was almost $2.5

trillion in purchasing power parity terms. According to the data, the top five R&D spenders include all major economies: the United States, followed by China, Japan, Germany, and the Republic of Korea. However, when spending is considered as a share of total gross domestic product, smaller high-tech economies such as Israel and South Korea invest a larger share of their GDP in R&D[1].

As part of the Sustainable Development Goals, most countries in the world, including Kazakhstan, have committed to significantly increasing R&D spending and the number of researchers by 2030.

Information: *Domestic expenditure on research and development (R&D) as* ***a share of gross domestic product*** *(GDP) – characterizes the contribution of science to GDP, and not the funding of scientific research. R&D expenditure shows the volume of the produced scientific product, which as an intangible object is measured by the costs of its production*.

An analysis of the R&D cost structure allows us to understand the ways and possibilities of regulating them.

The GDP research intensity in Kazakhstan in 2023 was 0.14% and, according to the UNESCO Institute for Statistics, it ranks among the last countries in the world in this indicator (Fig. 5.19). At the same time, the share of public investment in R&D in Kazakhstan was 75%. Consequently, investments from all other sources amount to only 25%. For comparison, in countries with developed economies, 60-75% of research and development funding is provided by the business sector of the economy. The state budget provides no more than 40% of the costs.

Public funding plays a significant role in stimulating and supporting R&D. First of all, this is justified by the fact that the creation of new scientific knowledge requires significant investment, and the guarantees of its commercialization and income generation are very insignificant.

This is precisely what hinders the active participation of the business sector in investments in scientific research. They are reluctant to take risks, since for entrepreneurs the only source of income is the funds received from their own activities. In general, the overall picture of funding sources demonstrates the process of the state displacing all other sources. Thus, if three years ago the share of budget funds averaged 65%, then in 2023 it already amounted to 83.4%.

Having studied the relationship between funding sources and R&D performance, analysts at the UNESCO Institute for Statistics came to the conclusion that an increase in government funding leads, firstly, to an inefficient use of resources; secondly, it suggests that strategic R&D goals are either irrelevant or unattractive to entrepreneurs.

International practice shows that at the stage of fundamental research, the main source of funding should be either the state or its significant participation. But as we move from fundamental research to applied or experimental design, the share of state participation should decrease.

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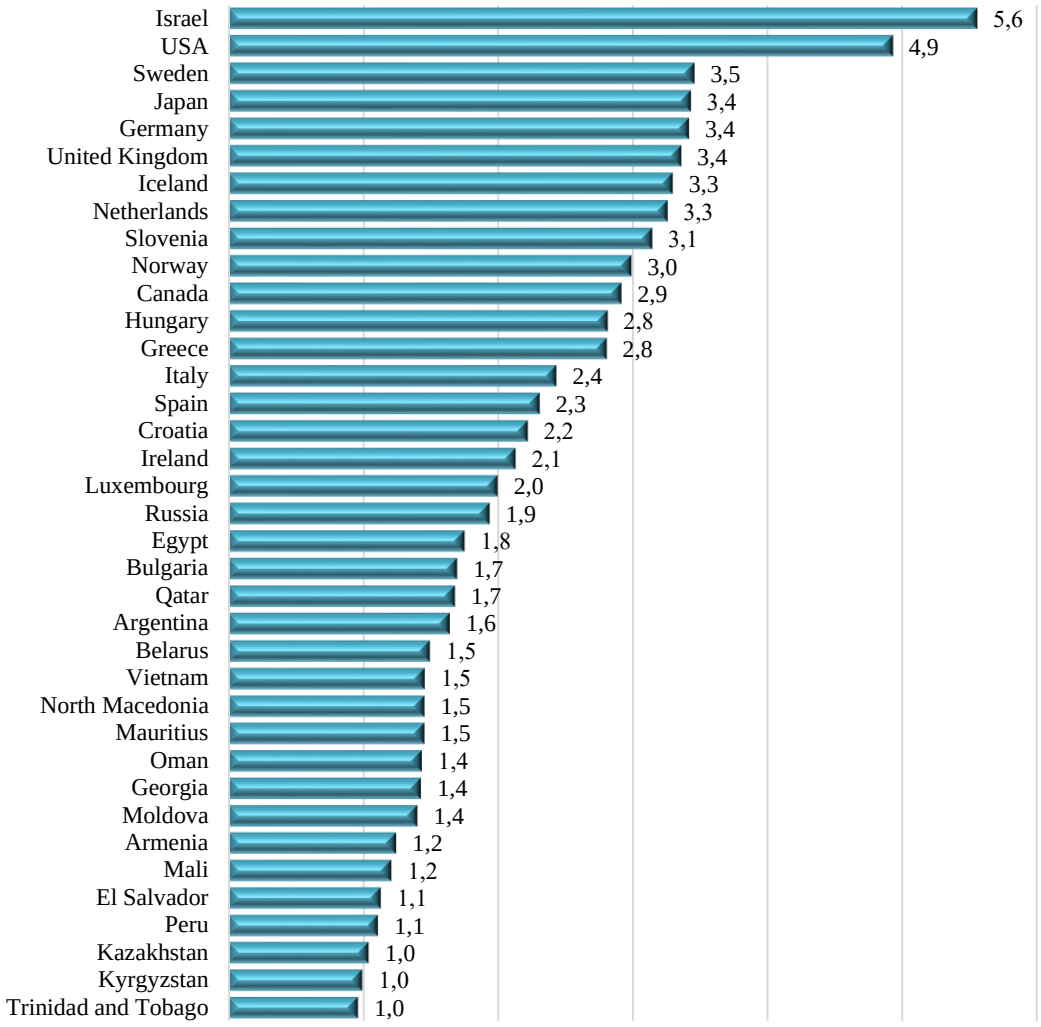
[1] *Source: Research and Development Worldwide – Statistics and Facts; https://www-statista-com.translate.goog/?_x_tr_sl=en&_x_tr_tl=ru&_x_tr_hl=ru&_x_tr_pto=sc&_x_tr_hist=true#topicOverview*

% to GDP



Source: UNECE SDG Knowledge Hub: Sustainable Development Goals.
Indicator 9.5.1. Статистические данные СИЮ (unesco.org)

Figure 5.19. – GDP Science Intensity by Country

As stated above, in Kazakhstan the main source of R&D funding is the state. In 2023, the volume of budget funds increased by 77 billion tenge, reaching 144 billion tenge (Table 5.34).

Table 5.34. Sources of financing for internal R&D costs

bln tenge

	2021	2022	2023
All costs, billion tenge	109,3	121,6	172,6
of which:			
budget funds	64,5	67,0	144,0
own funds of scientific organizations	36,5	43,0	12,7
foreign investments	2,1	2,8	2,9
bank loans	0,04	0,1	0,1
funds of legal entities	4,5	6,5	8,8
other sources of financing, including funds of legal entities (except for development institutions)	1,7	2,2	4,1
All costs, %	**100**	**100**	**100**
of which by funding source:			

budget funds	59,0	55,1	83,4
own funds of scientific organizations	33,3	35,4	7,3
foreign investments	1,9	2,3	1,7
bank loans	0,1	0,1	0,1
funds of legal entities	4,1	5,3	5,0
other sources of financing, including funds of legal entities (except for development institutions)	1,6	1,8	2,3

According to the Bureau of National Statistics of the ASP&R RK

For example, in Israel, the country with the highest share of R&D expenditure in GDP, fundamental research accounts for 8.9%, applied research - 10.0%, and R&D - 81.1%; in the Republic of Korea – 14.8, 21.0, 64.2%, the USA – 14.8, 18.1, 67.1% respectively. At the same time, in general, state funds in Israel make up only 8.9%, in the Republic of Korea – 22.8%, in the USA – 19.9%, while funds of entrepreneurs in these countries make up 40.0%, 76.1%, 67.9%.[2]

The level of participation in R & D financing by entrepreneurs in Western countries is quite high, which indicates the interest of business in introducing innovations into production, i.e. business in these countries is the main driving force of innovative development.

To understand the current situation in financing scientific research in Kazakhstani science, it is necessary to analyze the degree of integration of the R & D sphere into the economic system. Economists propose to identify three main types of relationships between the R & D sphere and the country's economy:

a) knowledge and innovation are an integral part of the country's economy;

b) knowledge and innovation have a certain independence, autonomy, but at the same time there is sufficient application of their results in the economic activity of the country;

c) knowledge and innovation are separated from the economy [392].

The interaction of science and economy in the Republic of Kazakhstan belongs to the third type, i.e. knowledge and innovation are separated from the economy. Therefore, the task of the state is to ensure the involvement of R & D results in the country's economy and to provide an ***adequate*** share of R & D expenditures from the state budget in the total volume of expenditures, as well as to promote demand for research results and ensure funding for scientific research from private investors.

However, the problem of moving away from the third type of interaction between science and economy in the Republic of Kazakhstan is that the share of the main consumer of R & D results - the manufacturing sector - in the GDP is decreasing from year to year. The production of goods that can be conditionally classified as knowledge-intensive, such as computers, electronic and optical equipment, is decreasing. The production of various machines, electrical and other equipment, wagons, etc. has decreased. The production of knowledge-intensive products, such as space technology, aircraft manufacturing, shipbuilding, production of electronic control systems, robots, flexible automated lines, some types of chemical production,

[2] ***Science Indicators: 2024****: statistical collection / L. Gokhberg, K. Ditkovskiy, M. Kotsemir etc..; Nat. reserach. univ-ty « Higher School of Economics ». – M.: IRIEK of HSE, 2024. – 412 p. – 300 pcs. – ISBN 978-5-7598-3015-3*

genetic engineering, microbiology, etc. does not exist at all, although Kazakhstani scientists have achieved significant success in genetic engineering and microbiology. Investment in scientific and (or) scientific and technical activities from the state budget in Kazakhstan is carried out in the form of basic, grant and program-targeted financing. In addition, since 2023, scientific organizations carrying out fundamental scientific research have been financed from the state budget (Table 5.35).

Table 5.35. Internal costs directed to the implementation of R&D, from the republican budget, by forms of financing

Indicators	2021	2022	2023	Total
Total from the republican budget	64 542,5	67 014,7	144 050,6	275 607,9
of which:				
Basic	5 715,2	5 711,1	8 236,7	19 663,0
Grant	19 608,5	30 281,8	51 184,3	101 074,60
Program-targeted	34 358,9	31 021,8	64 959,3	130 340
Commercialization grants	4 860	0	16 751,142	21 611,142
Financing of scientific organizations conducting fundamental scientific research	-		2 919,1	2 919,1

According to the Ministry of Finance of the Republic of Kazakhstan

As the data show, the cost structure by forms of financing has changed significantly over time.

Basic financing amounts to 8.2 billion tenge, grant financing - 51.2 billion tenge, and program-targeted financing - 64.9 billion tenge. In addition, 2.9 billion tenge were allocated from the budget to finance scientific organizations conducting fundamental research. Basic financing includes expenses for the current maintenance of scientific infrastructure and property, including buildings, equipment, materials, salaries of administrative service personnel, as well as information support for the scientific and technical activities of entities.

In general, basic financing is allocated to state scientific organizations or equivalent state, state higher education institutions that carry out a state assignment and (or) a state order for scientific research in priority areas determined by the Scientific and Technical Committee under the Government of the Republic of Kazakhstan.

Grant funding is provided free of charge and irrevocably from the state budget for the implementation of fundamental and applied scientific research and is carried out on a competitive basis within the funds provided in the state budget. In 2023, the costs of research within the framework of grant funding amounted to 51.2 billion tenge.

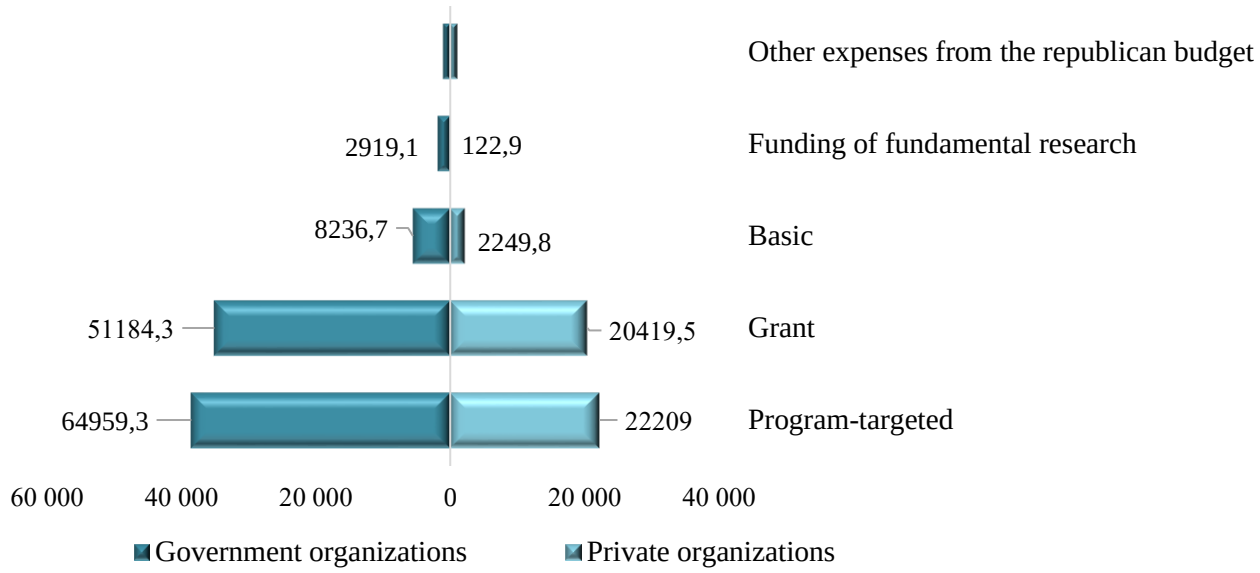
Any accredited subjects of scientific and (or) scientific and technical activities have the right to participate in the competition for grant funding on equal terms, therefore this type of funding was fairly evenly distributed between public and private organizations.

Program-targeted funding is aimed at solving strategically important state tasks and is carried out on a competitive basis or by decision of the Government of the Republic of Kazakhstan outside of competitive procedures. The basis for program-targeted funding of scientific research are strategic plans for the socio-economic

development of the country, industrial and innovative development programs and other programs aimed ***at implementing strategically important state tasks***.

The data show that the main focus of public investment is program-targeted and grant projects, which account for 47% and 43% of the total funding. Basic funding is 6%, funding for scientific organizations conducting fundamental scientific research is 2%, and other expenses from the republican budget related to research and development are 2%. According to statistics generated from reports of organizations performing R&D, in 2023, basic funding for state organizations amounted to 8.2 billion tenge compared to 2.2 billion tenge for private organizations (Fig. 5.20).

Mio. Tenge



According to the Bureau of National Statistics of the ASPR RK

Figure 5.20. R&D funding from the republican budget in 2023, by types of ownership of organizations

Expenditures on program-targeted financing increased almost 2 times, most of them (63%) went to the implementation of scientific, scientific and technical programs carried out in state-owned organizations (Fig. 5.21).

Over the same period, the volume of grant financing of state organizations was 1.7 times higher than the volume of financing of private ones, amounting to 51 billion tenge. Considering state financing by types of ownership of organizations, there is a decrease in the share of expenses on scientific projects carried out by private organizations from 43% in 2022 to 36% in 2023.

In 2023, 180 programs and 2488 projects were implemented in Kazakhstan. Based on the data provided by statistics on the amounts received by performers in the form of grant and / or program-targeted financing, we get an average of 22.3 million tenge per project per year, 337 million tenge per program. To understand how financially supported these studies are, we can compare them with the average monthly nominal salary of workers in such activities as professional, scientific and technical activities, which include scientific research and development, which is equal to 526,267 tenge. It turns out that grant funding for one project is approximately equal to the annual salary of 3.5 people, and for one program, in which more than one scientific team can participate, it is equal to 53.5 people.

Mio. tenge

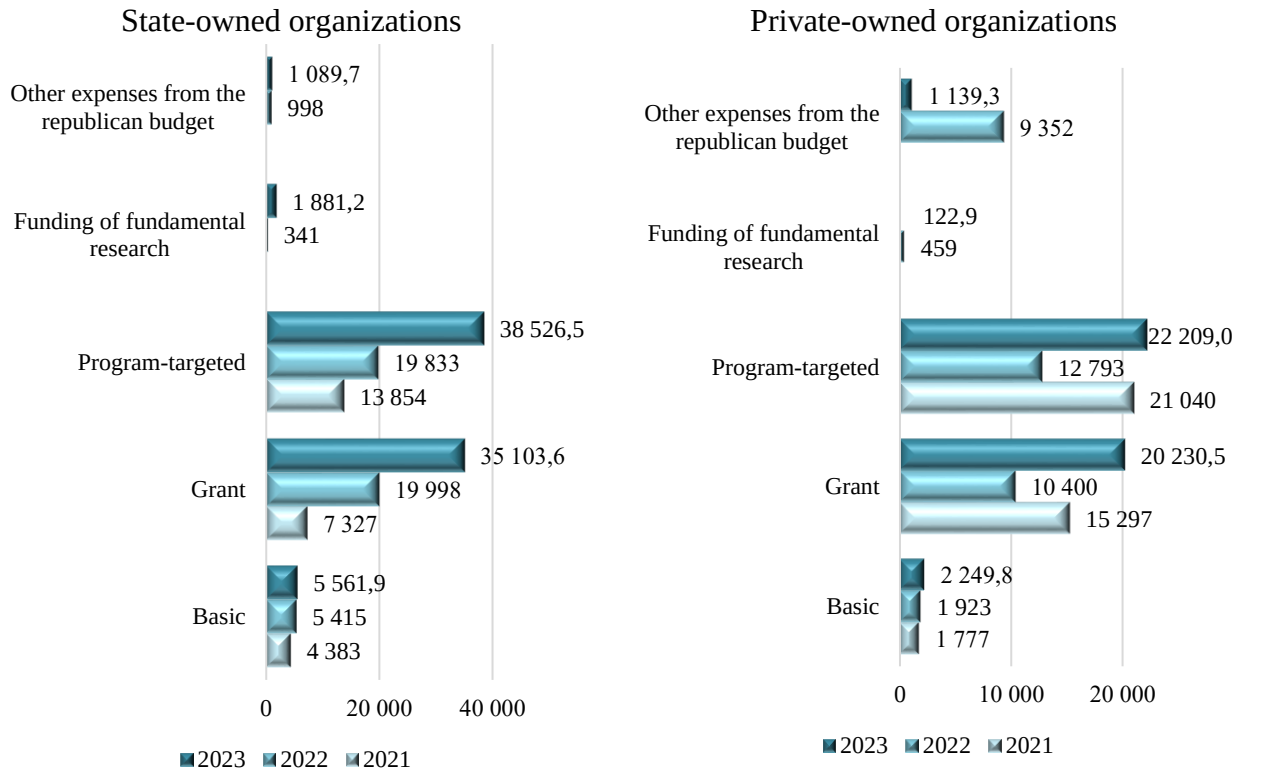


Figure 5.21. Dynamics of financing internal R&D costs by types of ownership of organizations for 2019-2023.

Mandatory payments, such as wages and expenses for raw materials and supplies, rent used in research, account for about 80%. And there is no money left for the development and renewal of fixed assets (machinery, equipment, etc.). Perhaps it is worth reducing the number of simultaneously performed studies carried out at the expense of public funds, which will increase the costs of the R&D carried out.

The second main source of R&D funding is the organizations' own funds, but in 2023 they decreased, amounting to only 7.3% of the total funds for research. This is the lowest figure in the last decade. In general, these two sources accounted for 91% of all R&D costs in 2023.

In order to achieve the goals of increasing R&D expenditures financed from all sources to 1% of GDP, set by the Concept for the Development of Higher Education and Science in the Republic of Kazakhstan for 2023-2029 (approved by the Government of the Republic of Kazakhstan dated March 28, 2023, No. 248), it is necessary to study the formation of costs by items.

According to the Methodology for the formation of statistical indicators for research and development work and innovation [393], the volume of R&D costs is equal to the costs of the following items: wages, purchase of services, fixed assets, other current costs (Table 5.36).

Table 5.36. – Internal R&D costs by cost items in 2023.

Mio. tenge

Indicator	**Total**	Public sector	Higher professional education sector	Business sector	Non-profit sector
Internal R&D costs, total	**172 585,9**	**49 686,1**	**68 338,3**	**35 509,7**	**19 051,8**
Labor costs	87 195,6	27 234,9	37 330,9	13 750,0	8 879,8
Purchase of services (for own projects)	20 880,2	4 632,0	8 082,6	4 453,2	3 712,5
Costs of fixed assets (machinery, equipment, buildings, etc.)	25 154,2	6 517,2	8 908,0	6 935,1	2 794,0
of which costs of acquiring scientific equipment	9 787,7	3 213,6	4 587,4	1 319,3	667,4
Other current costs (consumables, raw materials and equipment, rent, etc.)	39 355,8	11 302,0	14 016,8	10 371,5	3 665,5
External R&D costs	**33 179,6**	**1 902,1**	**863,3**	**27 909,8**	**2 504,4**

According to the Bureau of National Statistics of the ASPR RK

According to global standards, the cost of paying wages to personnel performing R&D constitutes the largest part of current costs. Remuneration includes wages and other related payments and costs: bonuses, vacation pay, contributions to pension funds and other deductions to social insurance funds, labor taxes.

In 2023, labor costs amounted to almost 87.2 billion tenge, which exceeds the previous year's figure by 28.7 billion tenge or 49%. The increase in costs is noted in all sectors. The growth in labor costs in nominal terms increased their share in internal costs by 2.4 percentage points, amounting to 50.5% in 2023. The average monthly salary of employees performing R&D in 2023 amounted to 285 thousand tenge (Table 5.37).

Table 5.37. – Average monthly wages of employees performing R&D by sector of activity

Thous. tenge

Year	By organizations engaged in R&D	Including			
		Public sector	Higher professional education sector	Business sector	Non-profit sector
2021	187,7	201,3	95,5	318,4	256,1
2022	217,0	270,9	151,6	256,5	315,5
2023	285,3	379,6	231,1	344,1	274,0

Calculated based on data from the Bureau of National Statistics of the ASPR RK

However, taking into account the full-time equivalent of employees performing R&D, equal to 0.66, the average monthly nominal wage was 432 thousand tenge. The average monthly wage of one employee in the Republic of Kazakhstan for 2023 was 394 thousand tenge and approached the average monthly nominal wage of employees in the type of activity "Professional, scientific and technical activities", equal to 526,267 tenge [394].

The average wage is in public sector organizations, the lowest - in the higher education sector, but it should be borne in mind that most researchers are engaged in teaching and the full-time equivalent in this sector was only 0.49, i.e. taking into account the FTE, the wages of employees in the higher education sector are twice as high. In 2023, budgetary allocations for research significantly exceeded inflation.

For information: *according to the Bureau of National Statistics of the ASPR of the Republic of Kazakhstan, annual inflation in 2023 amounted to 9.8% [395].*

The next item of expenditure is the purchase of services (for own projects). 20.9 billion tenge was used for this item of expenditure, which is 5.5 billion tenge more than in the previous year. Despite a significant increase in expenses under this item, its share in the total volume of financing decreased by 0.6 percentage points, amounting to 12.1% of total expenses.

Costs of fixed assets amounted to 25.2 billion tenge or 14.6% of total R&D expenses. Compared to the previous year, expenses under this item increased by 2.2 times or by 5.3 percentage points. Here it should be noted that the costs of fixed assets increased in all sectors, but the largest costs are incurred by organizations in the higher education sector - 8.9 billion tenge and the public sector - 6.5 billion tenge.

Investments in fixed assets annually fluctuate within 8-12% of internal costs, but in 2023 they increased to 14.6% - this is the maximum in recent years.

It should be noted that in 2023, 9.8 billion tenge or 39% of costs for fixed assets were used to purchase scientific equipment. At the same time, compared to the previous year, the share of costs for scientific equipment in total costs for fixed assets decreased by 2 percentage points.

Other current costs associated with the purchase of consumables, raw materials and equipment, payment of rent, utilities and other services increased by 0.8% in 2023, amounting to 39.4 billion tenge. They accounted for 22.9% of all internal current and capital costs for the year.

In general, it is clear that the increase in costs occurred across all items.

Analysis of internal R&D costs by expenses shows that it is impossible to achieve a GDP science intensity of 1% only by increasing them. Due to the fact that the manufacturing sector of the economy of Kazakhstan, which is the main consumer of scientific developments, is significantly inferior to the service sector in GDP, it is necessary to consider the possibility of shifting the vector of scientific research from the sphere of manufacturing to the service sector.

Given the limited opportunities for maneuvering R & D costs by items, other options should be considered that contribute to an increase in the share of R & D costs in GDP. One of them is to expand the network of organizations involved in R & D.

Higher professional education organizations represent a large reserve for expanding research activities. According to state statistics, at the beginning of the 2023/2024 academic year, 112 organizations were directly involved in the training of personnel with higher or postgraduate education, the scientific potential of which was 4,168 PhD doctors, 134 doctors in the profile, 2,744 doctors of science and 10,504 candidates of science.

In addition to human resources, higher professional education organizations have the opportunity to use laboratory equipment and other material resources of educational organizations for research activities. The continuing growth in R&D expenditure in 2023 is observed in all sectors except for the business sector, whose expenditure decreased by 6.3 billion tenge (Table 5.38).

Table 5.38. – Internal R&D expenditure by sector of activity

Mio. tenge

	2021	2022	2023
Domestic expenditure on research and development, total	109 332,7	121 560,1	172 585,9
including			
public sector	37 143,6	38 025,0	49 686,1
higher professional education sector	21 194,3	37 694,9	68 338,3
business sector	38 215,7	31 921,4	35 509,7
non-profit sector	12 779,2	13 918,8	19 051,8

According to the data of Bureau of National Statistics of the ASPR RK

The R&D expenditure growth index in 2023 was 42%.

Growth below the national average was observed in all sectors except the higher professional education sector, where growth was 1.8 times. In the public sector, this figure was 30.7%, in the non-profit sector - 36.9%, in the business sector - 11.2% (Table 5.39).

Table 5.39. – Index of growth in R&D expenditures

in % to the previous year

	2021	2022	2023	Average growth for 2021-2023
Total	22,8	11,2	42,0	25,3
Public sector	28,8	2,4	30,7	20,6
Higher professional education sector	43,2	77,9	81,3	67,5
Business sector	3,8	-16,5	11,2	-0,5
Non-profit sector	49,4	8,9	36,9	31,7

Calculated based on data from the Bureau of National Statistics of the ASPR RK

The dynamics of such an irregular distribution of costs by activity sectors indicates the absence of a specific and logical plan for the development of scientific research in the country.

2023 was marked by more active development of funds by state-owned organizations. The costs of organizations amounted to more than 91 billion tenge, while the growth rate was a record in recent years - 68.5%. In the reporting year, the costs of privately owned organizations increased by 20% and amounted to 78 billion tenge.

The network of organizations performing R & D in the Republic of Kazakhstan was replenished with 6 foreign legal entities and amounted to 19 units. During the analyzed year, they spent 3.3 billion tenge (Table 5.40).

Table 5.40. - R & D costs by type of ownership of organizations

Mio. tenge

	2021	2022	2023
Total	109 332,7	121 560,1	172 585,9
State property	29 886,7	54 132,2	91 218,8
Private property	75 998,9	65 049,6	78 068,4
Foreign property	3 447,1	2 378,2	3 298,7

According to the data of Bureau of National Statistics of the ASPR RK

In 2023, there was a uniform increase in expenditure across all branches of science. Engineering and technology accounted for 34.5% of all domestic expenditure. Next came the natural sciences, which accounted for 34.1%, agricultural - 11.7, humanities - 7.5, social (public) sciences 7.4% and medical - 4.9 (Table 5.41).

Table 5.41. – Internal R&D expenditures by branches of science

Mio. tenge

Indicators	2021	2022	2023
Internal costs, total	109 332,7	121 560,1	172 585,9
including by branches of science			
Natural	31 707,0	36 030,0	58 880,4
Engineering developments and technologies (technical)	43 732,1	48 881,2	59 462,0
Medical	8 822,2	7 929,3	8 516,9
Agricultural	14 734,3	14 868,1	20 109,9
Social sciences (public)	3 037,1	4 584,5	12 721,9
Humanities	7 300,1	9 267,0	12 894,9

According to the data of Bureau of National Statistics of the ASPR RK

However, compared to the previous year, the largest increase in costs is observed in social (public) (1.8 times). Next come natural sciences with an increase in costs by 63.4%, humanities - by 39.1% and agricultural sciences - by 35.3%. Against this background, medical sciences look unattractive, the increase in costs for 2023 was only 7.4%, which did not even cover the annual inflation of 9.8%.

In 2023, costs for fundamental research increased by 20 billion tenge, for applied research - by 35 billion tenge, the volume of costs for the implementation of experimental design work decreased by 4.2 billion tenge (Table 5.42).

As can be seen from the data in the table, research costs by type do not have any specific direction. Inconsistency and lack of system in R & D costs from year to year have been taking place over a long period.

Table 5.42. – Internal R&D expenditures by types of research and development

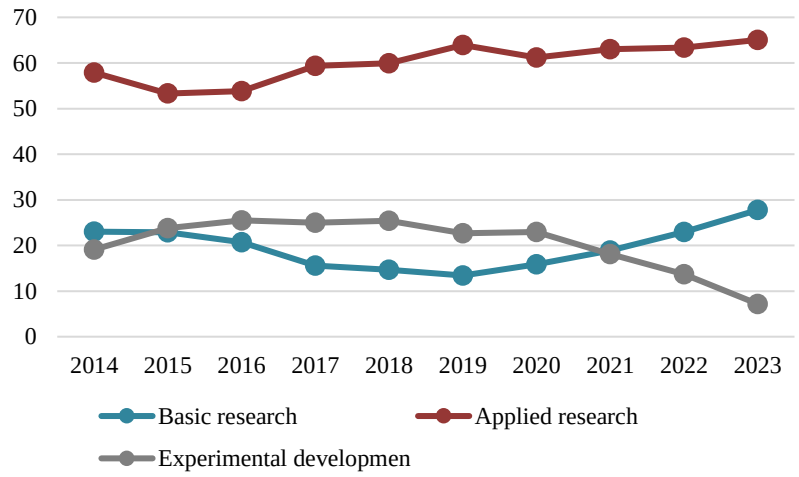
Mio. tenge

	2021	2022	2023
Internal costs, total, million tenge	109 332,7	121 560,1	172585,9
of which:			

fundamental research	20 639,8	27 907,1	47 914
applied research	68 925,7	77 041,6	112 271
experimental design development	19 767,2	16 611,4	12 401
Internal costs, %	100	100	100
of which:			
fundamental research	18,9	23,0	27,8
applied research	63,0	63,4	65,1
experimental design development	18,1	13,7	7,2

According to the data of Bureau of National Statistics of the ASPR RK

The almost twofold excess of applied research over fundamental and experimental design developments is a system (Fig. 5.22). All this indicates that there is no clear direction or system in the policy of planning scientific research. Long-term priorities that would meet the requirements of the country's economy have not been developed.



According to the data of Bureau of National Statistics of the ASPR RK

Figure 5.22. Internal costs by research type in %

The data provided by statistics are based on international standards adopted in all countries of the world, developed and approved by the OECD Committee on Science and Technology Policy (CSTP) and the OECD Committee on Statistics and Statistical Policy (CSSP).

According to the results of 2023, the following percentage ratio of fundamental, applied and experimental design developments was formed: 28/65/7. It follows from this that the costs of fundamental research, both in nominal terms and in proportion, exceeded the costs of experimental design developments by four times.

Basic research is experimental or theoretical work undertaken primarily to gain new knowledge about the fundamental basis of phenomena and observed facts, without any specific application or use in mind;

Applied research is original research undertaken to gain new knowledge. However, it is directed primarily toward a specific, practical goal or objective. Applied research is undertaken either to determine the possible uses of the results of basic research or to determine new methods or ways of achieving specific and predetermined goals. The results of applied research are intended primarily to confirm their possible application to products, operations, methods, or systems.

Experimental developmentis systematic work, building on knowledge gained from research and practical experience, and generating additional knowledge that is directed toward producing new products or processes or toward improving existing products or processes. (Ист. OECD (2015), Frascati Manual 2015: Guidelines for Collecting and

Reporting Data on Research and Experimental Development, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris. (п.1.35, п. 2.30, п. 2.31) DOI: http://dx.doi.org/10.1787/9789264239012-en

Meanwhile, in the Republic of Kazakhstan there is a law "On the commercialization of the results of scientific and (or) scientific-technical activity" (RSTA), where the commercialization of RTA is defined as an activity related to the practical application of the results of scientific and (or) scientific-technical activity, including the results of intellectual activity, with the aim of bringing new or improved goods, processes and services to the market, aimed at generating income. This concept correlates with the internationally accepted definition of experimental design and development.

In 2023, 137 organizations reported on their RTA commercialization activities, including 37 research institutes, 49 universities, 23 organizations for which research and development is a secondary activity, and 28 affiliated individuals and legal entities. After the adoption of the Law on Commercialization, an increase in R&D costs to 25.5% of the gross R&D costs in the country was observed already in 2016 (Fig. 5, 7). At the same time, the level of costs of the year under review was not surpassed in the subsequent years. 2023 turned out to be unsuccessful, since the share of experimental design work in the total R&D costs was only 7.2%, which is half as much as in the previous year, 2022, and 3.5 times less than in 2016. The main investors in R&D in 2023 were the organization's own funds (5 billion tenge), the state budget (3.7 billion tenge), funds of third-party legal entities (3.4 billion tenge), foreign entities (0.1 billion tenge) and other sources (0.2 billion tenge). The current situation suggests that the commercialization of R & D results is losing its significance from year to year.

The adoption of the Law on the financing of scientific organizations carrying out fundamental scientific research from the state budget has led to an even greater expansion of fundamental research, including in the regions, to the detriment of other types of R & D. It should be noted that in most regions there is a low provision of research specialists and a low full-time equivalent.

According to the results of 2023, only in the Zhambyl, Mangystau, North Kazakhstan and East Kazakhstan regions did R & D costs exceed the costs of fundamental research. The total share of fundamental and applied research in the regions significantly exceeds 64%, and in the Akmola, Kyzylorda and Ulytau regions it was 100%. (Table 5.43).

Table 5.43. Characteristics of research provision in the regions of the Republic of Kazakhstan in 2023

Region	Internal costs, total, million tenge	Fundamental research, million tenge	Research specialists, people	Full-time equivalent	Share of research expenditure in the region by research type, %		
					Funda-mental	Applied	R&D
Republic of Kazakhstan	172 585,9	47 914,1	21 534	0,65	27,8	65,1	7,2
Abai Region	5 802,0	824,4	951	0,47	14,2	84,2	1,5

Akmola	3 187,2	60,2	511	0,89	1,9	98,1	0,0
Aktobe	1 918,0	868,2	432	0,61	45,3	34,8	20,0
Almaty	2 300,5	433,9	217	0,90	18,9	81,0	0,1
Atyrau	620,5	200,3	128	0,49	32,3	67,0	0,0
West Kazakhstan	1 393,7	91,0	366	0,43	6,5	93,0	0,4
Zhambyl	4 801,8	84,7	362	0,95	1,8	82,8	15,4
Zhetysu Region	217,5	89,2	333	0,50	41,0	51,2	7,8
Karaganda	7 816,0	2 137,3	1 141	0,52	27,3	67,9	4,8
Kostanay	1 305,0	374,9	394	0,40	28,7	47,8	23,5
Kyzylorda	1 170,5	528,8	387	0,47	45,2	54,8	0,0
Mangistau	13 576,7	96,0	631	1,00	0,7	86,4	12,1
Pavlodar	1 226,8	416,2	390	0,46	33,9	42,2	23,8
North Kazakhstan	1 144,0	17,9x	115	0,54	1,6	67,8	30,6
Turkestan	1 018,3	380,6	310	0,95	37,4	34,0	0,0
Ulytau Region	189,3	164,3	13	1,00	86,8	13,2	0,0
East Kazakhstan	8 219,1	743,7	735	0,66	9,0	55,2	35,8
Astana	36 665,3	13 973,7	4 246	0,69	38,1	58,4	3,5
Almaty	77 204,1	26 136,1	8 699	0,70	33,9	62,1	4,0
Shymkent	2 809,6	292,7	1 173	0,51	10,4	73,2	0,0

According to the data of Bureau of National Statistics of the ASPR RK

R&D is one of the main factors determining economic growth in developed countries producing industrial products of the fifth and higher technological levels. The share of costs for experimental design development in these countries reaches 78%, and the ratio of fundamental, applied and experimental design development corresponds, on average, to the following layout: 15/35/50.

In 2023, a decrease in costs occurred only in the North Kazakhstan region by 7.7 billion tenge; in all the others, growth was noted (Table 5.44).

Table 5.44. Internal R&D expenditures by region

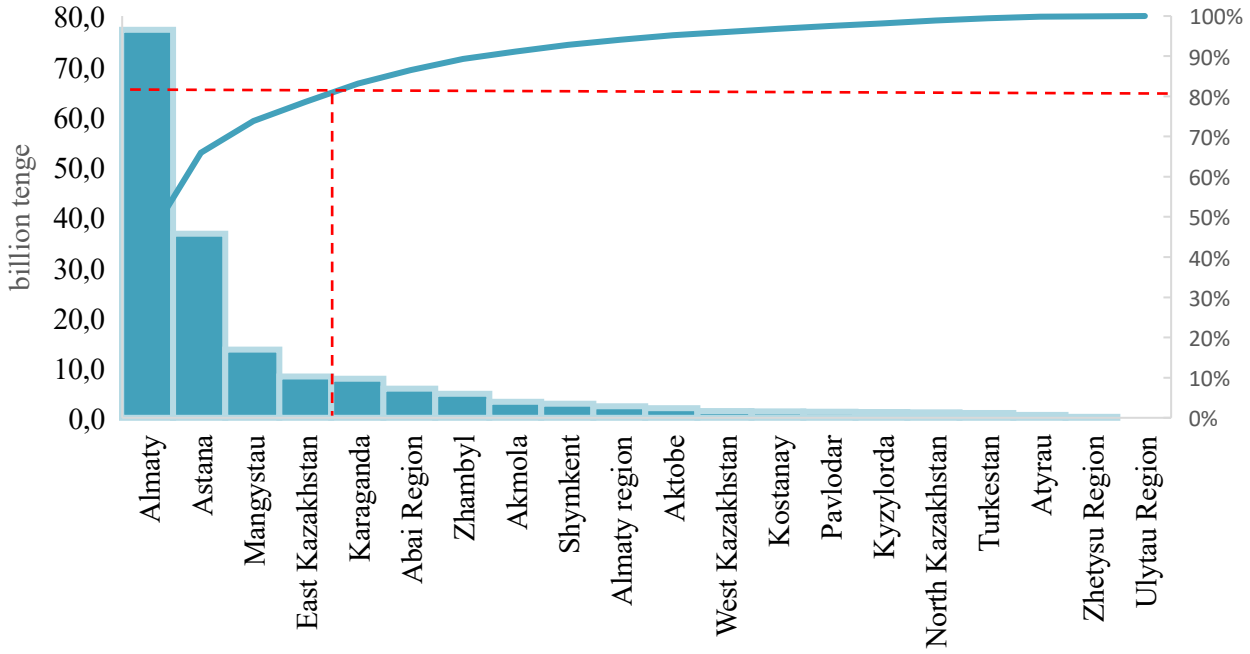
Mio. tenge

Region	2021	2022	2023
Republic of Kazakhstan	**109 332,7**	**121 560,1**	**172 585,9**
Abai Region	0,0	3 996,7	5 802,0
Akmola	1 695,2	1 736,1	3 187,2
Aktobe	1 604,2	1 596,9	1 918,0
Almaty	1 547,7	1 148,7	2 300,5
Atyrau	6 412,1	467,8	620,5
West Kazakhstan	1 298,7	994,7	1 393,7
Zhambyl	5 881,5	3 574,0	4 801,8
Zhetysu Region	X	127,2	217,5
Karaganda	4 718,8	5 363,5	7 816,0
Kostanay	1 091,3	1 036,8	1 305,0
Kyzylorda	429,3	526,6	1 170,5
Mangistau	11 089,6	13 521,0	13 576,7

Pavlodar	604,0	829,9	1 226,8
North Kazakhstan	411,1	8 839,7	1 144,0
Turkestan	719,9	659,9	1 018,3
Ulytau Region	X	3,6	189,3
East Kazakhstan	7 021,6	5 881,6	8 219,1
Astana	20 529,0	22 961,0	36 665,3
Almaty	42 738,7	46 759,4	77 204,1
Shymkent	1 540,0	1 534,9	2 809,6

According to the data of Bureau of National Statistics of the ASPR RK

To analyze the uneven distribution of costs across regions, a Pareto diagram is used, reflecting the universal principle of 20 percent of efforts: provide 80 percent of success, and the remaining 80 percent give only 20% of the result. The Pareto diagram allows you to evaluate the efficiency of work, understand who brings the most results and focus maximum efforts on this. The given diagram shows which regions of Kazakhstan make the greatest contribution to the research activities of the republic (Fig. 5.23).



According to the data of Bureau of National Statistics of the ASPR RK

Figure 5.23. R&D costs in 2023 according to the Pareto rule

The histogram column shows the volume of R&D expenditure in the region in million tenge and is plotted along the left axis; the graph curve represents the accumulated percentage of R&D expenditure (i.e. the share of cumulative total expenditure). A threshold horizontal line is drawn across the conditional boundary of 80%. Four regions to the left of the intersection of this line with the graph of accumulated expenditures carry out 80% of research in the republic, while the regions located to the right carry out the remaining 20%.

This ratio of expenditure distribution by regions characterizes their preparedness, specialization, and competence to carry out research activities. The Pareto diagram shows that the most prepared to carry out R&D in various areas and branches of science in 2023 were organizations in Almaty. The share of their expenditure in the total volume amounted to almost 45%, and compared to last year, it increased by 5 percentage points. In the reporting year, the contribution of Astana science to total R&D expenditure increased by 2.4 percentage points and amounted to 21.2% of the republic's internal R&D expenditure.

Mangistau region is in 3rd place in terms of the volume of annually increasing scientific research. It should be noted that 93% of R&D in this area was financed by its own funds. The independence of the region's scientific organizations from state funding allowed them to increase the monthly salary of their employees to 750 thousand tenge, which is 2.6 times higher than the national average salary level.

The fourth region in the Pareto diagram is East Kazakhstan region with 4.8%. The remaining 16 regions account for a total of 20% of the costs. According to the Pareto diagram, the outsiders are Zhetisu, Ulytau and Atyrau regions. In terms of R&D expenditure per employee, Mangistau Region came out on top with 19.9 million tenge (Table 5.45).

Table 5.45. – Internal R&D costs per employee engaged in research and development

Mio. tenge

	2021	2021	2023
Republic of Kazakhstan	**5,1**	**5,4**	**6,8**
Abai Region		3,8	4,8
Akmola	2,2	2,3	4,1
Aktobe	4,2	3,8	4,1
Almaty	2,2	3,5	5,7
Atyrau	15,0	4,2	4,4
West Kazakhstan	2,9	2,4	3,7
Zhambyl	15,0	8,8	11,9
Zhetysu Region		0,4	0,7
Karaganda	4,2	4,2	5,3
Kostanay	1,9	2,1	2,5
Kyzylorda	1,8	1,8	2,8
Mangistau	17,1	20,5	19,9
Pavlodar	1,4	1,7	2,2
North Kazakhstan	2,5	54,9	7,1
Turkestan	2,9	2,8	2,9
Ulytau Region		1,8	9,0
East Kazakhstan	3,7	5,9	7,8
Astana	5,3	5,4	7,5
Almaty	4,9	5,1	7,7
Shymkent	3,0	2,5	2,2

According to the data of Bureau of National Statistics of the ASPR RK

The next region that exceeds the national average is Zhambyl Oblast with costs equal to 11.9 million tenge per employee. Also above the national average are costs per employee in North Kazakhstan and East Kazakhstan Oblasts with 7.1 and 7.8 million tenge, as well as Ulytau Oblast and the cities of Astana and Almaty. These

seven regions significantly increased the national average cost per employee, which in the republic was 6.8 million tenge. For the rest, it fluctuated between 0.7 million tenge in Zhetisu Oblast and 5.7 million tenge in Almaty Oblast.

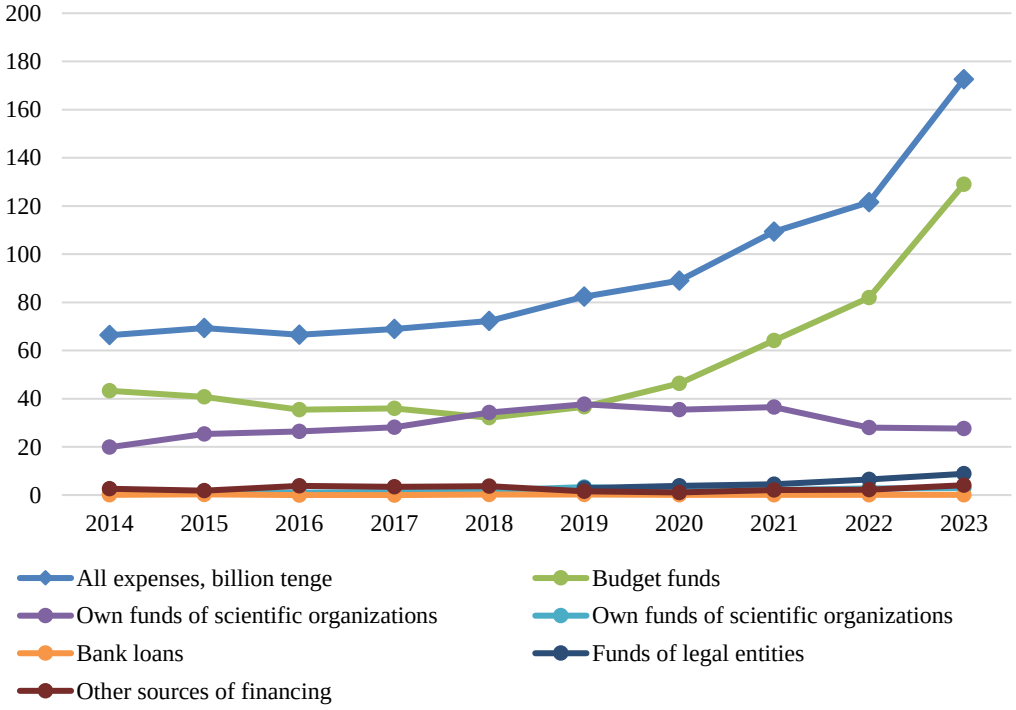
Conclusions. Domestic R&D costs are synonymous with research and development results and reflect scientific activity in the country.

In general, the financial component of scientific potential for 2023 shows that R&D costs increased by almost 42%. Investments from the state budget in total costs increased by 7.3 percentage points and amounted to 74.8%. Despite such significant state support, this had little effect on the science intensity of GDP, which increased from 0.12% to 0.14%.

The share of own funds in R&D costs for 2023 decreased by 7 percentage points, amounting to a minimum of 16% in a decade.

From an economic point of view, this indicates the inefficiency of the business activities of scientific organizations, provided that most of the organizations belong to the business sector. Due to the weak demand for the results of scientific activity and the inability to repay the debt, and, possibly, the lack of business reputation of scientific organizations, such a financing instrument as bank loans for R&D is practically not used. And most importantly, the funds of third-party legal entities invested in research and development, in the total volume of expenses, remained at the level of the previous year, i.e. only 5%.

One of the most important components of statistics is the study of indicators over time, i.e. their dynamics. This task is solved by analyzing the series of dynamics (time series), which determines the intensity or speed with which phenomena develop, find the tendency of their development, highlight fluctuations, compare the dynamics of development, find the relationship of phenomena developing over time (Fig. 5.24).



According to the data of Bureau of National Statistics of the ASPR RK

Figure 5.24. R&D costs by funding source

As can be seen, R&D costs are increasing annually. As the volume of expenditures from the state budget increases, revenues from one of the main sources of investment – own funds, which can be attributed to the funds of the business sector – are proportionally decreasing. Funds from other sources are at a minimum level.

All this indicates an unsatisfactory organization of the research and development process. Perhaps, along with researchers in organizations, it is necessary to provide for a group specializing in developing a research strategy aimed at implementing R&D results. This will increase the responsibility and interest of scientists in the results of their work, especially since the state in every possible way promotes innovative renewal of production and allocates quite large funds for these activities.

In general, according to state statistics, R&D in combination with other indicators, such as the number of publications, citations, patents and data on industrial production, objectively reflect the impact of R&D on the economic and social development of the country.

6. ANALYSIS OF WORLD TRENDS IN THE DEVELOPMENT OF SCIENCE (discoveries and achievements obtained by Kazakhstani science as a result of the implementation of scientific and technical agreements with foreign and international scientific organizations)

The development of the world economy in modern conditions is characterized by the globalization of international economic relations, the increasing role of information and communication technologies, the accelerated pace of technological renewal and the increasing influence of scientific and technical knowledge on the well-being of nations. Fundamental and applied research and development require significant investments of financial, labor resources, material and technical means, which limits the ability of an individual country to strengthen its competitive advantage in the scientific and technical sphere alone. The growing need for interdisciplinary research, the high degree of uncertainty and risk in obtaining results, the desire to minimize the "duplication of expensive research", the need to increase the speed of technology transfer contribute to the deepening of interaction between the world community in the scientific and technical sphere. In addition to the above, a number of scientific and technical problems, primarily of socio-economic orientation (the food problem, space exploration, maintaining the quality of the environment, etc.), are of global significance, which leads to the need to combine the efforts of states to solve them [396-398].

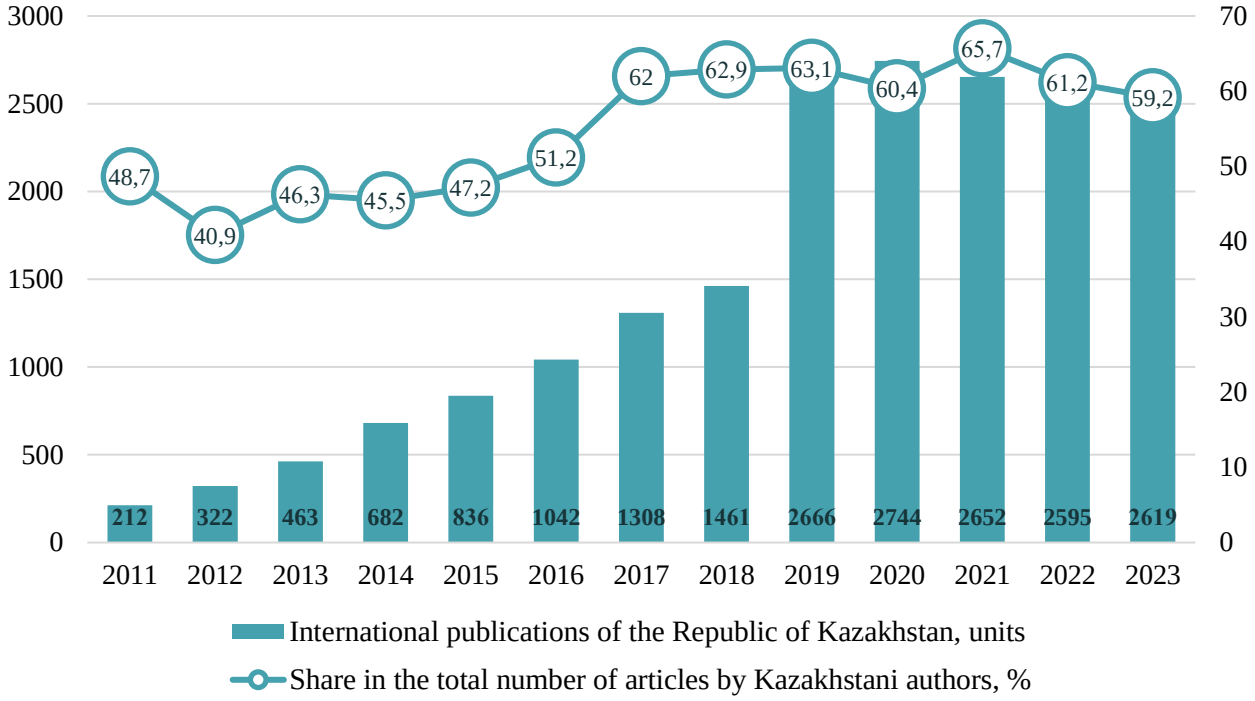
To carry out joint research, stable structurally organized research groups (teams) with a certain set of values and value orientations are created, working in the same direction and having a research program adopted by the subjects of this association. Associations are emerging that unite researchers from different scientific schools and directions [399].

In the Concept for the Development of Higher Education and Science in the Republic of Kazakhstan for 2023-2029 dated March 28, 2023, No. 248, one of the points indicates the development of issues of implementing scientific projects and programs within the framework of international collaboration based on intergovernmental agreements on scientific and technological activities. In order to integrate into the global scientific and technological community, increase the number of articles and reviews of Kazakhstani scientists in highly rated publications with quartile Q1, Q2, improve the quality and efficiency of publication activity, access to international databases will continue to be provided within the framework of a national subscription [400].

A convenient and productive approach to analyzing joint research activities to obtain new scientific knowledge is to use data on international co-authorship of scientific publications in the Web of Science citation database, including the analytical tool for assessing scientific activity InCites, as the main indicators of intercountry interaction. The volume of peer-reviewed research publications gives a general idea of research and technological activity worldwide, as well as in individual countries.

The total number of publications of Kazakhstan in the studied database, starting from 2011, amounted to 33,431 documents, of which purely Kazakhstani - 13,829 documents. (41.4%), jointly with foreign scientists - 19,602 documents. (58.6%).

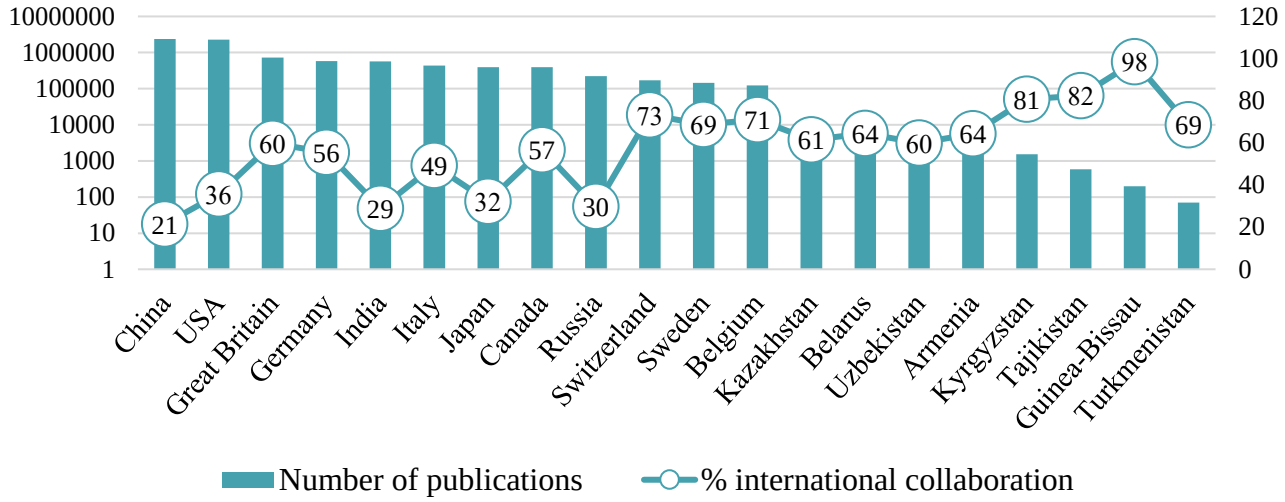
The dynamics of joint articles of domestic researchers with foreign scientists for the period under review shows a significant increase in their number and some stabilization after 2019. At the same time, the tendency towards stabilization of the share of international publications in the total array of Kazakhstani works has been observed since 2017 and fluctuates within the range of 59-66% (Fig. 6.25).



According to Web of Science (Clarivate Analytics), as of 02.04.2024.

Figure 6.25. Dynamics of Kazakhstani publications prepared in international cooperation

For the period 2021-2023, the share of international cooperation in Kazakhstan amounted to 61.5%, while the global average is 22.4%. It should be noted that developed countries with high publication activity are characterized by shares of cooperation below 60%, with the exception of small countries with highly developed science - Switzerland (73.2%), Sweden (68.7%), Belgium (71%), etc. At the same time, developing countries, represented in the database with an insignificant number of publications, are characterized, for the most part, by a high share of collaboration with other countries (Fig. 6.26).



According to InCites (Clarivate Analytics), as of 03.04.2024.

Table 6.26. Indicators of international cooperation of countries with different publication activity, 2021-2023.

Along with the growth of publications, the geography of Kazakhstan's partner countries is also expanding: 2019-2021 - 180 countries; 2020-2022 - 184; 2021-2023 - 188 countries. Kazakhstan's main scientific partner is Russia, with which about a third of all works were published in 2021-2023, followed by the United States and China, in total - 26.7%. All the countries shown in the figure, with the exception of Saudi Arabia, have consistently been among the top 10 scientific partner countries of the republic in previous periods (Fig. 6.27).

Analysis by three time periods shows active cooperation throughout the entire period with the United States, China, Great Britain, England, Turkey, India and Saudi Arabia. Scientific cooperation with Germany remains at the 2020-2022 level, and a decrease in the intensity of cooperation is observed with Russia and Poland.

Cooperation with Russia for 2021-2023 is developing in 125 research areas. Over 100 publications are presented in such areas as physics (454 units), chemistry (372), materials science (315 units), engineering (257), mathematics (221), Science Technology Other Topic (167), metallurgy and metal science (115 units).

Country	2019-2021		2020-2022		2021-2023
Russia	35,7	↓	34,7	↓	32,6
USA	12,5	↑	13,3	↑	14,1
China	10,7	↑	11,2	↑	12,6
Great Britain	7,6	↑	8,7	↑	9,4
England	6,9	↑	7,8	↑	8,4
Turkey	5,6	↑	6,4	↑	8,0
Germany	6,8	↑	7,3	=	7,3
Poland	7,9	↓	7,3	↓	6,9

India	5,3	↑	5,9	↑	6,4
Saudi Arabia	4,1	↑	5,3	↑	6,2

According to InCites (Clarivate Analytics), as of 04/04/2024.

↓ - decreased cooperation; ↑ - strengthening cooperation

Figure 6.27. Share of Kazakhstan's publications with leading partner countries by time periods, %. Top 10 countries by publications in 2021-2023.

The main funding organizations for research with Russia are the Government of the Republic of Kazakhstan (550 publications), the Ministry of Science and Higher Education of the Republic of Kazakhstan (566), the Russian Science Foundation (250) and the Ministry of Science and Higher Education of the Russian Federation (219). Close cooperation of Kazakhstani scientific organizations has been established with the Russian Academy of Science (686 publications), the Joint Institute for Nuclear Research of Russia (238), Moscow State University (217), Ural Federal University (159), Peoples' Friendship University of Russia (151), Tomsk Polytechnic University (127), and I.M. Sechenov First Moscow State Medical University (124). Among Kazakhstani organizations in cooperation with Russia, high publication activity is noted at L.N. Gumilyov Eurasian National University (464), Al-Farabi Kazakh National University (452), the Institute of Nuclear Physics (321), and Nazarbayev University (214). Joint publications with Russia - 2589 units, have 16536 citations, average citation rate - 6.39 and H-Index 46 (hereinafter - data on WoS as of 04.04.2024).

Cooperation with the USA is noted in 123 research areas, of which the natural and technical sciences have received the greatest development: physics - 122 publications; Science Technology Other Topic - 108; chemistry - 98; engineering – 96, etc. More than 1,000 organizations from different countries participated in funding the research, the main ones being the Ministry of Science and Higher Education of the Republic of Kazakhstan (199 publications), the Government of the Republic of Kazakhstan (138), the US Department of Health (90), the US National Institutes of Health NIH (84), Nazarbayev University (68), the National Science Foundation/NSF (67), the US Department of Energy (46 publications), etc. Nazarbayev University (445), KazNU named after Al-Farabi (230), Florida State University System (113), University of California (113), Harvard University (86), Asfendiyarov KazNMU (83), Columbia University (81), Ohio State University System (78), etc. Joint publications with the USA - 1159 units, have 12926 citations, average citation rate - 11.15 and H-Index 38.

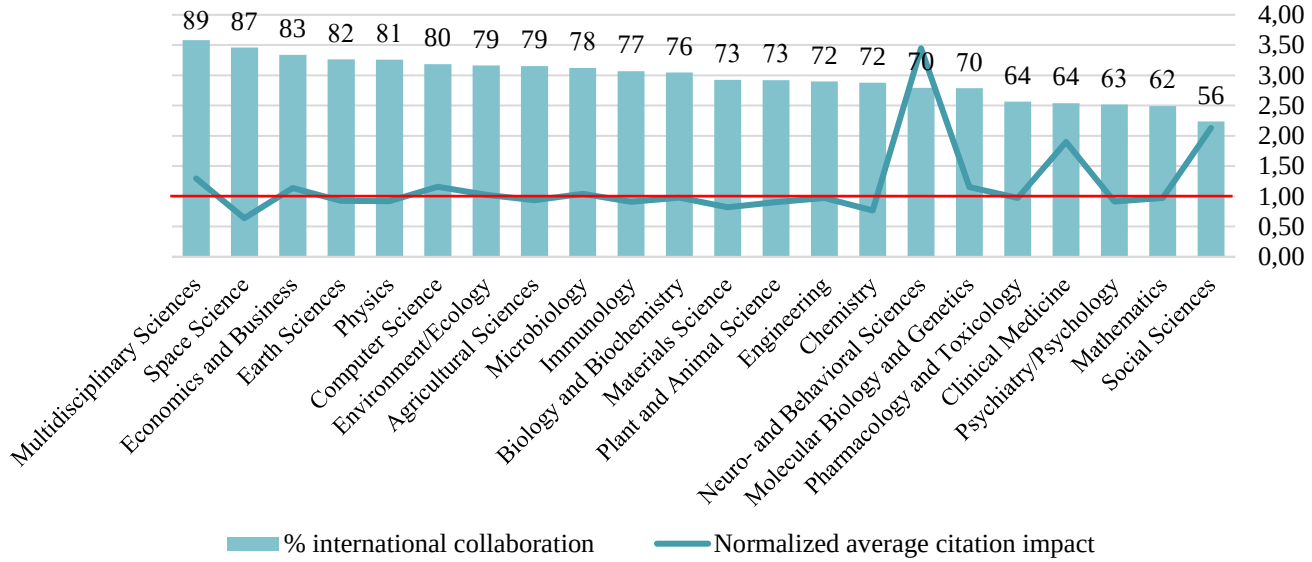
Cooperation with China, which has been developing especially actively in recent years, is represented in 103 research areas, mainly in the natural and technical sciences. The largest number of publications are in chemistry (166 units), engineering (146), physics (143), Science Technology Other Topics (115), materials science (100), environmental sciences, ecology (90), energy and fuel (68), etc. The funding organizations by the number of publications are represented by the National Natural Science Foundation of China NSFC (274 units), the Government of the Republic of

Kazakhstan (107 publications), and the Ministry of Education and Science of the Republic of Kazakhstan (101). The main research implementers are Nazarbayev University (368 publications), Al-Farabi Kazakh National University (212), Chinese Academy of Science (147), KBTU (101), L.N. Gumilyov Eurasian National University (85), Northwest University of China (57), etc. Joint publications with China - 1047 units. have 16733 citations, the average citation rate is 15.98 and H-Index 54.

In general, Kazakhstan cooperates in 146 areas of research, mainly in the field of engineering (1131 publications), physics (1112), chemistry (1025), materials science (830), Science Technology Other Topics (622), environmental sciences, ecology (514), mathematics (495), computer science (359), energy and fuel (320). About 4 thousand organizations from different countries participate in financing these studies. However, the main source of funding is the Ministry of Science and Higher Education of the Republic of Kazakhstan (1479 publications) and the Government of the Republic of Kazakhstan (1419), also worth mentioning are Nazarbayev University (879 units), the National Natural Science Foundation of China NSFC (274), the Russian Science Foundation (243), the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (183). The largest number of joint publications are presented by Nazarbayev University (2108 units), Al-Farabi Kazakh National University (1708), L.N. Gumilyov Eurasian National University (792), Russian Academy of Science (760), Satpayev University (454), Institute of Nuclear Physics of the Republic of Kazakhstan (391), KBTU (307). Joint publications - 8023 units have 46673 citations, average citation rate - 5.82 and H-Index 68.

In the context of 22 thematic categories on natural and social sciences of the Essential Science Indicators rubricator, the share of collaborations is most developed in such areas of Kazakhstani science as Multidisciplinary Sciences, Space Science, Economics and Business, Earth Sciences, Physics, Computer Science, where 80% and more of the works in the database are presented in international cooperation (Fig. 6.28).

The relevance and demand for research determine the level of citation indicators of publications. In the scientific world, international publications written in co-authorship attract much more attention and, as a rule, are cited more. As can be seen, the normalized average citation of works prepared in international collaboration, in almost all the considered fields of science, has a value above the world average, equal to 1.

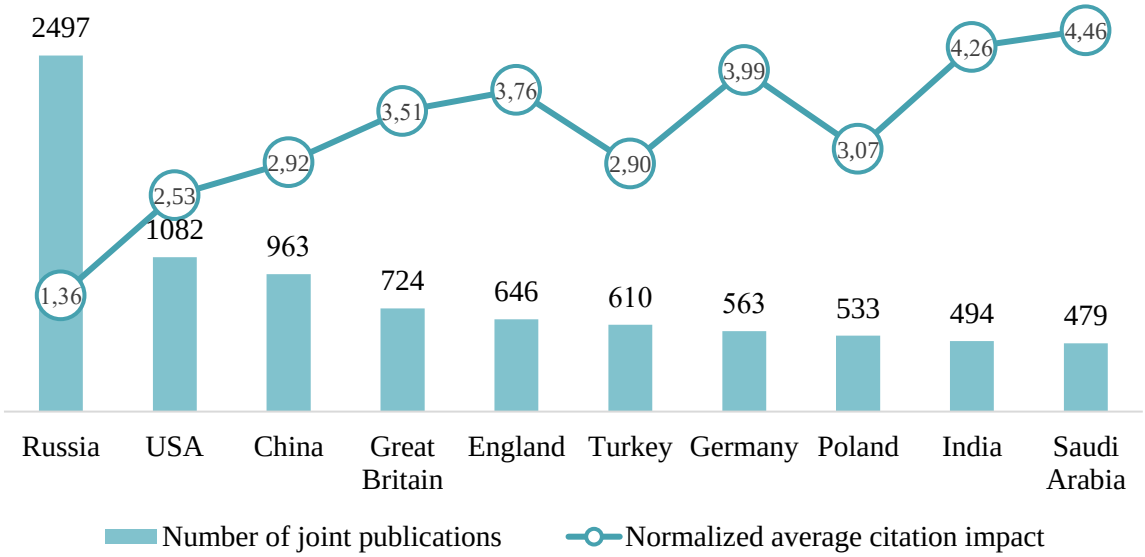


According to InCites (Clarivate Analytics), as of 04/04/2024.

Figure 6.28. Indicators of Kazakhstan's international cooperation by fields of science, 2021-2023.

In general, the works of domestic scientists for 2021-2023, created with foreign colleagues, have an average number of citations of 5.84, while publications prepared only by Kazakhstani authors - 1.70, that is, cooperation contributes to an increase in the citation rate of domestic works by more than three times.

With a normalized average citation rate of Kazakhstan - 1.14, the value of this indicator for publications with Russia is slightly higher - 1.36; the USA - 2.53, with China - 2.92. For the top 10 countries studied, joint works with Saudi Arabia, India, Germany, England and Great Britain have the highest values (Fig. 6.29).

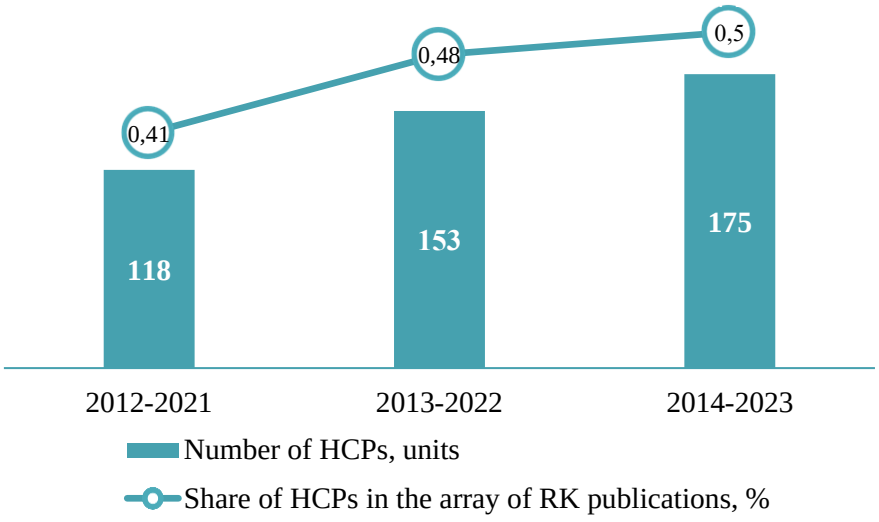


According to InCites (Clarivate Analytics), 2021-2023, as of 04/04/2024.

Figure 6.29. Bibliometric indicators of Kazakhstan with the top 10 countries by number of publications

An important indicator of research quality is the share of highly cited publications (HCP). In Essential Science Indicators (ESI), a separate tool on the InCites platform, highly cited publications are those that are included in the top one percent of the most cited documents of a given type, year of publication, and category in each of the 22 subject categories presented in the Web of Science in a given year. Publications for the last 10 years are used for the calculation.

Of the 175 HCPs in ESI for 2014-2023, 168 papers (>96%) were prepared in international collaboration. The observed growth in the number and share of HCPs in the total number of publications in a country indicates the fruitfulness of joint research (Fig. 6.30).



According to InCites Essential Science Indicators, as of 04/04/2024.

Figure 6.30. Dynamics of highly cited publications in Kazakhstan

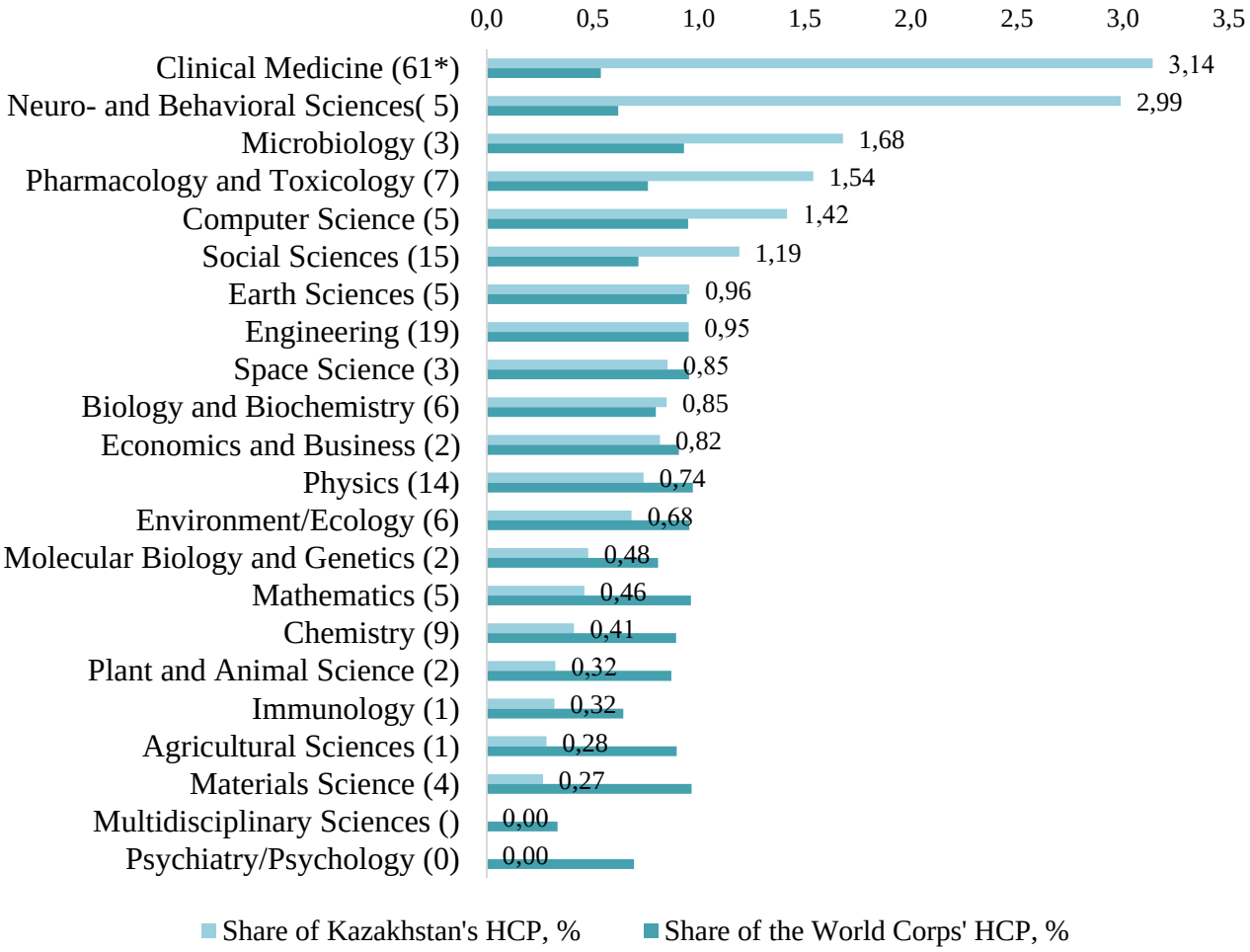
Highly cited papers indicate a high level of scientific research and can be used to assess the influence of publications in comparison with the world average in various subject categories. Highly cited publications with Kazakhstan's participation in all 10-year periods under consideration are presented in 20 thematic areas out of 22 in the Essential Science Indicators rubric. Highly cited publications were not identified in such areas as Multidisciplinary Sciences and Psychiatry/Psychology (Fig. 6.31, a).

In 2021-2023, 90 works, or more than 51% of all highly cited publications for 2014-2023, were included in the total array of highly cited publications of Kazakhstan. They were distributed among 18 areas as follows: clinical medicine accounts for more than 22%; engineering, social sciences, physics and chemistry - another 45.6% of in-demand domestic publications; pharmacology and toxicology - 4.4%; biology and biochemistry, environment/ecology, neuro- and behavioral sciences, earth sciences and mathematics – 3.3% each; computer science, materials science, microbiology – 2.2% each; molecular biology and genetics, economics and business, plant and animal husbandry, agricultural sciences – 1.1% each. Publications in the categories of space science, immunology, multidisciplinary sciences and psychiatry/psychology were not included in the array of the TCVs over the past three years (Fig. 6.31 b).

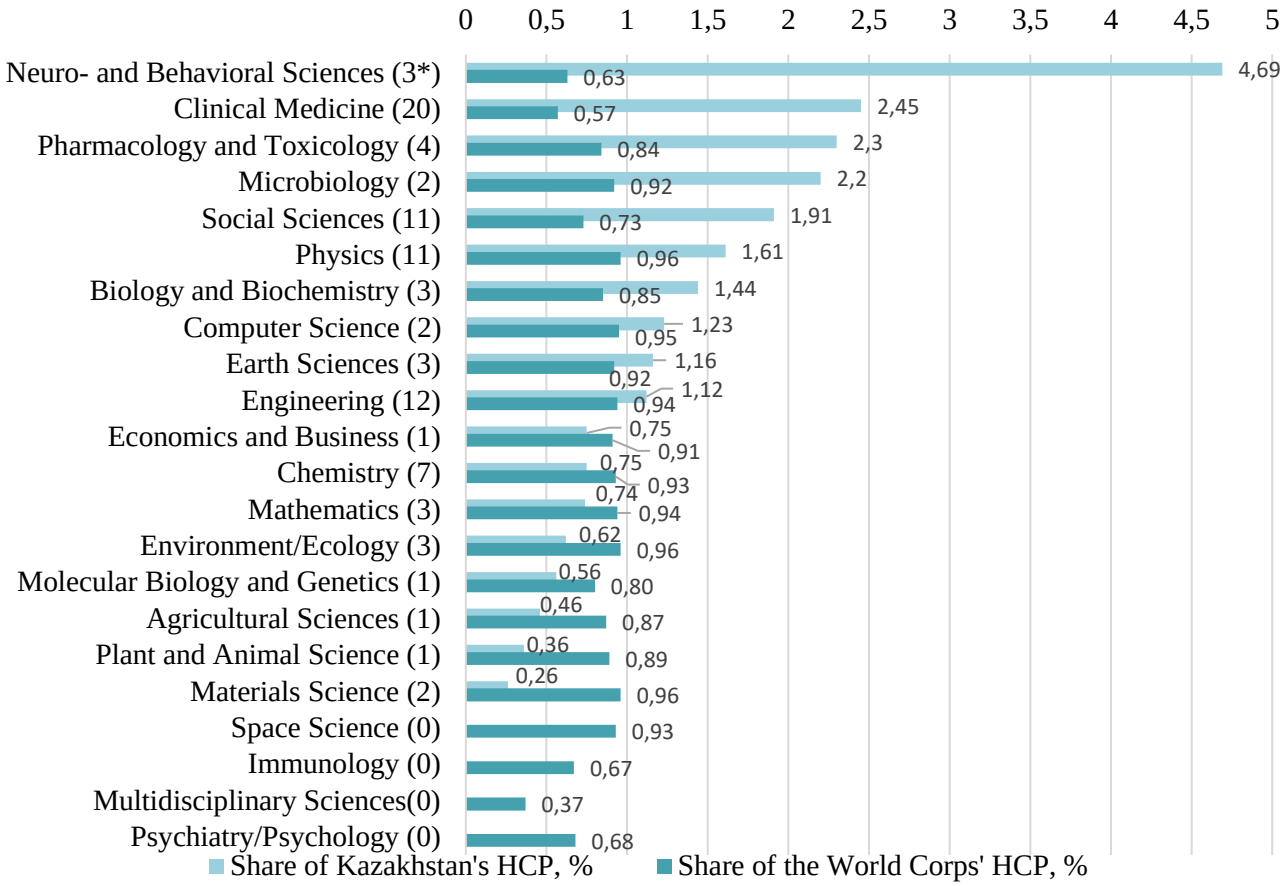
It should be noted that the share of works on neuro- and behavioral sciences increased, 3 out of 5 TCVs were presented in these years, which gave a noticeable jump in the specific weight – from 2.99 to 4.69%. The same situation is typical for many other categories. The positions in such categories as clinical medicine, computer science, materials science, environment/ecology, economics and business, immunology, and space science have weakened.

In the Kazakhstani array, there is an excess of the world indicator of the share of the global central budget in 7 categories for 2014-2023 and in 10 categories for 2021-2023. Over a three-year period, these are neuro- and behavioral sciences - an excess of 7.4 times; clinical medicine - 4.3; pharmacology and toxicology - 2.7; microbiology - 2.4; social sciences - 2.6; physics, biology and biochemistry - 1.7; computer science and earth sciences - 1.3; engineering - 1.2 times. Obviously, international cooperation in these areas is the most effective (Fig. 6.31 a, b).

In general, during the period under study, the share of highly cited works in the Kazakhstani array is higher than in the world – 1.13 and 0.8%, respectively.



a)



b)

According to InCites (Clarivate Analytics), as of 04.04.2024
**The number of HCPs of RK is given in brackets*

Figure 6.31. Distribution of highly cited publications by research areas, 2014-2023 (a), 2021-2023 (b)

Proof of the country's high achievements, the main scientific indicator of the popularity of an article in WoS, are *Hot Papers - hot articles* that have made it into the top 0.1% of the world citation ranking over the past two years.

In the array of Kazakhstani publications for 2021-2023, 14 such works were identified, representing 7 research areas, with the number of citations from 8 to 731 (as of 04/10/2024). All these publications were created as a result of the implementation of scientific and technical agreements with foreign and international scientific organizations.

In the field of social sciences, 3 publications are presented, one of them "*Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019*" in the ***Public, Environmental & Occupational Health*** category has the highest citation rate. The article is devoted to research to expand previous forecasts of the prevalence of dementia worldwide, by world regions and countries. The prevalence of dementia in 2019 associated with three risk factors for dementia (high body mass index, high fasting plasma glucose, and smoking) was examined and projected from 2019 to 2050.

It was found that the number of people with dementia will increase, with more women than men with dementia, a pattern that is expected to persist through 2050. There is geographic heterogeneity in the projected increase across countries and regions, with the smallest percentage changes in the number of projected dementia cases in high-income Asia and the Pacific and Western Europe, and the largest in Northern Africa, the Middle East, and eastern sub-Saharan Africa. The projected increase in cases can be largely explained by population growth and population ageing, although their relative importance varies by region of the world, with population growth contributing most to the increase in cases in sub-Saharan Africa and population ageing contributing most to the increase in cases in East Asia. Characterizing the distribution and magnitude of the expected increase is critical for public health planning and prioritizing resources to meet the needs of this group. Research funding: *Bill & Melinda Gates* Foundation and *Gates Ventures*. The work, presented by a team of scientists from 52 countries, is published in the *Lancet Public Health* journal with impact factor 50, quartile Q1 in the *Clinical Neurology* category. The author from Kazakhstan includes scientist *Sh. Bolla* (Nazarbayev University).

The next article in the field of **social sciences** «*Economic impact of crude oil supply disruption on social welfare losses and strategic petroleum reserves*» belongs to the category of ***Environmental Sciences & Ecology***. This paper presents results on measuring the physical risk of crude oil supply and strategic petroleum reserves using econometric estimation and a combination of multiple relevant, multivariate, and comprehensive sets of indicators and Principal Component Analysis (PCA). The analysis shows that 30% of the crude oil shortfall in markets is attributable to the most volatile crude oil costing system. This shortfall immediately increases the projected social welfare loss due to a 40% decline in gross domestic product, estimated at US$700 in South Asia and US$3,000 in the largest oil economy. The quantity and value of oil supply required for strategic petroleum reserves to trigger optimal increases and decreases in oil production are calculated using PCA and a game solution. Limited testing of private sector inventory adjustments was less encouraging, suggesting that private sector actions may have partially offset some of the government cuts. Thus, the expected costs increase by 4% in normal market situations, decrease by almost 8% in volatile market conditions, and decrease by 9% in severe market disruption conditions. In retrospect, improved management could significantly increase the value of strategic petroleum reserves, especially during peak shocks. Quantifying the risk of oil disruptions shows the importance of stockpiling crude oil and drawing down vital national crude oil stockpiles as governments seek to optimize consumer welfare while maintaining control over oil reserves, as oil supply disruptions cause serious damage to energy security and economic growth. The paper, authored by H. *Saidaliyev* (Suleyman Demirel University) and researchers from China, Uzbekistan, and Pakistan, is published in *Resources Policy*, a journal with an impact factor of 10.2, quartile Q1 in the *Environmental Studies* category.

The third paper in the **Social Sciences** category, "*Exploring the nexus between monetary uncertainty and volatility in global crude oil: A contemporary approach of regime-switching*", also belongs to the ***Environmental Sciences & Ecology*** category.

It provides insights into the complex relationship between global crude oil market volatility as it affects economics and geopolitics, and monetary uncertainty generated by monetary policy decisions, exchange rate fluctuations, and global economic conditions that may affect crude oil markets. It examines the impact of monetary uncertainty on global crude oil price volatility, accounting for potential nonlinearities and changing patterns in the relationship between crude oil volatility and monetary uncertainty. It finds that monetary uncertainty has an asymmetric effect on crude oil price volatility. Overall, the study highlights the need for a more nuanced approach to understanding the relationship between crude oil prices and monetary uncertainty. Funding: National Social Science Foundation of China. The work was presented by scientists *E. Oskenbayev* (Narxoz University) and *Zh. Karabayeva* (K. Sagadiev University of International Business) together with Chinese colleagues in the journal *Resources Policy* with an impact factor of 10.2, quartile Q1 in the category *Environmental Studies*.

The article "*Pharmaceutical pollution of the world's rivers*" pertains to the field of **environment/ecology**, devoted to the study of the impact of active pharmaceutical ingredients (API) on the environment, in particular, on 258 rivers of the world, 471.4 million people in 137 geographic regions. Samples were obtained from 1052 locations in 104 countries (representing all continents and 36 countries previously not studied for API pollution) and analyzed for 61 API. The highest cumulative concentrations of API were observed in sub-Saharan Africa, South Asia and South America. The most contaminated sites were in low- and middle-income countries and were associated with areas with poor wastewater treatment and disposal infrastructure and pharmaceutical manufacturing. The most frequently detected APIs were carbamazepine, metformin and caffeine, which were detected in more than half of the sites surveyed. Concentrations of at least one API in 25.7% of the sampled sites exceeded concentrations considered safe for aquatic organisms or of concern for selection for antimicrobial resistance. It was concluded that pharmaceutical pollution poses a global threat to the environment and human health, and to the achievement of the UN Sustainable Development Goals. Funding: *UK Research & Innovation Fund*, *Medical Research Council UK*, etc. Representatives of 67 countries took part in the study, from the Kazakh side - *B. Aubakirova* (Nazarbayev University, Higher School of Engineering and Digital Sciences) and *R. Beisenova* (L.N. Gumilyov Eurasian National University). The work was published in the journal *"Proceedings of the National Academy of Science of the United States of America"* with an impact factor of 11.1, quartile Q1 in the *Multidisciplinary Sciences* category.

In the field of clinical medicine, 6 publications created as part of international collaborations were among the "hot" ones.

The article "*Global change in hepatitis C virus prevalence and cascade of care between 2015 and 2020: a modeling study"* was published in the ***Gastroenterology & Hepatology*** category. It is dedicated to estimating the burden of hepatitis C virus (HCV) in 2020 and projecting the burden of HCV by 2030, taking into account current trends. Mathematical modeling methods were used to estimate the prevalence of HCV and the degree of medical care among people of all ages for the period from January 1,

2015 to December 31, 2030; a Markov model was used to project them for the period from 1950 to 2050 for countries and territories for which data are available. Regional and global estimates of HCV prevalence, the cascade of care, and the burden of the disease were calculated based on 235 countries and territories. At the start of 2020, there were an estimated 56.8 million cases of viraemic HCV infection worldwide. It is noted that while this is a decrease from 2015, projections currently indicate that global elimination targets by 2030 are not being met. As countries recover from Covid-19, these findings may help refocus efforts to eliminate HCV. Funded by the John C Martin Foundation and others. The work prepared by A. Nersesov (S. Asfendiyarov KazNMU), G. Sarybaeva (Kazakh Scientific Center for Dermatology and Infectious Diseases), K. Esmembetov (National Scientific Center for Oncology and Transplantology) together with scientists from 87 countries, was published in the journal Lancet Gastroenterology & Hepatology with an impact factor of 35.7, quartile Q1 in the category Gastroenterology & Hepatology. Another article from the Gastroenterology & Hepatology category made it to the hot list: "Global, regional, and national burden of colorectal cancer and its risk factors, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019", dedicated to examining temporal patterns of the global, regional, and national burden of colorectal cancer and its risk factors in 204 countries and territories over the past three decades, stratified by age, sex, and geography. Globally, between 1990 and 2019, the number of colorectal cancer cases more than doubled: from 842,098 to 2.17 million, and the number of deaths increased from 518,126 to 1.09 million. The global age-standardized incidence rate increased from 22.2 to 26.7 per 100,000, while the age-standardized death rate decreased from 14.3 to 13.7. Taiwan, Monaco, and Andorra had the highest age-standardized incidence rates, while Greenland, Brunei, and Hungary had the highest age-standardized death rates. The main causes of colorectal cancer worldwide were low-milk diet (15.6%), smoking (13.3%), low-calcium diet (12.9%), and alcohol consumption (9.9%). From 1990 to 2019, a significant increase in incidence was observed among young adults (age <50 years), especially in countries with a high sociodemographic index, requiring vigilance by researchers, clinicians, and policymakers, as well as possible revision of screening guidelines. Funding: Bill & Melinda Gates Foundation. The work, prepared by a team of scientists from 61 countries, including *I. Fakhradiyev* (S. Asfendiyarov KazNMU), was published in the journal "*Lancet Gastroenterology & Hepatology*" with an impact factor of 35.7, quartile Q1 in the category *Gastroenterology & Hepatology*.

The ***General & Internal Medicine*** category presents the article "*The global burden of cancer attributable to risk factors, 2010-19: a systematic analysis for the Global Burden of Disease Study 2019"*, which analyzes the results of the Global Burden of Disease, Injuries, and Risk Factors (GBD) study 2019 to estimate the burden of cancer caused by behavioral, environmental, occupational, and metabolic risk factors and plan its control worldwide. A total of 82 risk-outcome pairs were included based on the World Cancer Research Fund criteria. Estimated rates of cancer mortality and disability-adjusted life years (DALYs) in 2019, as well as changes in these rates between 2010 and 2019, are presented. Globally, in 2019, the risk factors

included in this analysis accounted for 4.45 million deaths and 105 million DALYs for both sexes combined, accounting for 44.4% of deaths. The leading risk factors at the most detailed level globally for cancer deaths and DALYs in 2019 for both sexes combined were smoking, followed by alcohol use and high BMI. The cancer burden attributable to risk varies by world region and sociodemographic index (SDI), with smoking, unsafe sex, and alcohol use being the three leading risk factors for cancer-attributable DALYs in low SDI regions in 2019. From 2010 to 2019, global cancer deaths increased by 20.4% and DALYs by 16.8%. It is noted that the leading risk factors contributing to the global cancer burden in 2019 were behavioral, while metabolic risk factors had the greatest increase between 2010 and 2019. Reducing the impact of these modifiable risk factors will reduce cancer mortality and DALYs worldwide, and policies should be tailored accordingly to the local burden of cancer risk factors. The work was prepared by a team of scientists from 84 countries, including *Sh. Bolla* and *A. Gaipov* (Nazarbayev University), *I. Fakhradiyev* (S. Asfendiyarov KazNMU), *M. Kulimbet* (S. Asfendiyarov KazNMU, Al-Farabi KazNU). Published in the *Lancet* with an impact factor of 168.9, quartile Q1 in the *Medicine, General & Internal* category.

The ***General & Internal Medicine*** category also presents the article *"Global, regional, and national burden of diabetes from 1990 to 2021, with projections of prevalence to 2050: a systematic analysis for the Global Burden of Disease Study 2021"* with the results of estimating the prevalence and burden of diabetes by location, age, and sex from 1990 to 2021, the proportion of type 1 and type 2 diabetes in 2021, the proportion of the type 2 diabetes burden attributable to individual risk factors, and projections of diabetes prevalence to 2050. It is shown that in 2021, there were 529 million people with diabetes worldwide, and the global age-standardized overall prevalence of diabetes was 6.1%. At the super-regional level, the highest age-standardized rates were observed in Northern Africa and the Middle East (9.3%), and at the regional level - in Oceania (12.3%). Nationally, Qatar has the highest age-specific prevalence of diabetes in the world, at 76.1% among those aged 75–79 years. The overall prevalence of diabetes, particularly among older adults, is primarily reflected by type 2 diabetes, which accounted for 96% of diabetes cases in 2021. By 2050, more than 1.31 billion people are projected to have diabetes, with age-standardized overall diabetes prevalence rates expected to exceed 10% in two super-regions: 16.8% in North Africa and the Middle East and 11.3% in Latin America and the Caribbean. By 2050, 89 (43.6%) of 204 countries and territories will have an age-standardized prevalence rate above 10%. It is noted that type 2 diabetes, which accounts for the majority of diabetes cases, is largely preventable and in some cases potentially reversible if detected and treated early in the disease. However, all data indicate that the prevalence of diabetes is increasing worldwide, primarily due to the rise in obesity caused by many factors. Prevention and control of type 2 diabetes remains an ongoing public health challenge. Funding: Bill & Melinda Gates Foundation. The study involved Nazarbayev University scientist A. Gaipov and researchers from 82 countries. The article is published in the Lancet journal with an impact factor of 168.9, quartile Q1 in the *Medicine, General & Internal* category.

The following article in the ***General & Internal Medicine*** category, *“Population-level risks of alcohol consumption by amount, geography, age, sex, and year: a systematic analysis for the Global Burden of Disease Study 2020”,* presents a population-based analysis of the 2020 global burden of disease (GBD) attributable to alcohol consumption by amount, region, age, sex, and year to estimate the minimal risk exposure level (TMREL) and non-drinker equivalent (NDE). The GBD data covered 21 regions, including 204 countries; moreover, the data were stratified by age group, sex, and year for the 15-95 year-old age group from 1990 to 2020. In 2020, among individuals aged 15-39 years, the TMREL and NDE ranged from zero to 0.603 and from 0.002 to 1.75 standard drinks per day, respectively. In people aged 40 years and over, the TMREL and NDE ranged from 0.114 to 1.87 and 0.193 to 6.94 standard drinks per day, respectively. Of those who drank alcohol at harmful levels in 2020, 59.1% were in the 15–39 age group and 76.9% were men. The study highlights the need to consider background rates of disease and injury for each population group before issuing guidelines and recommendations on the optimal level of alcohol consumption, for example, in young people, the level of alcohol consumption that minimizes health losses is close to zero. Similarly, older populations in many regions of the world with a high burden of cardiovascular disease show health benefits with light alcohol consumption. Stronger measures are needed to reduce the significant global health losses associated with alcohol use, especially those targeting younger people. Funding: Bill & Melinda Gates Foundation. The article was prepared by scientists from 72 countries, with *K. Davletov* (Al-Farabi Kazakh National University) and *I. Fakhradiyev* (S. Asfendiyarov Kazakh National Medical University) participating from the Kazakh side. It was published in the *Lancet* journal with an impact factor of 168.9, quartile Q1 in the *Medicine, General & Internal* category.

The article *"Global, regional, and national burden of low back pain, 1990-2020, its attributable risk factors, and projections to 2050: a systematic analysis of the Global Burden of Disease Study 2021"* has been published in the ***Rheumatology*** category. The article presents a systematic analysis of the 2021 global burden of disease studies related to low back pain and estimates by age, sex, year, and location of the prevalence of low back pain and years lived with disability (YLD) from 1990 to 2020 for 204 countries and territories. It was found that in 2020, low back pain affected 619 million people worldwide, and the number of prevalent cases is projected to be 843 million by 2050. In 2020, the global age-standardized rate of YLD was 832 per 100,000. Between 1990 and 2020, age-standardized prevalence and YLD rates decreased by 10.4% and 10.5%, respectively. A total of 38.8% of YLD cases were associated with occupational factors, smoking, and high body mass index. It is noted that although age-standardized rates have slightly decreased over the past three decades, low back pain remains the leading cause of YLD worldwide. Funding: Bill & Melinda Gates Foundation. The work, prepared by a team of scientists from 51 countries, including *Sh. Bolla* (Nazarbayev University), was published in the *Lancet Rheumatology* with an impact factor of 25.4, quartile Q1 in the *Rheumatology* category.

In the field of **engineering**, the article *"How do ICT and renewable energy impact sustainable development?"* made it to the hot list, presented in the ***Green & Sustainable Science & Technology Energy & Fuels*** category and devoted to the analysis of the possibility of contributing to information and communication technologies (ICT) and renewable energy sources (RES) in improving environmental quality. Using econometric methods, their use was studied for the period from 1990 to 2019 in the USA, UK, China, Russia, Canada, Australia, Sweden, Norway, Switzerland and Italy. It was shown that, on average, the impact of ICT and RES lasts from one to seven years. A segmentation study of the error correction model confirmed that ICT and RES contribute to the volatility of carbon dioxide emissions. There is convincing evidence that carbon dioxide emissions, ICT and the use of RES have a bidirectional causal relationship in most cases. Several ICT and RES strategies were developed and studied to benefit from the possible positive impact of their use on environmental quality. Funding was provided by the Ministry of Education, Culture, Sports, Science and Technology of Japan. The work was prepared by scientist H. Saidaliyev (Suleyman Demirel University, Tashkent State University of Economics) together with colleagues from Japan and China. Published in the journal *Renewable Energy* with an impact factor of 8.7, quartile Q1 in the *Energy & Fuels* category.

In the field of ***neuro- and behavioral sciences***, a review is presented "*Diagnosis and classification of optic neuritis"*, dedicated to the diagnosis and classification of optic neuritis. It is noted that accurate diagnosis of optic neuritis on admission can contribute to timely treatment of people with multiple sclerosis, neuromyelitis optica spectrum disorder, or myelin oligodendrocyte glycoprotein antibody disease. Epidemiological data show that, in general, optic neuritis is most often caused by many conditions in addition to multiple sclerosis. Around the world, the cause and treatment of optic neuritis vary by geography, treatment availability, and ethnicity. However, diagnosis of diseases whose first manifestation is optic neuritis is challenging. The authors have developed diagnostic criteria for optic neuritis and a classification of its subgroups. The diagnostic criteria are based on clinical features that allow the diagnosis of possible optic neuritis; further paraclinical testing using brain, orbital, and retinal imaging together with antibody and other protein biomarkers may lead to a diagnosis of definite optic neuritis. Paraclinical testing can also be applied retrospectively to stored specimens and historical brain or retinal scans, which will be useful for future validation studies. The presented criteria can reduce the risk of misdiagnosis, provide information on the course of optic neuritis that can help in the development of future treatment studies, and allow physicians to judge the likelihood of the need for long-term pharmacological treatment, which may vary depending on the optic subgroup of neuritis. Funding agency – YNT – Schering Fellowship. Prepared by a team of scientists from 57 countries, including *Zh. Idrisova* (KazNMU named after S. Asfendiyarov), the review was published in the journal «*Lancet Neurology*» with an impact factor of 48, quartile Q1 in the category *Clinical Neurology*.

The *Hot Papers* group in the field of **mathematics** includes *"Review of Artificial Intelligence and Machine Learning Technologies: Classification, Restrictions,*

Opportunities and Challenges" - a review of artificial intelligence and machine learning technologies: classification, limitations, opportunities and challenges. Artificial intelligence (AI) is an evolving set of technologies used to solve a wide range of applied problems. The core of AI is machine learning (ML) - a set of algorithms and methods that solve problems of classification, clustering and forecasting. Practical application of AI&ML has promising prospects. The review presents the identification and discussion of the problems of using artificial intelligence technologies in the economy and society of resource-oriented countries. Systematization of AI&ML technologies is carried out on the basis of publications in these areas. Such systematization allows us to clarify organizational, personnel, social and technological limitations. The work outlines research areas in the field of artificial intelligence and machine learning, which will overcome some limitations and achieve an expansion of the scope of AI&ML. The main grantor of this study was the Ministry of Higher Education of the Republic of Kazakhstan. The review was prepared by scientists *R. Mukhamediyev, A. Symagulov and Ya. Kuchin* (Satpayev University, Institute of Information and Computational Technologies), A. Kalimoldaev (Al-Farabi Kazakh National University), *F. Abdoldina* (Almaty Management University) and *K. Yakunin* (Satpayev University, Institute of Information and Computational Technologies, Almaty Management University) together with scientists from Latvia and Slovakia. Published in the journal "*Mathematics*" with an impact factor of 2.4, quartile Q1 in the *Mathematics* category.

In the field of **physics**, the list of the most popular works included the publication *"Observational constraints on a logarithmic scalar field dark energy model and black hole mass evolution in the Universe"*. It proposes a logarithmic form of parameterization of the dark energy density of a scalar field within the framework of the standard theory of gravity, which provides the necessary transition from the decelerated to the accelerated behavior of the Universe. The model under consideration is limited by the available observational data. The obtained data are consistent with recent observations and the results obtained in Planck 2018. The change in the mass of a black hole containing both matter and dark energy over time in the Universe is studied. It is shown that the mass of the black hole initially increases, but stops increasing as dark energy dominates. The funding agencies are Jiangsu Polytech Institute, Key Program of Natural Science of Changzhou College of Information Technology, Centre for Cosmology and Science Popularization, SC MCHE and Zhejiang Normal University. The work was prepared by *N. Myrzakulov* (L.N. Gumilyov Eurasian National University, Eurasian International Center for Theoretical Physics) together with scientists from China, Uzbekistan, Pakistan and Morocco. The article was published in the journal «*European Physical Journal C*» with the impact factor 4.4, quartile Q2 in the category *Physics, Particles & Fields*.

As you can see, domestic *Hot Papers* articles over the past 2 years have been created in collaboration with scientists from different countries, united mainly by solving global problems in the fields of *medicine, environmental protection/ecology, as well as engineering, mathematics and physics*.

Summarizing the above, it is possible to note the strengthening of international cooperation of Kazakhstani scientists, expressed in the growth of the number of joint articles of domestic researchers with foreign scientists. The main scientific partner of Kazakhstan is Russia, with which about a third of all works have been published. A high

share of cooperation has also been noted with the USA and China. The closest ties have been established in the field of natural and technical sciences. In general, Kazakhstan cooperates in 146 areas of research, mainly in the field of engineering, physics, chemistry, materials science, Science Technology Other Topics, environmental sciences, ecology, mathematics, computer science, energy and fuel. In the context of 22 thematic categories in natural and social sciences, the share of collaborations is 80% and higher in such areas of science as Multidisciplinary Sciences, Space Science, Economics and Business, Earth Sciences, Physics, Computer Science. Works created jointly with foreign colleagues are cited 3.4 times more, which is an indicator of greater efficiency and demand for these studies. As a result of the fruitfulness of joint research, it should be noted that the share of highly cited publications has increased, most of which were prepared in international cooperation. During the study period, the HCPs were presented in 18 of the 22 thematic areas of the Essential Science Indicators rubricator. A large share of the HCPs falls on Clinical Medicine, followed by Engineering and Social Sciences. An indicator of the high quality of research is *Hot Papers*, the number of which in the array of Kazakhstani publications has grown to 14 units over the study period. All of them were created as a result of the implementation of scientific and technical agreements with foreign and international scientific organizations.

In conclusion, it can be noted that international scientific and technical cooperation, allowing for joint development of scientific and technical problems, promotes the mutual exchange of scientific achievements, industrial experience, and increased visibility of domestic research. International relations in the field of science, technology and education, accumulating the potential for solving such important problems as achieving a level of development that meets the needs of modern international society, contribute to improving the quality of national science and technology systems, as well as training qualified personnel for the national economy.

7. ANALYSIS OF THE DEVELOPMENT OF THE NATIONAL INNOVATION SYSTEM (through mechanisms for the commercialization of technologies and the results of scientific and (or) scientific and technical activities, the integration of science, industry and the business community, an assessment of the contribution of science to the development of the country's economy and the impact of the results of scientific and (or) scientific and technical activities on the growth of the gross domestic product)

In Kazakhstan, in 2023, the costs of research and development (R&D) in 2023 increased by 41.9%, amounting to 172.6 billion tenge. In general, financing is considered as a percentage of GDP - 0.84 percent was in 1991; 0.12 percent in 2021; 0.13 percent in 2022 and 0.14 percent in 2023.

JSC "Science Fund", being the operator for the provision of grant financing for projects for the commercialization of the RSSTA, carries out tasks to organize high-quality and timely selection of projects subject to grant financing.

In 2022, JSC "Science Fund" had 155 projects in implementation, of which: - 60 at the stage of desk monitoring; - for 14 projects, final reports were sent to the NSC to close the projects; – 14 projects at the post-implementation stage after the relevant decision of the Scientific and Technical Council to close the projects; – 67 at the main stage of project implementation. The above-mentioned commercialization projects are mainly implemented in the following areas: agro-industrial complex, biotechnology, IT technologies, medicine, food production, chemical industry, energy, production of machinery and equipment, metallurgy and ecology.

Thus, for the period from 2016 to 2020, the following results were achieved in the implementation of RSTA commercialization projects supported by the Science Foundation based on the results of three competitions: the total income from the sale of innovative products amounted to 8 billion tenge, the total amount of taxes paid was about 3.2 billion tenge, the volume of exports was 243 million tenge, the amount of royalties was 178 million tenge.

In 2022, funding was resumed and in the middle of the year a competition for grant funding for 2022-2024 was held. A specialized National Scientific Council for Commercialization has been created, 50% of which are representatives of the business community. 152 applications were submitted, 134 of which passed the examination, 72 projects were approved by the decision of the NSC, 68 contracts were concluded. According to the results of this competition, 66 projects are being implemented. For the period 2022-2023, 12.9 billion tenge were allocated.

In 2023, a competition was held for 2023-2025, within the framework of which twice as many applications were submitted - 320, of which 233 passed the examination. 76 projects were approved for financing by the decision of the specialized NSC for commercialization of the RSSTA, 72 contracts were concluded with grantees. In 2023, 5.2 billion tenge were allocated.

With the adoption of the Law on the commercialization of the RSTA in 2016, 2017 and 2018, 2022, 2023, the Science Foundation held competitions for grant financing of RSTA commercialization projects, for which 1742 applications were

submitted, 1370 passed the examination, 341 were approved by the decision of the NSC, 310 contracts were concluded, about 290 projects were supported, 138 projects are at the implementation stage, 155 productions entered into sales, of which 16 projects are exported abroad and 5 projects achieved sales with a volume of more than 1 billion tenge.

The total contribution of the projects of 4 competitions in 2016, 2017, 2018 and 2022 (as of the end of 2023) to the scientific and technical development of the country amounted to 72.5 billion tenge, including sales, co-financing, tax payments, purchased equipment and royalties paid. The total revenue from sales of high-tech products amounted to 33.7 billion tenge, including the creation of more than 1,700 jobs, more than 7.8 billion tenge paid to the budget in the form of tax payments and 9.7 billion tenge attracted in private co-financing. Royalty was paid in the amount of 534 million tenge, fixed assets were purchased in the amount of 20.8 billion tenge.

Implementation of high-tech technologies in production, examples of successful projects

Project AP15573624 "Commercialization of the bio-product with adhesive properties "BioLip" is aimed at creating the production of a domestic biological adhesive based on natural polymers for plant growing. EcoSave LLP acts as a grant recipient and private partner. The goal of the project is to create a bio-product with adhesive properties "BioLip" to increase the effectiveness of plant protection products and fertilizers. The advantages of this product are its lower price due to the localization of production and the absence of transportation costs. Its use also allows you to comply with the regulations for use, eliminating complaints from customers due to violation of the regulations for use. Due to the biological nature of the drug, it contains vitamins, hormones and nutrients, which is also its advantage. The project is being implemented in the city of Stepnogorsk.

Project AP15573781 "Organization of production of composite materials based on wood components". KazNewTech LLP LLP is a grant recipient of the project.

The goal of the project is to organize the production of building materials using industrial products of the woodworking industry and secondary raw material waste. The advantages of this material include: - complete protection against rot and mold; - increased mechanical strength; - color fastness when exposed to ultraviolet light; - environmental safety and no unpleasant odor; - ease of processing and installation, as well as safety in operation; - fire safety. The project is being implemented in the city of Almaty.

Project AP15573920 "Creation of an innovative center for the production of high-quality forage crop seeds" is an important initiative in the field of agriculture. LLP "Kazakh Research Institute of Agriculture and Plant Growing" acts as a grant recipient of the project. The goal of the project is to organize the production of high-quality forage crop seeds using digital technologies. The project is aimed at providing agricultural producers with high-quality and competitive forage crop seeds, including highly reproductive seeds. Competitive advantages of the project include the production of high-quality seeds of varieties and hybrids of forage crops, provision of

seed farms and agricultural producers with high-quality and conditioned seeds, as well as an increase in the production, quality and competitiveness of crop products. The project is being implemented in the village of Almalybak, Karasai district, Almaty region.

Project AP15573960, "Production of domestically developed unmanned aerial systems (UAS) for the needs of various spheres of economic activity", Research & Development Center Kazakhstan Engineering LLP acts as a grant recipient, and SC TECH LLP is a private partner. The main goal of the project is to bring innovative unmanned aerial vehicles to the market and organize their production. The advantages of the project include high functionality and flexibility of using UAS in various fields. The expected results of the project include the development and production of UAS for various needs, organizing their sale, as well as transferring the rights to serial production to interested enterprises. The location of the project is Astana.

Amount of funding, regions where projects are carried out on the basis of grants allocated by the Science Foundation.

For the period 2022-2023, the Science Foundation allocated more than 18 billion tenge for projects selected within the framework of grant financing of the most promising projects for the commercialization of the results of scientific and (or) scientific and technical activities. The bulk of funding was distributed between the cities of Almaty (34%) and Astana (18%), while less than 1% was allocated to projects in the Aktobe, Atyrau and Zhetysu regions.

If we compare business requests for problem solving and scientists' proposals to the market, the showcase of scientific developments of JSC "Science Fund" publishes the following data: among the finished projects seeking co-financing, there are currently several scientific papers for oil and coal mining companies, manufacturers of building materials, geological surveys, and communication technologies. Technological requests from businesses for scientific projects have a slightly different focus. A construction company is turning to scientists to develop innovative technologies that would reduce the time and cost of building schools. The Farmers' Association plans to solve the problem of feed for livestock in arid regions with the help of scientists; a meat processing plant is to finance a scientific solution to the problem of organizing meat production and its export to China and the UAE. The creation of an effective system for commercializing the results of scientific and technical activities will become the main mechanism for bringing new innovative products or technologies to the market – it will transform a scientific idea into a market product.

Commercialization of scientific activities of universities in 2023

Al-Farabi Kazakh National University. The project AP15573976 "Creation of an innovation and production center for finishing electrochemical processing of metal products for the needs of mechanical engineering and instrument making" has been completed. Head Galeeva A.K. Executing organization: LLP "Center for Chemical Engineering and Materials Science". Amount of funding - 43,840,786 tenge, co-financing - 8,768,158 tenge.

Results: patent No. 8521 dated 13.10.2023 "Method for producing an electrochemical coating in the form of an alloy" was received. A galvanic workshop was launched as part of the scientific and production center "Chemical Coatings Innovations" on the territory of the applicant NAO "Al-Farabi Kazakh National University".

Kazakh National Agrarian Research University. Implementation certificates for 4 scientific and technological progress projects have been received, including project AP09259400-“Selection of non-traditional crops for intensive use of irrigated lands and creation of a green conveyor depending on the bioclimatic potential of growing zones”. Head Erzhanova K.M. Funding volume 36,000,000 tenge. Application for a utility patent 10/12/2023.

The results have been implemented in the production of Bayserke-Agro LLP.

L.N. Gumilyov Eurasian National University. In 2023, the university conducted 244 studies in such areas as nuclear energy, molecular biology, genetic engineering, biomedicine, construction and road industry, petrochemistry, environmental monitoring, water and land resources management, geoinformation modeling, etc.

In 2023, 4 patents, 25 copyright certificates, 7 implementation certificates were received within the framework of grant and program-targeted financing.

Astana Medical University. The commercialization project of the Science Fund of the Ministry of Health of the Republic of Kazakhstan on the topic "Radiation monitoring of the territory of oil producing enterprises" (2022-2024) is being implemented for a total of 63,285,000 tenge. As part of the project, contracts were concluded with 3 oil producing companies for the provision of industrial radiation monitoring services for a total of 3 million 144 thousand tenge. The Institute's scientific developments have been implemented in the educational process and in the cycle of advanced training for doctors to ensure radiation safety. At the same time, the amount of paid services provided in 2023 amounted to 4 million tenge.

M. Auezov South Kazakhstan University. 2 projects have been implemented in production:

1. The project "Modernization of the technological line for dressing and dyeing sheepskins for the production of export-oriented eco-products for household and special purposes." Head B.E. Kalymbetov. Grant 286,279,003 tenge, Co-financing 71,569,753. Implemented in IE "Kozhabekova G.T." Production has been launched.

2. The project "Implementation of the production of dressings and a medical mask with antiviral and antibacterial action based on silver and copper nanocitrate." Head. Tashmenov R. Result: patent for utility model No. 5863 dated 19.02.2021 was received. Samples of gauze and dressings were obtained in pilot industrial conditions of Yuzhpharm LLP. Implementation certificate dated 11.12.2023.

East Kazakhstan Technical University named after D. Serikbayev. 5 commercialization projects were implemented, implementation certificates were received, including BR10865102 - "Development of scientific and methodological approaches to the implementation of remote sensing technologies (RS) to improve agricultural management." Head Sadenova M.A. 92,634,118 tenge, PCF Competition. The results have been implemented in the production process of JSC NC Kazakhstan

Gharysh Sapary (implementation act No. 1 dated October 27, 2023), Mayak farm, and in the educational process at NJSC EKTU named after D. Serikbayev (implementation act dated October 17, 2023).

Kazakh Agrotechnical Research University named after S.Seifullin. The research results have been implemented in 28 agricultural enterprises, 5 - in the educational process, including:

1. Scientific and technological progress "Development of technologies for maintenance, feeding, growing and reproduction in dairy cattle breeding based on the use of adapted resource-energy-saving and digital technologies for various natural and climatic zones of Kazakhstan". Head Bostanova S.K. Funding volume - 584,827.7 thousand tenge. The results have been implemented in 12 agricultural enterprises.

2. Scientific and technological progress "Creation of highly productive varieties and hybrids of grain crops based on the achievements of biotechnology, genetics, physiology, plant biochemistry for their sustainable production in various soil and climatic zones of Kazakhstan". Head Savin T. V. Funding volume - 1,206,514.8 thousand tenge, Results implemented in 7 agricultural enterprises. Thus, university science can become a driver of scientific and technological breakthrough of Kazakhstan. The vector taken on the development of university science demonstrates high efficiency and return.

7-1) analysis of the completeness of the implementation of recommendations given following the approval of the National Report by the President of the Republic of Kazakhstan, assessment of progress in key areas of development of domestic science, results of foresight studies (once every 3 years)

Results of foresight studies

Priority I – ***"Rational use of water resources, flora and fauna, ecology"***

In the near future, in the field of rational use of flora and fauna, the following issues will be important: conservation of biodiversity, protection, restoration, conservation of rare and endangered animal species, rare and endemic flora species, forecasting forest pyrological and forest pathological situations; solving problems associated with the invasion of introduced species used in landscaping urban areas.

Priority is given to research related to the assessment of the ecological state of wastewater storage tanks for the development of scientific foundations for their disposal. A new stage of research in the field of ecology is associated with the initiatives of the UN and other international organizations to develop the concept of a green economy, GreenTech technologies. In the future, there will also be research on the development of an environmental accounting and audit system, which has just begun to form, and the model has not yet been fully formed.

Priority II – ***"Geology, extraction and processing of mineral and hydrocarbon raw materials, new materials, technologies, safe products and structures"***

A promising area is a set of geochemical, paleothermobaric studies of promising areas of sedimentary basins of Kazakhstan for the reconstruction of oil and gas

systems, determination of generation potential and identification of the main centers of generation of gaseous and liquid hydrocarbons.

Green hydrogen transition. Green hydrogen (GH2) can currently become a means of decarbonization of the industry. Kazakhstan should start working in this direction, since about 45 countries of the world have already published their hydrogen strategies. In the European strategic agenda on the future transition to green energy, hydrogen ranks first. Another technology is to obtain hydrogen by cracking methane (90% of hydrogen is currently produced using this technology), but a huge amount of CO2 is released. This technology for capturing CO2 can be successfully applied in Kazakhstan, since gas, including methane, is extracted from underground reservoirs, which are often exploited by secondary and tertiary methods (MOR), incl. underground CO2 injection.

Green technologies. One of the sectors that should be more actively developed in Kazakhstan is electric motorization (including urban transport: cars, buses, urban transport vehicles, and mining/industrial equipment), to "green" mining using electric scarers/motors, automatic mining/excavation, cyber mining, driverless mining vehicles, robots in risky areas). This type of equipment is now available on the international market, but the infrastructure of some countries is not ready for its implementation. In Kazakhstan, there is a need to develop recharging infrastructure due to the expected growth of electric vehicles.

One of the main challenges of green energy technologies is energy storage; a commercial underground storage developed by a Swedish Consortium could change the picture by reviving abandoned mines for use as energy storage sites.

Green energy sources. Clean energy that can produce more than it uses: safe laser-induced nuclear fusion. This technology is being commercialized by Starburst LD-IFE (Laser Diode Inertial Fusion Energy), LLC. The first of its kind fusion power plant ("FOAK") with sustainable baseload and flexible power (400-2000 MW) will be operational in the U.S. within the next 5-6 years, and the economic benefits will be realized across many sectors and industries.

*Priority III – **"Power Engineering and Mechanical Engineering"***

Energy. In the direction of "Energy" in Kazakhstan, according to the results of the foresight, significant steps have been taken in recent years to improve the investment climate in the renewable energy sector, taking into account global practices.

The selected priority areas include: large-scale introduction and implementation of renewable energy projects; flexible and sustainable energy systems; optimization of energy consumption in buildings; efficient energy management.

In order to maximize the demand of energy consumers, modernize existing energy sources and gradually reduce carbon dioxide emissions in electricity generation, work has been carried out to implement technological modernization and innovative development of the energy sector of Kazakhstan. The tasks and indicators characterizing scientific research work include a set of interrelated measures to improve the effectiveness of scientific research in priority areas: the formation of new scientific schools; attracting foreign teachers and scientists from leading universities

and leading scientific centers for the joint development of priority research areas in the field of renewable energy sources, energy saving, IT technologies and robotics; participation in international scientific and educational projects; conducting joint research projects with the industrial and corporate sectors.

Mechanical engineering.

The efforts of domestic and engineering personnel should be focused on finding new technological solutions and implementing advanced world experience in developing not only the economy as a whole, but also the manufacturing industry in particular. At present, there are reserves for developing production in the automobile, railway, agro-industrial, oil and gas, mining and metallurgy, and energy sectors. It is also necessary to focus on the development of "green" technologies.

*Priority IV – **"Information, Communication and Space Technologies"***

Information technologies. Artificial intelligence, the Internet of Things, blockchain technologies and cloud computing are just some of the trends that define the modern IT world. It is necessary to develop effective strategies for managing information technologies and ensure the security and confidentiality of data.

In the future, the prospects for the development of information technologies will be based on social networks due to the high percentage of integration of a large number of users into the information space. Information technologies will remain the driving force behind the development of the industry.

Communication technologies. Digital technologies for transmitting sound and images will be supplemented by technologies for transmitting smells, sensations and, perhaps, even emotional states of a person. Internet technologies will develop quantitatively rather than qualitatively; personal computers and mobile phones, means of reproducing sounds and images, as well as devices for orientation in space will be embodied in a single system that is extremely convenient for use and applicable almost anywhere in the world.

Space technologies. As global geopolitical tensions intensify, the goal of sovereign states and private companies to develop their own space capabilities is paramount.

Advances in sectors such as life sciences and materials science are a potential gold mine for new classes of drugs, and new materials developed in space could have a transformative impact on industries such as pharmaceuticals, telecommunications, and microelectronics.

Kazakhstan needs to make significant efforts to develop space technologies, as the gap in this scientific area is obvious.

*Priority V - **"Scientific research in the field of natural sciences"***

Currently, humanity is in the process of a mass transition to a post-industrial society, and all progressive countries are concerned about building an economy that corresponds to the "Industry 4.0" initiative. Those countries that show the right vision of the future and are concerned about taking timely measures for reforms (the predicted duration is 10-15 years) will be the leaders of the post-industrial era. The main trends are Artificial Intelligence, Big Data, Cybermedicine, Neurocomputer interface, Virtual and augmented reality, Additive technologies (3D printing),

Materials with dynamically programmable properties (smart matter), Nanorobots, Thermonuclear energy, Quantum computers, Settlement of near space.

The technical basis of this revolution is quantum technologies, which are being developed by advanced technology giants in cooperation with leading research universities. In this regard, foresight research in the field of physics in Kazakhstan should be focused on the development of quantum physics, where the most important areas will be research in the field of quantum computing, quantum cryptography and quantum teleportation. These studies will form the basis for the creation of new technologies that will provide Kazakhstan with a leading position in the field of high technology and data security. It is impossible to develop any particular science in isolation from the rest, or one area of science separately from other areas necessary for the development of the country. It is necessary to conduct targeted training of highly qualified specialists who are capable of creating viable high-tech innovative firms in the conditions of scientific institutes and universities in Kazakhstan, using the full potential of these institutions.

Priority VI – ***"Life Sciences and Health"***

The main key products and services resulting from interdisciplinary research and development in the direction of "Scientific and Innovative Biomedicine" will be: bioengineered organs and tissues; personalized DNA and RNA sequencing services; biomedical cell preparations and treatment protocols; methods for overcoming drug resistance in microorganisms and viruses.

The key products and services resulting from interdisciplinary research and development in the direction of "Integrated Healthcare" will be: IT technologies in the diagnosis and treatment of diseases; research in the development of a robotic system for determining the physiological status of a person; development of control and automation tools for the treatment and diagnostic process based on artificial intelligence technologies.

The direction of "Society and Health" identifies the following products and services as such: innovative technologies for managing public health and healthcare; effective programs and models for forming a healthy lifestyle; an effective model of school medicine; methods for screening and improving the health of children and adolescents; "smart" nursing homes; and technologies for early detection, effective treatment and prevention of occupational diseases.

Priority VII – ***"Research in Education and Science"***

The future of education and science is variable, as is research in this area. On the one hand, scientists from leading universities around the world are developing courses to teach students how to conduct foresight studies, on the other hand, they conduct such studies and offer different forecast scenarios for the development of education until 2030, 2040.

The main skills of employees during retraining according to foresight studies are: analytical thinking and creative skills, resilience and flexibility, motivation and self-awareness; lifelong learning, adaptation to changes in the workplace; technological literacy, reliability and attention to detail; empathy and active listening,

leadership and social influence, quality control of activities. In Kazakhstan, the project "Mamandygym – Bolashagym" can be singled out as a foresight study, launched in 15 regions of Kazakhstan, according to which regional maps of personnel needs were developed, and professions in priority industries of each region were identified.

Priority VIII – ***"Research in the field of social and human sciences"***

When forecasting future scenarios for the development of social and humanitarian research in Kazakhstan in the medium term, we can highlight several possible areas, each of which can have a significant impact on society:

1. Strengthening interdisciplinary research. The trend towards integrating data from different fields of knowledge (Data Science) can also enhance the quality and depth of research.

2. Focus on cultural heritage and identity. Current trends: digitalization of cultural heritage (digitization of archives, creation of virtual museums) will make cultural values more accessible to a wider audience and younger generations.

3. Development of social responsibility and ethics. Trends in corporate social responsibility (CSR) and environmental, social and governance (ESG) investing can contribute to more responsible behavior of companies and institutions, which will have a positive impact on the state of society and its environment.

4. Integration and globalization of research. The trend towards creating international research consortia and participation in global research initiatives can significantly increase the competitiveness of Kazakhstani science on the world stage.

5. Technological innovations in social sciences. Trends in the use of machine learning and big data analysis make it possible to identify hidden patterns and trends in social processes, which can help in the development of more effective social programs and policies.

These scenarios can help Kazakhstan improve its scientific and social practices, stimulating innovation and strengthening the social and cultural development of the nation.

Priority IX - ***"Sustainable development of the agro-industrial complex, safety of agricultural products"***

Priority areas of foresight research for support and development in the agro-industrial complex of Kazakhstan in the short and long term:

- selection and seed production - to ensure food security and adaptation to climate change;
- introduction of high-tech agricultural technologies - to increase the efficiency and sustainability of agriculture;
- development of pasture forage production - to develop the livestock industry and ensure high-quality feeding;
- elimination of degradation of agricultural landscapes - requires the development of sustainable farming methods and soil restoration;
- effective phytosanitary monitoring - to protect crops from pests and diseases;
- the use of biological plant protection technologies - to develop environmentally friendly agriculture and reduce the use of chemicals.

To ensure food security and sustainable development of the country's agro-industrial complex, the Ministry of Agriculture of the Republic of Kazakhstan must take these areas into account when planning and implementing strategies for the development of the agro-industrial complex.

Priority X - ***"National security and defense"***

Problems, threats and challenges by type are reflected in the following areas of foresight research:

Geopolitical, social and political tensions. Adaptability in the security policy of the region and the country. Hybrid wars (methods of struggle). Protection of personal data. Cooperation between the public and private sectors is a fundamental and developing aspect of national security. New approaches have incorporated the provisions and terminology of the innovative concepts of "soft power", "smart power".

Terrorism and extremism. The fight against terrorism, cybersecurity issues, biological threats as a tool of terrorism and extremism, an effective cybersecurity system, espionage and state-sponsored threats, the fight against terrorism, the close connection between the fight against terrorism and national security, the balance between security and civil liberties.

Military power and the balance of power. The protection of critical infrastructure, the dependence of military security and defense issues on digital technologies, espionage and state-sponsored threats, hybrid wars (methods of combat), disinformation and information warfare have become the most important elements of national security in the digital era. Space plays a decisive role in communication, navigation, intelligence and many other activities that directly affect the country's defense, economic interests and technological prowess.

The possibility of using biological weapons. These threats cover a whole range of potential dangers, from natural pandemics to bioterrorism, and have far-reaching consequences for the security and well-being of the nation.

A modern scientific infrastructure is needed to increase the global competitiveness of domestic science. An outdated, uncompetitive scientific infrastructure and the low level of material and technical equipment of scientific organizations and universities are hindering the development of domestic science.

8. ANALYSIS OF THE ACTIVITIES OF SECTORAL AUTHORIZED BODIES (for the management of science and scientific and technical activities)

8.1 Ministry of Agriculture of the Republic of Kazakhstan

The system of agricultural science of the country is represented by the National Agricultural Research and Educational Center (hereinafter referred to as the NJSC NAREC), the main objective of which is to promote innovative development of the agro-industrial complex of the republic through scientific research and training of agricultural personnel.

Thus, to solve the above-mentioned task, the NJSC NAREC system includes 34 organizations: 3 universities (KazNAIU, KazATIU named after Seifullin, ZKATU named after Zhangir Khan), 12 research institutes and research and production centers, 17 agricultural experimental stations and farms, 2 service companies (Asyl Tulik, CTCA). The Ministry of Agriculture provides stable financing of agricultural science through basic financing, as well as on a competitive basis - program-targeted financing.

The NAREC organizations have received 741 security documents, more than 20 developments are being implemented, strategies for combating animal brucellosis and bovine leukemia have been developed, a dossier has been compiled on the territory of 9 regions as foot-and-mouth disease-free zones, National programs for the control of foot-and-mouth disease, brucellosis, leukemia have been developed, thematic digital maps of the distribution and number of locusts have been created, the use of elements of precision farming, smart farms, an interactive geoinformation map of degraded pastures in the Republic of Kazakhstan with various degrees of degradation, etc.

10 areas of the agro-industrial complex were announced for the 2021-2023 competition: crop production, animal husbandry, veterinary medicine, plant protection, processing of agricultural products, economics of the agro-industrial complex, organic farming, natural resource management, smart agriculture and agricultural mechanization. Subsidiaries of the National Agrarian Scientific and Educational Center actively cooperate in various areas with international scientific and other organizations in China, Brazil, Argentina, the USA, Belarus, Russia, Holland, France, etc. At the same time, there are systemic problematic issues in agricultural science (low funding, lack of funds for the modernization of scientific and technical infrastructure, weak implementation of scientific developments, demand for the seizure of scientific land plots, etc.), which cannot be solved without state support. Subsidiaries of the National Agrarian Scientific and Educational Center implemented 27 scientific and technological progress projects in 2021-2023, and 4 scientific and technological progress projects were carried out by third-party organizations within the framework of the priority area “Sustainable development of the agro-industrial complex and safety of agricultural products” in 9 specialized scientific areas.

The effectiveness of individual completed scientific projects

STP "Development of technologies for effective management of the selection process for the preservation and improvement of genetic resources in beef cattle breeding".

In beef cattle breeding, 5 programs have been developed to improve the selection and breeding work of 5 beef breeds. The level of profitability for five breeds - Kazakh white-headed, Auliekol, Hereford, Angus and Kalmyk on average was within the range of 33.50% to 41.57%. Research on selection and breeding work has been implemented in 28 farms of the country.

Scientific and technical progress "Development and proposal for production methods of diagnostics, disease prevention, therapy of infected animals and disinfection of soil anthrax foci"

The technical and economic efficiency of implementing the research results consists of developing 8 domestic vaccines, 13 diagnostics, 2 medicinal preparations, 1 disinfectant for disinfection and elimination of soil anthrax foci with a description of the methods and schemes of application that are ready for commercialization.

Scientific and technological progress "Creation of highly productive varieties and hybrids of grain crops based on the achievements of biotechnology, genetics, physiology, and plant biochemistry for their sustainable production in various soil and climatic zones of Kazakhstan"

In 2021-2023, 23 varieties of agricultural crops were submitted for State Variety Testing, 4 recommendations and 1 monograph were developed, 5 patents of the Republic of Kazakhstan were received, 20 patent applications were filed, 59 scientific articles were published, including 8 articles in journals included in the international Scopus and Web of Science databases, 12 implementation certificates were received, and a license agreement was concluded. Original seeds of grain crops were produced in the amount of 441.7 tons.

The economic effect is expressed in additional profit due to the high productivity of new varieties and hybrids against previous analogues by at least 10% at the same costs per unit area. The production of seeds that meet the requirements of GOST will allow producers to obtain a high and stable yield. Saturation of the market with seeds of varieties and hybrids of domestic selection will reduce the share of imported seeds.

Scientific and technical progress "Study and provision of storage, replenishment, reproduction and efficient use of genetic resources of agricultural plants to ensure the selection process"

In 2021-2023, 3,188 samples were actually collected; - exchange and participation in the International Variety Testing - 2,493, including: grain - 1,076; legumes - 90; oilseeds - 1,047; technical - 50; cereals - 230; expeditionary collection - 693 samples of forage crops and 2 samples of oilseeds.

1,494 samples of grain, oilseeds, cereal crops were transferred for agronomic and molecular characterization of the collection material of the gene pool.

8 articles were published, included in the international Scopus database; 4 - in the RSCI; 23 - in the list of Committee for Quality Assurance in Science and Higher Education; 2 recommendations were issued.

Scientific and technical progress "Development of technologies using new strains of beneficial microorganisms, enzymes, nutrients and other kits in the production of special dietary food

products" (National Joint-Stock Company "Kazakh Agrotechnical University named after Saken Seifullin)

As a result of the research conducted in 2021–2023, the following were developed: 11 technologies for obtaining functional products; functional additives; 5 recommendations; 1 regulatory documentation for preventive drinks; 3 recipes; 1 technological regulation. A mini-plant for processing sheep and goat milk and producing fermented milk products and cheeses from sheep and goat milk was created on the basis of the S. Seifullin Kazakh Agrotechnical Research University.

Scientific and technical progress "Regulatory and methodological support for the development of organic production in the Republic of Kazakhstan in accordance with international and foreign standards and requirements of priority sales markets"

The following has been developed: a model of an information platform for the main participants in the organic products market, a system for accounting and traceability of organic products, a model for interaction between participants in the organic products market at the stage of extraction, processing and presentation of agricultural raw materials to the international market. A draft Concept for the formation and functioning of the PGS-Qazaqstan program has been developed. A draft professional standard "Organic Production" has been developed. 6 articles have been published in domestic and 2 articles in foreign journals of Scientific Horizons (recommended by the Committee for Quality Assurance in Science and Higher Education), 1 article has been published in foreign journals with a non-zero impact factor in interdisciplinary journals of Scopus (Q3).

Scientific and technical progress "Development of scientific and methodological approaches to the implementation of remote sensing technologies (RS) to improve agricultural management"

Based on remote sensing data (space photography) and remote sensing methods, a scientifically based method for identifying the main types of agricultural crops (grains, legumes, oilseeds and forage crops) has been developed. The economic effect of implementing the results obtained is the timely receipt of information on the state of the soil cover in real time.

Based on the research results, 3 articles were published in domestic and 12 articles in foreign journals with an impact factor indexed in Q1, Q2, Q3 and Scopus journals (2). 5 patents were received and one collective monograph was published.

8.2. Ministry of Health of the Republic of Kazakhstan

The infrastructure of scientific activity is represented by 8 medical universities, including 3 non-departmental, 22 subordinate research organizations, of which 5 research organizations are subsidiaries of the Kazakh National Medical University named after S.D. Asfendiyarov (hereinafter - KazNMU named after S.D. Asfendiyarov) and 7 subsidiaries of the National Holding "QazBioPharm". Among the subordinate research organizations - 17 clinical profile and 5 non-clinical profile.

In the healthcare system, there are 3 laboratories for collective use, including scientific molecular genetic laboratories for collective use on the basis of KazNMU named after S.D. Asfendiyarov and the Medical University of Karaganda and the National Scientific Laboratory of Biotechnology on the basis of the National Center

for Biotechnology, which provide access to modern devices and research for young scientists and employees of medical education and science organizations within the framework of research projects. To develop a support system and promote the results of scientific research, a scientific and technological park operates on the basis of KazNMU named after S.D. Asfendiyarov.

The human resources potential for scientific activity in the field of healthcare (11,892 people) is represented by research personnel (850 people), scientific and pedagogical personnel (7,416 people), clinical personnel of university and republican clinics (3,626 people).

The share of personnel with an academic degree accounts for 23% (2,786 people). In total, 581 doctors of science, 1,806 candidates of science, 399 PhD doctors work in organizations carrying out scientific activity in the field of healthcare.

For information. *In 2023, medical universities and research institutes, scientific centers participated in the implementation of scientific and technological progress at the expense of other domestic grantors and funding organizations (national companies, business structures). At the same time, representatives of the business community financing scientific research in the field of healthcare include 16 organizations from among Kazakhstani companies and representative offices of foreign companies in the territory of the Republic of Kazakhstan - SAUTS-OIL LLP, BARK Technology LLP, PTC Therapeutics International Ltd, Boehringer Ingelheim RCV GmbH & Co KG, Vita Eterna LLC, National Confederation of Employers (Entrepreneurs) of the Republic of Kazakhstan, PARYZ, Alimentiv B.V. Corporation, GENERIUM JSC, Russia, Biofarmed LLP, Medoptik LLP, Standard Pharma LLP, etc.*

Research programs and projects were carried out in 2023 at the expense of foreign grantors. At the same time, the number of foreign grantors and funding organizations includes more than 20 organizations, including Astra Zeneca, the Centers for Disease Control and Prevention (CDC), the Global Fund to Fight AIDS, Tuberculosis and Malaria, Columbia University, Partners in Health (PIH), the US Center for Infectious Disease Control, UNAIDC, SMCT GROUP, Wilmington, DE, USA, Erasmus+, AbbVie LLC, RF, UNDP, IAEA, the EU Education, Culture and Audiovisual Executive Agency (EACEA), etc.

Development of clinical research. Over the past three years, the number of submitted applications for clinical trials in the Republic of Kazakhstan has increased by 1.1 times, approved applications by 1.6 times, and active trials by 1.3 times. In 2023, 17 clinical trials are being implemented (in 2022 - 12 trials, in 2021 - 10 trials) (according to the website of the National Center for Expertise of Medicines and Medical Devices).

Research performance indicators. The analysis of research performance indicators for 2023 was carried out for all medical education and science organizations (27 organizations).

According to the analysis of the assessment indicators for the indicator *"Number of patents and other security documents"*, the leaders in the number of security documents received among universities in proportion to all organizations are West Kazakhstan Medical University named after M. Ospanov (40%) and Astana Medical University (33%). Among research institutes, the top three scientific centers are NCAID (13%), NSCTO (11%), MCH PAA RK (10%). Over the past 3 years, the number of articles published by medical universities and scientific organizations in the field of healthcare annually in publications indexed by Scopus and Web of Science has

increased from 469 articles in 2020 to 955 articles in 2023.

Achievements of scientific and educational organizations of the Ministry of Health of the Republic of Kazakhstan

Undoubtedly, the most significant achievement of domestic scientists in 2023 was the invention by the employees of the UMC (National Scientific Cardiac Surgery Center) of a new device ALEM (Astana Life Ex-situ Machine) for storing and transplanting donor organs. In this regard, the risk of not having time to transport organs and perform an operation is significantly reduced, since now the extracted organs can be suitable for 24 hours. The domestic method is safe, because the device creates an imitation of a heart contraction.

The *Karaganda Medical University* has launched a commercialization project on the topic "Exoskeleton" - a mobile lift - an assistant for people with disabilities, with an implementation period of 2023-2024. The project is based on our own development of a device that ensures unhindered and safe overcoming of stairs for people with disabilities who move in wheelchairs. The device is characterized by convenience and ease of use, while the cost is 2-3 times lower than that of analogues. The implementation of the project will allow establishing our own production of a high-tech product to improve the quality of life of people with disabilities.

Astana Medical University is implementing the Science Foundation's commercialization project “Radiation Monitoring of the Territory of Oil-Producing Enterprises” (2022-2024) for a total of 63 million 285 thousand tenge. As part of the project, contracts were concluded with 3 oil producing companies for the provision of industrial radiation monitoring services for a total of 3 million 144 thousand tenge. The Institute's scientific developments have been introduced into the educational process and in the cycle of advanced training for doctors to ensure radiation safety. At the same time, the amount of paid services provided in 2023 amounted to 4 million tenge.

The *Research and Production Center of Transfusiology*, as part of a scientific research, has begun work for the first time in the republic on the isolation and cultivation of mesenzymal stem cells (hereinafter referred to as MSC). MSC preparations are intended for therapeutic purposes in oncohematological pathologies and joint diseases.

On the basis of the *Scientific and Technological Park of KazNMU named after Asfendiyarov*, the implementation of 4 projects was continued at the specialized dialogue platform for the integration of science and business "Reactor of commercialization of technologies". Based on the results of the study, 2 security documents were received, 2 projects entered the final stage of commercialization. The income received will allow the product to be self-sufficient.

As an example of successful interdepartmental collaboration, we can note the Batpenov NRCTO, which, in the framework of cooperation with the East Kazakhstan Technical University named after D. Serikbayev, is participating in the formation of a scientific technopark for the creation of domestic metal implants and further participation in the grant for the commercialization of their manufacturing technologies.

The *National Center for Biotechnology*, within the framework of grant funding for the development of a biomedical technology for the treatment of ankle cartilage pathology using an injectable biocomposite hydrogel, obtained and characterized a heparin-conjugated fibrin hydrogel (HCFH) containing autologous mesenchymal stem cells (MSCs) of the synovial membrane and growth factors to stimulate the regeneration of cartilage tissue. Successful implementation of the program will allow in the future not only to increase the effectiveness of the treatment of osteoarthritis of the knee joints, but will also lay the methodological foundations for the use of cellular and tissue engineering technologies for the treatment of injuries to the musculoskeletal system in Kazakhstan. In 2023, the National Scientific Oncology Center was the first in Kazakhstan to use targeted therapy with venetolax to treat patients with acute myeloid leukemia - patients over 60 years of age with comorbid conditions, which made it possible to increase the survival of 17 elderly patients with acute myeloid leukemia. In addition, the use of target therapy with daratumumab to treat patients with multiple myeloma who are planned to undergo bone marrow transplantation made it possible to improve the survival of 13 patients with multiple myeloma.

In the reporting year, the *National Reseach Medical Center* began a clinical trial (phase 3) of a drug manufactured by Boehringer Ingelheim for the treatment of obesity (non-hormonal drug). 48 countries of the world (the European Union and the USA) are participating in the clinical trial. Participation in such a study is prestigious and implies further cooperation in international projects.

In turn, the Ministry has launched the Roadmap for the Scientific and Technological Development of the Healthcare System of the Republic of Kazakhstan for 2023-2027 to successfully and effectively conduct the MedTech pilot project.

The National Scientific Center of Health Development of the Ministry of Health of the Republic of Kazakhstan continued to work on the Cerebra and Lung Cancer Screening System Using Computed Tomography and Artificial Intelligence/Forus Data technologies. In 2024, it is planned to conduct an on-site audit of seven technologies for further scaling and practical implementation.

Brief results obtained within the framework of scientific programs financed by the Ministry of Health of the Republic of Kazakhstan.

In 2023, work was completed on the implementation of scientific research in accordance with the calendar plan of 9 scientific and technical programs of program-targeted financing with an implementation period of 2021-2023. For example:

1. Scientific and technological program "Development and advancement of innovative technologies for early diagnosis and treatment of malignant diseases, taking into account modern approaches to genomics" (executor - JSC "Kazakh Research Institute of Oncology and Radiology"). Implementation period - 2021-2023.

Program goal: development and advancement of innovative technologies for early diagnosis and treatment of malignant diseases, taking into account modern approaches to genomics and proteomics in lung cancer, stomach cancer, ovarian cancer, cervical cancer, colorectal cancer and in children with acute leukemia, extragonadal germ cell tumors.

The results of the work and the novelty of the research were presented at

international and national scientific events (123 reports). 37 articles were published (18 of them in international publications), 6 guidelines, 36 abstracts. 52 implementation certificates were issued. 8 patents and copyright certificates were received.

2. *Scientific and technical program "Aging and Healthy Lifespan" (implemented by Nazarbayev University)*. Implementation period: 2021-2023. The goal of the program is to implement a multifaceted, organically interconnected state target program of high international level research in the field of aging and healthy life. In 2021-2023, 10 articles were prepared and published in highly rated foreign and domestic publications.

3. *Scientific and technical program "Development and scientific substantiation of innovative technologies to improve the efficiency of diagnostics, treatment of injuries, consequences of injuries, diseases of the limbs, spine and pelvis"* (implemented by N.D. Batpenov National Research Center of Traumatology and Orthopedics). Implementation period: 2021-2023.

A new universal classification and differentiated approach to the treatment of various chest deformities are proposed. A method of double cementation has been introduced in patients with bone tissue defects after knee arthroplasty.

Scientific result: 1 Eurasian patent, 2 patents for invention, 2 patents for utility model, 4 copyright certificates received, 3 applications for security documents filed, 35 reports made at national and international conferences, 28 publications published, including 5 in foreign peer-reviewed journals included in the Scopus and Web of science databases, 7 in journals recommended by the Committee on Quality Assurance of the Republic of Kazakhstan, and 2 articles at the review stage, 1 monograph, 4 methodological recommendations, 16 implementation certificates.

4. *Scientific and technological program "Development of innovative and highly effective technologies aimed at reducing the risk of premature mortality from diseases of the circulatory system, chronic respiratory diseases and diabetes"* (Contractor - JSC "Research Institute of Cardiology and Internal Medicine"). Implementation period - 2021-2023.

The program is aimed at reducing the risk of premature death by developing and implementing innovative, highly effective technologies for diagnostics, treatment and monitoring of major cardiovascular, chronic respiratory diseases and diabetes. The results of the program can significantly improve postoperative outcomes, reduce the patient's stay in hospital and improve the quality of life.

As a result of the implementation of the STP, 14 scientific articles were published (7 foreign in international peer-reviewed journals, 7 - CQASHE), 4 patents were received (including 1 patent for invention), 6 author's certificates, 5 acts of implementation.

8.3. Ministry of Ecology and Natural Resources of the Republic of Kazakhstan

The Ministry of Ecology and Natural Resources of the Republic of Kazakhstan

(hereinafter referred to as the MENR RK) implemented 7 programs for a total of 7.3 million tenge (including Committee on Forestry and Wildlife - 3, Fisheries Committee - 2, GC - 3) for 2021-2023 within the framework of program-targeted financing.

During the implementation of competitive programs of program-targeted financing for 2023, 4 security documents were received, 57 scientific papers were published, of which 29 or more than 51% are presented in foreign publications, including 8 in Web of Science and 5 in Scopus. The results of 2 R&D (100%) have implementations, the number of which amounted to 15 units.

Forest resources are one of the most important types of biological resources related to exhaustible, but renewable, multi-purpose. Research on the rational use of forest resources is the focus of the activities of the Kazakh Research Institute of Forestry and Agroforestry named after A.N. Bukeikhan (hereinafter referred to as KazRIFA).

During the implementation of competitive programs of program-targeted financing for 2023, KazRIFA received 1 security document, published 16 scientific papers, of which 9 or more than 55% are presented in foreign publications, including 3 in Web of Science and 5 in Scopus. The results of 1 R&D (100%) have implementations, the number of which amounted to 12 units.

Based on the results of research in 2023, 10 recommendations were developed for production, increasing sustainability, restoring tugai forests and afforestation in the southern regions of Kazakhstan, etc. 1 database of valuable genotypes of plus trees of Scots pine for Northern Kazakhstan was created. Received 1 patent for utility model No. 8091 dated 02/23/2023 "Method for increasing the survival rate and growth of forest crops on saline soils". In 2023, the Illustrated Atlas of Pests of the Green Zone of Astana was published, 12 acts of implementation of the results of research work in production were received (state forestry institutions of the Akmola, East Kazakhstan and West Kazakhstan regions). 5 scientific articles were published in peer-reviewed foreign scientific journals included in the Web of Science and Scopus databases (based on the conclusion of the NCSSTE on report BR10263776-OT-23).

The Institute of Botany and Phytointroduction of the CFW MENR RK (hereinafter referred to as the Institute of Botany and Phytointroduction) has provided a comprehensive cadastral assessment of the current state of flora, vegetation and plant resources within the Almaty region.

During the implementation of competitive programs of program-targeted financing for 2023, the Institute of Botany and Phytointroduction received 3 security documents, published 41 scientific papers, of which 20 or more than 50% are presented in foreign publications, including 5 in Web of Science and Scopus. The results of 1 R&D (100%) have implementations, the number of which amounted to 3 units.

In 2023, based on the inventory of flora and mycobiota of the study areas, annotated lists of flora of higher vascular plants were compiled from 3165 species, algae - 1227 species and varieties, mycobiota - 412 species of micromycetes and 60

species of macromycetes, including 7 new for Kazakhstan. A phytocenotic assessment was carried out based on 228 geobotanical descriptions, combined into 8 vegetation types and 24 ecological and physiognomic categories. A modern assessment of the raw material base was given and maps of the locations of 33 species of economically valuable plants were developed, including 18 used in official medicine, of which 11 form commercial thickets.

A website for potential nature users “Cadastre of resource species of the Almaty region” (https://botany.oopt.kz/) has been prepared for work. The Seed Bank of Natural Flora contains 659 samples, including 13 rare ones. 32 rare plant communities and species have been identified for the Almaty Region. A list of invasive plants (42 tree species and 29 herbaceous species) has been compiled and their aggressiveness has been assessed. 40 forms of Sievers apple and 32 forms of common apricot, which are of high value for breeding, have been selected. 5 cadastres, a Seed Atlas, the Red, Green, and Black Books have been published, as well as 41 scientific publications, including: 5 articles in highly rated journals (Q1, Q2, Q3), 10 in the Russian Science Citation Index, 3 in the Russian Collection of Crops and Vegetables of the Russian Academy of Science, 21 articles in the Proceedings of International Scientific Conferences. Received: 3 security documents (copyright certificates) and 3 implementation acts of the Forestry Development Department of the Ministry of Ecology and Natural Resources of the Republic of Kazakhstan (based on the conclusion of the National Center for State Technical Expertise on report BR10264557-OT-23).

In addition, we present the results of ongoing scientific, scientific and technical programs within the framework of grant funding for 2021-2023.

In 2023, within the framework of the competition for grant funding held by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan, KazRIFA LLP and the RSE on the Right of Economic Management IBF took part.

KazRIFA LLP implemented 2 projects, 2 of which are scheduled for completion in 2023. During their implementation in 2023, 1 security document was received, 4 scientific papers were published, 4 of which, or 100%, were presented in foreign publications, including 3 in Web of Science and 4 in Scopus. The results of 1 R&D (50%) have implementations, the number of which amounted to 1 unit. In 2023, within the framework of the grant funding project of the Science Committee of the Ministry of Health of the Republic of Kazakhstan “Development of a method for preserving a rare species of Kazakhstan, *Aflatunia ulmifolia* (Franch.) Vassilcz., using biotechnology methods and studying its phytochemical composition” (IRN AP09057922), a method for clonal micropropagation of *Aflatunia ulmifolia* (Franch.) Vassilcz. was developed for the first time and individual indicators of the phytochemical composition of the species, the floristic composition of aflatunniks were studied, 2 scientific articles were published (based on the conclusion of the National Center for State Scientific and Technical Expertise on report AP09057922-OT-23); under the project "Development of technologies for plantation cultivation of medicinal herbs in the Northern region of Kazakhstan without reducing the content of

biologically active substances in them" (IRN AP09259323), a technology for cultivating medicinal plants was developed and recommendations were drawn up for growing plantations of medicinal plants in the Northern and South-Eastern regions of Kazakhstan. 2 scientific articles were published (based on the conclusion of the NCSSTE on report AP09259323-OT-23).

RSE on the Right of Economic Management "IBF" implemented 5 projects, of which 1 with a completion date this year and 4 ongoing R&D with implementation dates in 2021-2023, 2022-2024, 2023-2025. During their implementation, 9 scientific papers were published in 2023.

In 2023, within the framework of 5 projects of grant financing of the Science Committee of the Ministry of Health of the Republic of Kazakhstan, the following results were obtained:

1. IRN AP09258929 "*Prospects for using the correlation between the composition of the anthropophilic element of the flora of the desert part of the Syr Darya River valley and the type of land disturbance for forecasting purposes*" (2021-2023). The novelty of the proposed project lies in identifying patterns in the dynamics of the addition of both the general species composition of vegetation in areas disturbed as a result of various impacts, and directly its anthropophilic element. Such a study was conducted in Kazakhstan for the first time. The revealed parabolic dependence of the composition of anthropophiles on the type and degree of vegetation disturbance can be used in planning economic activities, as well as solving issues of environmental regulation. In 2023, 7 articles were published, including: 1 in the highly rated databases Scopus, Web of Science, CQASHE - 1, 5 in conference materials, 1 brochure was published (Report AP09258929-OT-23).

2. IRNAR19677563 "*Research of paleoflora and climate of Central Kazakhstan at the turn of the Oligocene and Miocene and the initial stage of desertification of the region*" (2023-2025). A review and analysis of the Cenozoic floras collected and studied in the Uly-Zhilanshik River valley (South Torgay Depression, Kazakhstan) was carried out. This region is key to understanding the processes of environmental change in the Paleogene and Neogene (Brief information - AP19677563-KS-23).

3. IRN AP19679078 "*Study of species diversity of the ecotone territory of northeastern Betpakdala for the preservation of the relic gene pool of the arid flora of Kazakhstan*" (2023-2025) during the program, screening of the species composition of the Betpakdala desert flora was carried out and preliminary lists of rare, endemic, relict plants of this region were compiled. Descriptions of 17 plant communities were made, materials for anatomical studies of 14 species and 26 samples of molecular studies were selected. One rare species, one endemic species and 7 relict plants were identified (Brief information - AP19679078-KS-23).

3. IPH AP14870712 "*Study of species diversity and genetic polymorphism of tulips (Tulipa L.) of Northern Kazakhstan*" (2022-2024). During the program implementation, the geographic distribution and habitats of tulips in the territory of Northern and Central Kazakhstan were identified and a map was compiled in the ArcGIS program. 131 locations of tulip growth in Northern and Central Kazakhstan were identified.

4. IRN AP19680161 "*Taxonomic revision of the genus Gagea (Liliaceae Juss.) in the flora of Northern and Central Kazakhstan using molecular phylogenetic research methods*" (2023-2025). During the program implementation, the geographic distribution of Gagea species in the flora of the Akmola and Kostanay regions was studied, maps of their ranges were compiled in the ArcGIS program.

8.4. Ministry of Energy of the Republic of Kazakhstan

In accordance with the Concept of Development of the Fuel and Energy Complex of the Republic of Kazakhstan for 2023-2029 (PPRK dated June 28, 2014 No. 724), one of the key tasks of the nuclear industry is the development of nuclear science. To solve this problem, the Development Plan of the Ministry of Energy of the Republic of Kazakhstan provides for the implementation of the budget program "Development of Nuclear and Energy Projects".

Within the framework of the subprogram "Applied scientific research of a technological nature in the field of nuclear energy", five target scientific and technical programs of the budget program "Development of Nuclear and Energy Projects" are being implemented:

1. Development of nuclear energy in the Republic of Kazakhstan.
2. Scientific and technical support for experimental research at the Kazakhstani materials science tokamak KTM.
3. Development of comprehensive scientific research in the field of nuclear and radiation physics based on Kazakhstani accelerator complexes.
4. Development of nuclear physics methods and technologies for innovative modernization of the economy of Kazakhstan.
5. Development of new scientific research in the field of radiation materials science, structural materials, nanomaterials at the VVR-K research reactor.

As part of the implementation of target scientific and technical programs for 2023, 50 scientific articles were published, 35 scientific developments were prepared ready for use in the field of nuclear science and technology, 5 applications for patents of the Republic of Kazakhstan were submitted.

The program *"Development of Nuclear Energy in the Republic of Kazakhstan"* is aimed at scientific and technical substantiation of the sustainable and safe development of the peaceful use of atomic energy, obtaining a set of scientifically based calculation, theoretical and experimental data necessary for the development of the nuclear energy industry in the Republic of Kazakhstan. As a result of the work performed under this program, the following main results were obtained:

On the direction of "*Research to improve the safety and efficiency of nuclear and thermonuclear energy"*, processes aimed at improving the safety and efficiency of nuclear energy were studied on reactor and non-reactor stands.

On the direction of *"Nuclear, radiation technologies and materials in nuclear power engineering"*, research has been carried out in the field of nuclear, radiation technologies and materials of nuclear power engineering, facilitating the implementation of science-intensive technologies and allowing to solve urgent

problems of direct conversion of nuclear energy, reducing the amount of radioactive waste, obtaining new, promising materials with improved properties.

On the direction of *"Radiation and environmental safety of nuclear power engineering"*, research has been carried out in the field of developing new methods of radioecological research, dosimetry of ionizing radiation, which are relevant at all stages of the development of nuclear power engineering and allow to form a true understanding of possible mechanisms of the impact of hazardous factors on humans and the environment, to develop solutions for their minimization.

On the direction of *"Development of the Nuclear Event and Radiation Accident Monitoring System"*, research has been conducted to support the development of nuclear event and radiation accident monitoring, which will form the basis for the creation and operation of a corresponding system in Kazakhstan.

The program "*Scientific and technical support for experimental research at the Kazakhstan Materials Science Tokamak KTM*" is aimed at solving the urgent problem of supporting experimental research at the Kazakhstan Materials Science Tokamak (KTM). As a result of the work performed under this program, the following main results were obtained:

On the direction of "*Development of methods for conducting research at KTM and means for monitoring the physical parameters of high-temperature KTM plasma during its interaction with materials*", research has been carried out aimed at obtaining experimental data on the plasma discharge at the KTM tokamak, as well as on setting up and developing the operating modes of systems that ensure the discharge, control of the plasma cord and display of its parameters, which are an important part and a necessary condition for high-quality testing of promising materials for thermonuclear technology under KTM conditions.

On the direction of "*Development and experimental substantiation of innovative technologies for the creation of a fusion reactor*", research was carried out on the development of innovative technologies for the creation of a nuclear fusion reactor to obtain experimental data on testing promising materials for fusion technology.

On the direction of "*Modernization of the technology for preparing the KTM tokamak for plasma experiments*", a set of works was carried out aimed at optimizing the methods and operating modes of systems that ensure the quality and safety of tests. For the first time, a real-time system was developed for the KTM tokamak for injecting working gas into the vacuum chamber in order to create conditions for breakdown and growth of the plasma cord current and control the plasma density, the modes and methods for cleaning the KTM tokamak discharge chamber were optimized.

In the direction of "*Experimental and theoretical studies of the effects of plasma, hydrogen and helium ions on the surface and bulk layers of KTM materials*", data were obtained on the effect of neutron irradiation in a helium environment on the structure and properties of high-purity tungsten DFW, as well as the accumulation of helium and its effect on the mechanical properties of high-strength, heat-resistant metal and ceramic coatings, which will form the basis for choosing the optimal method for increasing the radiation resistance of materials used in thermonuclear reactors, the

nature and extent of changes in the microstructure, phase composition, physical, mechanical and corrosion properties of candidate materials for the thermonuclear installations being developed were established, which makes a significant contribution to the development of radiation materials science.

The program "*Development of complex scientific research in the field of nuclear and radiation physics based on Kazakhstan's accelerator complexes*" is aimed at obtaining new experimental data for modeling processes occurring in nuclear power plants, as well as obtaining new experimental knowledge on the effect of irradiation with thermal and fast neutrons, as well as charged particles, on changes in the phase structural state, mechanical and corrosion characteristics of structural materials of nuclear reactors.

The program "*Development of nuclear-physical methods and technologies for innovative modernization of the economy of Kazakhstan*" is aimed at expanding the possibilities of practical application of nuclear-physical methods and technologies in medicine, industry and environmental protection.

The program "*Development of new scientific research in the field of radiation materials science, structural materials, nanomaterials at the VVR-K research reactor*" is aimed at developing new scientific directions in the field of studying the stability of structural materials, inert matrices of nuclear fuel, nanostructured materials to neutron radiation and the kinetics of radiation damage.

As a result of the successful implementation of research under this scientific program BR10965284 "*Development of technologies for the production and storage of hydrogen for the development of alternative energy in the Republic of Kazakhstan*" in the framework of the development of materials for hydrogen storage and research into the impact of thermal cycling sorption/desorption processes on the Ti-25Al-25Nb alloy system, it was found that after the thermal cycle, the material retains a two-phase structure with the formation of new precipitations. These results emphasize the importance of understanding changes in the structure of the material under thermal cycling effects and can be key to the development of more effective sorption materials for hydrogen storage.

8.5. Ministry of Digital Development, Innovation and Aerospace Industry of the Republic of Kazakhstan

The purpose of scientific research in the field of space activities is the development and implementation of high-tech space technologies in the sectors of the economy of Kazakhstan. The scientific and scientific-technical potential includes such enterprises as the joint-stock company "National Center for Space Research and Technology" (JSC "NCSR&T") and JSC "National Company "Kazakhstan Gharysh Sapary", limited liability partnerships V.G. Fesenkov Astrophysical Institute (hereinafter - LLP "FAPI"), "Institute of the Ionosphere" (hereinafter - LLP "II") and "Institute of Space Engineering and Technology" (hereinafter - LLP "ICET") and "Ghalam" (hereinafter - LLP "Ghalam"), as well as the Republican State Enterprise "Infrakos" (hereinafter - RSE "Infrakos").

In 2023, JSC NCSR&T completed the target scientific and technical program No. BR109019/0221/PCF within the framework of RBP 008 “Applied scientific research in the field of space activities and information security”. The program has the DSP stamp.

During the program, research was conducted on rocket fuel, software and hardware and design technologies for key launch vehicle subsystems: engine, body and power elements, control system, and possible ways of creating a space rocket complex and rocket were studied. The results of the work on the Program are reflected in the final report, the conclusion of the state scientific and technical examination and approval of the National Scientific Council were received.

In 2023-2025. within the framework of RBP 008 “Applied scientific research in the field of space activities and information security”, the target scientific and technical program BR No. 203002/0223/PCF is also being implemented with the "DSP" stamp, which is a continuation of the previous program. Within its framework, methods and tools for designing a space rocket complex are being developed.

In 2023, within the framework of grant financing from the Ministry of Education and Science of the Republic of Kazakhstan, work was also completed on the project "Development of a methodology for analyzing indirect effects from the prevention and elimination of emergencies (*minimization of victims, budget expenditures, environmental impact, etc.*) when using space assets" within the framework of the program "Development of a multi-purpose aerospace monitoring system and services for integrated situational presentation of information on emergencies in the cross-border regions of the territory of the Republic of Kazakhstan and the Russian Federation". During the project implementation, methods for analyzing indirect effects from emergency prevention and response (minimization of casualties, budget expenditures, environmental impact, etc.) were developed when using space vehicles for the basin of large rivers in Northern and Eastern Kazakhstan. As a result of the work, an interactive map of irrigated territories and areas promising for irrigation and recommendations for the rational use of irrigated areas and areas promising for irrigation were developed.

In 2023, 2 projects were completed within the framework of grant financing for scientific and (or) scientific and technical projects for 2021-2023 (MSHE RK): "Development of a domestic technology for producing a radio-transparent high-strength composite for the bodies of military unmanned aerial vehicles and aerospace equipment" (AP090558225) and "Development of basic technological operations for producing a domestic light alloy for the defense and aerospace industry" (00037 / GF-DSP-20). Within the framework of the above projects, technological modes for molding organoplastics were developed, samples of aluminum-lithium alloy with the required chemical composition and minimum content of impurities and porosity were obtained.

In 2023, the PCF 2021-2023 program No. BR109018 / 0221 / PCF with the "DSP" stamp, aimed at the development of satellite technologies, was successfully completed. The purpose of the research and development work was to develop and test key technologies for the creation of spacecraft (SC) at the production base of *Ghalam*

LLP.

Results obtained: the technology was developed, technical documentation was approved and preliminary tests of the integrated S-, X-band communication earth station based on SDR technology were carried out. Technical documentation was developed and an engineering model of the on-board control computer and the spacecraft power supply system was created. Based on the results of the work, 4 scientific articles were published (including 2 in the indexed international journal Q3, 2 in journals recommended by the Ministry of Higher Education of the Republic of Kazakhstan), 2 patents, 2 copyright certificates for intellectual property.

In 2023, *Institute of Space Engineering and Technology* LLP carried out 4 scientific projects within the framework of grant funding from the Ministry of Science and Higher Education of the Republic of Kazakhstan for 2021-2023 and 2022-2024 (including 2 projects with the secrecy classification "FOU").

By priority "*Information, communication and space technologies*"

1. Project AP09259684 "Development of methods and hardware and software for improving the accuracy of satellite navigation definitions without using differential corrections" (implementation period 2021-2023, funding volume for 2023 - 17,599.00 thousand tenge).

Results obtained for 2023: experimental samples of hardware and software for high-precision satellite navigation definitions were developed, test reports were signed, design documentation was adjusted. The software of the experimental sample of the high-precision satellite navigation system based on the inertial-satellite navigation system was introduced into the educational process of the Almaty University of Power Engineering and Communications named after Gumarbek Daukeev. Based on the results of the work, 1 article was published in the foreign scientific journal "Applied Sciences" (the journal's percentile in Scopus is 73%, the quartile in Web of Science is Q2), 1 copyright certificate for software was received, 1 act of implementation of R&D results was received.

2. Project with the "DSP" stamp AP148043/0222 "Development of a system for positioning ground objects based on the Earth's magnetic field data using BigData technology" (implementation period 2022-2024, funding volume for 2023 is 26,344,371 thousand tenge).

Results obtained: a prototype of the magnetic positioning system of objects was manufactured and tests of the prototype of the magnetic positioning system of objects were carried out. Recommendations for the practical use of the system and an assessment of the accuracy of positioning objects in various regions of the Republic of Kazakhstan based on its tests were developed. Based on the results of the work, 1 article was published in the foreign scientific journal "Recent Progress in Science and Technology", 1 article in the domestic journal "Journal of Problems of Open Systems Evolution", included in the list of CQASHE and in the RSCI database.

RSE "*Infrakos*" ASC MDDIAI RK within the framework of grant financing of the Ministry of Higher Education of the Republic of Kazakhstan for the project "Study of the processes of identification of rocket hydrocarbon fuel in soils of launch vehicle

operation areas and development of their hygienic standard". The results of the project will be reflected in the assessment of environmental damage to the environment and health of the population living in the territories adjacent to the fall areas. In 2023, based on the results of the research, 2 scientific articles were published in the journal recommended by CQASHE.

Within the framework of fundamental scientific research and program-targeted financing of the Ministry of Higher Education of the Republic of Kazakhstan and the International Center for Research and Atomic Energy of the Republic of Kazakhstan, grant financing of the Ministry of Higher Education of the Republic of Kazakhstan for scientific and (or) scientific and technical projects for 2023, 24 works were carried out at the *Institute of the Ionosphere* LLC.

In 2023, the following results were obtained:

Modules for loading and pre-processing satellite data for the space monitoring system of active forest and steppe fires were developed. New modules for the automated space monitoring system of active forest and steppe fires and algorithms for assessing burnt areas of the transboundary regions of the Republic of Kazakhstan and the Russian Federation were developed. An automated system for space monitoring of active forest and steppe fires and assessment of burnt areas of the transboundary regions of the Republic of Kazakhstan and the Russian Federation was developed. A system for operational space monitoring of floods and freshets in the transboundary river basins of the Republic of Kazakhstan and the Russian Federation was developed, etc.

In 2023, 9 articles were published in highly rated foreign publications, 7 in domestic publications recommended by the CQASHE MSHE RK, 8 reports were presented at international conferences.

RSE "*Institute of Information and Computational Technologies*" completed the scientific and technical program "Development of an expert system for supporting decision-making in the space industry" in 2023. Based on the results of the program implementation, an information platform was created for collecting and analyzing publications on space topics, assessing development models for areas and drawing conclusions based on it.

Thus, based on the results of the programs within the framework of RBP 008 "Applied scientific research in the field of space activities and information security" (hereinafter referred to as the Program), 13 science-intensive space technologies were developed in 2023. Of these, 8 were developed and are ready for use within the framework of the "FOU" program, the remaining 3 - within the framework of open programs: an expert decision support system in the space industry, a wide-angle optical system, an innovative spectral device.

The results of the Programs will be further used in the structures of the space industry of Kazakhstan in the design of subsystems of light and ultra-light launch vehicles, as well as domestic spacecraft.

9. CONCLUSIONS AND RECOMMENDATIONS

(on the further development of the national scientific system)

Priority I – "Rational use of water resources, flora and fauna, ecology"

Conclusions. Scientists of Kazakhstan have obtained new knowledge about the state of river basins, monitoring and assessment of the hydrographic network, developed models and forecasts for making scientifically sound management decisions on water use. A new direction in this area of knowledge should be considered research on the forecast and assessment of the environmental risk of spring floods and their consequences in flooded areas. In matters of rational use of animal and plant resources, it is important to preserve biodiversity, study rare and poorly studied species and subspecies of fauna and flora, identify new species, their adaptability to existing regional climate changes. New knowledge in issues related to urbanization and landscaping revealed a tendency towards homogenization of ecosystems and a decrease in the biodiversity of cenoses.

Recommendations:

- focus on the development of fundamental research. It is discoveries in interdisciplinary science that make a fundamental contribution to the creation of breakthrough technologies. In Kazakhstan, the development of interdisciplinarity is constrained by such factors as funding, project implementation deadlines, imperfect expertise, personnel training, article review, etc.;
- develop digital transformation at all stages of research;
- implement "artificial intelligence" that will generate fundamentally new knowledge and make discoveries;
- generate scientific ideas and concentrate scientific knowledge on the basis of established scientific schools in conjunction with business, stakeholders, the educational environment and other interested parties;
- form motivation in the educational environment aimed at acquiring knowledge and increasing the level of professionalism based on improving the content of the curricula of educational institutions, since the scientific way of thinking is formed precisely in universities;
- consider the approach to distributing funds for scientific research allocated on a competitive basis with extremely short terms of actual implementation of projects to be non-constructive, which often cannot provide breakthrough results at the global level and most often do not have a systematic and finished form.

Priority II – "Geology, extraction and processing of mineral and hydrocarbon raw materials, new materials, technologies, safe products and structures"

Conclusions. Whoever owns geological information owns the subsoil. Kazakhstan is of significant interest for geological exploration of metals, oil, gas, rare and rare earth minerals. It is necessary to determine the list of metals and minerals that are critical for its economy, the extraction and processing of which can serve as a further scientific and technological breakthrough in the mining, oil and gas production, beneficiation industries, and, more importantly, related scientific fields and manufacturing industries.

Recommendations:

1. Ensure high-quality and systematic state geological study of the country's territory at the regional stage, which will lead to the localization of new potential oil and gas regions, ore regions, deposits of oil shale, groundwater and geothermal sources, which will further allow the discovery of new deposits.

2. Strengthen the requirements for the training of bachelors, masters, doctoral students, for the Final Certification, the level of master's dissertations. One of the requirements could be the presence of at least one article in a journal included in the List of publications recommended by the CQASHE MSHE RK (and not just publications that involve the usual inclusion of an abstract in the conference proceedings, as a rule, even without preliminary review). For comparison, in China, for a similar level of training of specialists, an article corresponding to quartile Q4 is required.

3. Create a new center for thermobarometric and geochemical research on the basis of the already established laboratory "Sedimentology and Earth thermobarometry" of Satbayev University. This laboratory will provide a unique opportunity to study the evolution of paleotemperatures of planet Earth, which is currently of critical importance due to climate change. 4. Start developing geothermal energy production (GEP), energy storage (ES), and carbon storage and sequestration (CSS), using as a basis a major 3-year research project of Nazarbayev University “Potential for Geothermal Energy Production (GEP), Energy Storage (NE), and Carbon Storage and Sequestration (CSS) in Kazakhstan Sedimentary Basins – Geological Baseline Study”. Their development will help strengthen Kazakhstan’s position as one of the leaders in the green economy, create many jobs throughout the country, and improve the environmental conditions of the population.

Priority III – “Power Engineering and Mechanical Engineering”. Power Engineering

Conclusions. The scientific community of Kazakhstan is working to implement the energy transition and reduce greenhouse gas emissions. To achieve carbon neutrality, Kazakhstan is encouraging initiatives to create and develop low-carbon technologies, such as wind and solar power, and hydrogen generation.

The key trend in the energy sector, which served as an idea for research, is the creation of autonomous hybrid energy complexes. The development of energy accumulation and storage systems is a priority in the work of the scientific community. The development and implementation of digital substations is characterized by the unification of the power grid and information infrastructure and opens up opportunities for fast and easy exchange of information between devices. The main trends in the energy sector at the present stage are: geothermal energy; wind energy; solar energy; biofuel; hydrogen energy; closed-loop nuclear energy; coal gasification. Suggestions:

Kazakh scientists and researchers should pay key attention to such issues as: ensuring and improving the reliability of energy systems with a significant volume of renewable energy sources, systems for forecasting the production of renewable energy sources, energy storage systems, energy efficiency throughout all energy cycles, starting from the operation, generation, transmission, distribution, use and

decommissioning of energy systems, since, according to the forecast of the International Energy Agency, natural gas, renewable energy, and energy efficiency are taking the leading positions in meeting the growing global energy needs.

In order to reduce greenhouse gas emissions and meet the growing need for electricity, nuclear and hydrogen energy should be explored as a serious alternative to coal.

Mechanical engineering

Conclusions. Despite the growth of almost all types of activity in the mechanical engineering industry for the period from January to November 2023 and the support provided by the state to enterprises, ranging from preferential financing ("Economy of Simple Things", "Business Roadmap-2025", "Preferential Lending Program") to sales assistance (preferential leasing), as well as the import substitution program and the "offtake agreement" mechanism of JSC "NWF "Samruk-Kazyna", the indicators of mechanical engineering development in the republic did not show noticeable growth.

For the further development of the country, large-scale diversification of the industry is necessary, which should lead to the systematization and streamlining of the most popular niches of the domestic goods market, which over time should allow mechanical engineering to begin to restructure itself to production with high technological complexity with the emergence of a multiplier effect, expressed in the development of related industries.

Recommendations:

- stimulate the widespread establishment of mechanical engineering enterprises of all types of ownership and various scales;
- the state should comprehensively study the issue of providing priority and affordable financing, first of all, to small and medium-sized businesses to stimulate modernization, expansion of existing and creation of new production facilities in the mechanical engineering industries;
- develop a mechanism to stimulate enterprises to produce high-tech products with a gradual move away from low- and medium-tech production;
- study the issues of creating leasing financing for new projects, which will increase the interest of customers in high-quality equipment with an attractive total cost of the life cycle of mechanical engineering products;
- in every possible way stimulate the implementation of R&D with their further commercialization;
- encourage the influx of new personnel through various incentive measures, since the mechanical engineering industries are experiencing a shortage of qualified personnel at all levels;
- study the issue of introducing a system of state grants in relevant areas of mechanical engineering to solve existing problems by scientists, provide a transparent reporting mechanism for the funds used; the term of such grants should be at least five years;
- change the procedure for conducting an examination of scientific applications. Introduce personal liability of NSC members for making an incompetent decision when approving a scientific application.

Priority IV - "Information, communication and space technologies"

Conclusions. Government decisions voiced the need to develop digital technologies, with priority given to artificial intelligence. A global task has been set for the country - the creation of technologies for processing the natural Kazakh language. The research results, in turn, will lead to the rapid development and implementation of digital communications at the level of the natural Kazakh language, the improvement of software and hardware that can affect the global transformation of the country's economy.

Recommendations:

- in light of the adopted Law of the Republic of Kazakhstan "On Science and Technological Policy", pay more attention to newly created technologies in the field of ICT and CT, recording in the tender documentation the volumes of funding for applied projects that could lead to the creation of ready-made technologies with the prospect of implementation in the country's economy; - begin developing state and commercial programs for the effective development of IT technologies;

- develop an educational program for training highly qualified IT specialists, review the level of training of doctoral students in higher education institutions;

- develop our own electronics industry with the active use of the latest scientific achievements in this area both within the country and in leading universities and research institutes with the creation of a corresponding consortium.

Priority V - "Scientific Research in the Field of Natural Sciences"

Conclusions. Kazakhstan's science in the field of natural sciences (physics, chemistry, astrophysics, geography, mechanics) has achieved significant success.

Recommendations:

- conduct a complete modernization of scientific institutes, laboratories and observatories, equipping them with modern equipment and technologies. This will allow scientists to conduct research at the world level and attract international partners to cooperation;

- encourage scientists to publish their results in international peer-reviewed journals. To do this, it is necessary to create conditions for conducting high-quality research, provide access to international databases and journals;

- create support programs for young scientists, including grants, scholarships and participation in international projects to attract talented youth to science and ensure the continuity of scientific schools;

- create and support scientific and technical clusters that unite scientific institutes, universities and businesses, which will accelerate the commercialization of scientific developments and their implementation in industry;

- use modern information technologies and artificial intelligence for data analysis, modeling and research, which will increase the efficiency of scientific work and open up new opportunities for research;

- develop national scientific journals and conferences, which will allow scientists to share their results and exchange experiences within the country.

Priority VI - "Life Sciences and Health"

Conclusions. The UN General Assembly declared the period from 2021 to 2030 the "Decade of Healthy Ageing", covering four areas of activity: long-term care, combating age-related changes, an environment favorable for older people and integrated care. It will be necessary to strengthen the systems approach and international cooperation in conducting national scientific research in all these areas of activity to develop regional and national policies on ageing.

Recommendations:

1. Support research to create a gerontological care service and a long-term care service for the elderly, as well as the development of the next (after 2025) National Action Plan to improve the situation of older citizens with an emphasis on systemic activities.

2. Strengthen the systemic approach and international cooperation in conducting national scientific research in the field of pharmacy. This is consistent with the provisions of the National Plan "Active Longevity" until 2025. Target indicator: production of more than 50% of all drugs, most at prices affordable for the elderly. This provision dictates the need for active research in the field of pharmacy.

3. Develop neuroscience in Kazakhstan by conducting fundamental and applied research in the field of cognitive, clinical and research in accordance with the main world trends in this area.

4. Conduct:

- biomedical research, since knowledge of the mechanisms of aging gives researchers an idea of how they can directly intervene in the aging process to prevent age-related diseases;

- research on the development of remote medicine in Kazakhstan for the remote provision of medical services and monitoring the health of citizens, especially those living in villages and districts; - research in the field of artificial intelligence, for which purpose it is necessary to actively involve young people in research activities in the healthcare sector, where AI is being introduced at a high rate, and to train personnel for this.

Priority VII - "Research in Education and Science"

Conclusions. Research in the field of education and science studies is actively developing; there is a reflection of the trends of UNESCO global research in domestic projects: on STEM education, gender education, digitalization of education, problems of mental well-being of schoolchildren, prevention of cyberbullying, development of physical health of children. The conducted research corresponds to the Concept of Development of Science and Higher Education of the Republic of Kazakhstan for 2023-2029 and their analysis shows the continuity of research: from the past to the present and the future.

Recommendations:

- to create a Psychological Institute under the Ministry of Higher Education of the Republic of Kazakhstan or the National Academy of Science of the Republic of Kazakhstan under the President of the Republic of Kazakhstan. It is necessary to coordinate research of psychological services of schools, universities, clinics, special

institutions, in general, areas of development in the training of psychologists, educational psychologists, social workers, etc.;

- to expand the network of ethical committees for conducting research in educational organizations, support in their certification and interaction with international organizations;

- create electronic databases in libraries with the results of scientific research translated into Kazakh (similar to abstract journals). A similar collection is published by the Scientific Library of the NAS RK, NCSSTE, but they are very brief and are not freely available;

- develop infrastructure, create laboratories, provide them with a modern scientific and technical base for conducting scientific research in the field of education, pedagogy and neuroscience, psychodiagnostics in education, improving the ecology of schools, universities, institutes and centers.

Priority VIII - "Research in the field of social sciences and humanities"

Conclusions. The introduction of digital technologies in research methods of social sciences, a focus on global challenges and problems, as well as taking into account cultural diversity and promoting inclusiveness reflect modern trends in scientific approaches and methodology. Such areas as interdisciplinary research and digitalization create new opportunities for analyzing and solving complex social problems, increasing the effectiveness of scientific research and their practical significance.

Recommendations:

Stimulating interdisciplinary research: the state should encourage and finance interdisciplinary projects that combine social, humanities, engineering and natural sciences to solve complex social problems and promote the integrated development of society.

Focus on cultural heritage: it is important to increase funding for projects aimed at studying and preserving national cultural heritage and identity, which will help strengthen national self-awareness and foster respect for the country's cultural diversity.

Support for young scientists: the state should establish scholarships and grants for young researchers in the social sciences and humanities to stimulate their professional development and involvement in scientific activities at an early stage of their careers.

Development of scientific publications and conferences: it is necessary to increase support for national and international scientific conferences, as well as journals that publish research results in the field of social sciences and humanities, to ensure a wider dissemination of knowledge and exchange of experience.

Integration of technologies into research: Encouraging the introduction of new technologies such as artificial intelligence and big data analysis into social sciences and humanities research to improve the quality of research, as well as its effectiveness and practical value.

Priority IX - "Sustainable development of the agro-industrial complex and safety of agricultural products"

Conclusions. In the period 2021-2023, scientific research was mostly fragmented, aimed at solving local problems, there was no comprehensiveness and implementation of an interdisciplinary approach. In most cases, outdated instruments, equipment and machinery are used in scientific research, which also raises great doubts about the accuracy and reliability of their results.

Agricultural science is becoming increasingly complex, in the context of rapid variability of factors, and therefore it is important to introduce new approaches, methods and technologies in ongoing and planned scientific research, and to increase the requirements for their effectiveness in terms of solving applied problems of the agro-industrial complex industries.

Recommendations:

1. Create a system of independent formulation of scientific problems based on the results of periodically conducted foresight studies, technological scouting, ongoing analysis of current industry needs and forecasting. Such a system should be organized under the Ministry of Agriculture of the Republic of Kazakhstan.

2. Increase funding for agricultural science to at least 1% of GDP in the agro-industrial complex. Ensure the implementation of an inter- and transdisciplinary approach to organizing scientific research by introducing appropriate conditions into the technical documentation of program-targeted and grant financing of scientific and technical programs and projects.

3. To solve strategically important problems, provide a tool for financing integrated, targeted national programs, following the example of the Strategic Program "Designing the Future of Wheat", funded by the Biotechnology and Biological Sciences Research Council (BBSRC) of the UK Government.

4. In order to accelerate the development of scientific collaboration between domestic and foreign scientific organizations, provide a tool for financing research cooperation programs, following the example of the US Department of Agriculture, which supports joint research and educational projects between US and foreign specialists in the field of agriculture.

Priority X - "National Security and Defense"

Conclusions. It is necessary to focus efforts on the development of science in the direction of "National Security and Defense". This is due to the unresolved problems of military science as one of the significant branches of science in the Republic of Kazakhstan. Thus, to date, no significant research is visible. In practical terms, there are isolated cases at the tactical level, but breakthrough projects, based on the experience of modern wars, are also not observed. In addition,

- there is no separate scientific structure authorized to consolidate the efforts of law enforcement agencies and organizations that solve problems of ensuring the security and defense of the country;

- scientific organizations (quasi-public sector organizations) do not have real estate on the right of ownership, which does not allow their high-quality development and conducting research and laboratory experiments, including closed ones;

- there are no testing grounds for defense industry enterprises, other organizations and individual inventors, where they could conduct practical testing in

such areas as rocket science, unmanned vehicles, conduct explosive and other experimental work; - there is no independent Competence Center with a laboratory base that could conduct an examination of military equipment, weapons and other means accepted into service by the Armed Forces of the Republic of Kazakhstan;

- there is no funding for the development of scientific organizations of the defense industry, which negatively affects the development of the defense industry as a whole. The declared fund for the development of the defense industry is not operational.

Recommendations:

1. Further funding in the context of the development of science "National Security and Defense" should be directed to the study of:

- the nature of military conflicts (wars) themselves; - international military cooperation; - a multi-level intelligence and analytical system; - a comprehensive defense system of the state from the impact of opposing parties in the information (cybernetic), aerospace, maritime spheres; - governance of the state, its military organization in times of crisis and wartime.

The study of issues of the land element as the main component of the Army of Kazakhstan should be comprehensive, multi-level and interconnected.

2. The National Defense University should be removed from the department of the Ministry of Defense of the Republic of Kazakhstan and made an independent state educational institution.

3. Create an independent Center of Competence in the military sphere, with the following infrastructure:

- a powerful laboratory base, where purchased (supplied) samples of military equipment and other means for defense needs can be analyzed (tested), as well as theoretical and practical aspects of the proposed scientific research and developments of applicants;

- a complex with areas and equipment for developers who do not have scientific accreditation, but are patent holders or developers of promising ideas and projects;

- a territory for a testing ground for defense industry products.

4. Based on the experience of advanced countries, create research military units to test the results of scientific research.

5. Gifted graduates of military educational institutions with scientific achievements, after completing their studies, immediately send them to study in master's and doctoral programs.

6. Solve the problem of openness in matters of expert examination of scientific projects, which will allow a more substantiated approach in expert opinions.

These proposals must be considered at the level of the Head of State, since the Academy of Military Sciences has already raised them at the level of the Ministers of Defense, Emergencies, Science and Higher Education, Industry and Construction of our country.

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11. GLOSSARY

Adventitious (adventitious) root - roots that arise on a shoot - stem-like adventitious roots.

Active longevity is a state of social, economic, physical and psychological well-being of older citizens, which provides them with the opportunity to meet their needs, engage in various spheres of society and is achieved with their active participation;

Andragogy is the science of teaching adults.

Blockchain is a continuous sequential chain of blocks (linked list) containing information built according to certain rules. Blockchain is used in such areas as financial transactions, user identification or the creation of cybersecurity technologies.

BLAST (English Basic Local Alignment Search Tool) is a family of computer programs used to search for similar amino acid or nucleotide sequences.

WAMS (Wide Area Monitoring/Measurement System) is a technology for managing, monitoring and controlling the dynamics of electrical networks, which is carried out in real time through the use of GPS trackers.

A fiber optic sensor is a small device that uses optical fiber both as a data transmission line and as a sensing element capable of detecting changes in various quantities.

A virtual educational space is a space that can expand into the outside world, discovering its external spheres through the activities of a learner using his or her senses, emotional, imaginative, and intellectual abilities.

A virtual observatory is a set of interacting data archives and software tools that use the Internet to create a scientific research environment in which astronomical research programs can be conducted.

Gerontology is 1) a section of biomedical science that studies the aging of living organisms, including the patterns of human aging: biology of aging, geriatrics, gerohygiene, and gerontopsychology; 2) a science that studies issues of aging, the causes that accelerate it, and the search for means of combating and preventing premature aging. Longevity – 1) reaching an age significantly exceeding the average life expectancy, 90 years or older; 2) predicted or actually achieved life expectancy over 90 years. Active longevity is significant, i.e. the ability of a long-liver to engage in socially useful activity.

Drug Design – search for and design of lead compounds; optimization of a lead compound; development of a drug.

EAPC – Eurasian Patent Convention

Green hydrogen – hydrogen obtained by electrolysis of water using renewable electricity.

SCADA – software package designed to develop or ensure the operation in real time of systems for collecting, processing, displaying and archiving information about a monitoring or control object. Smart Grid – smart power supply networks that use information and communication networks and technologies to collect information on energy production and consumption, allowing to automatically increase efficiency, reliability,

SMART environment – educational and research environment, in which self-, media-, art-, re- and trans-technologies are implemented.

Introducer – intentional or accidental resettlement by humans of individuals of any species of animals and plants beyond their natural range to new habitats. Introduction is the process of introducing alien species into a certain ecosystem.

Invasive – a biological species, the spread of which threatens biological diversity.

Citation index – an abstract database of scientific publications, indexing references indicated in the article lists of these publications, and providing quantitative indicators of these references.

Hirsch index – a quantitative characteristic of the productivity of a scientist, a group of scientists, a scientific organization or a country as a whole, based on the number of publications and the number of citations of these publications. Interactive mapping (Web mapping) is the process of using maps provided by geographic information systems (GIS) on the World Wide Web.

Immersive technologies (immersive English - to immerse) - technologies of full or partial immersion in a virtual world or various types of mixed and real world.

Ionomics - the study of the ionome, involves the quantitative and simultaneous measurement of the elemental composition (mineral elements) of living organisms (in plant tissues and organs) and changes in this composition in response to physiological stimuli, developmental state and genetic modifications methods of simultaneous assessment of the quantitative composition.

Ionome is defined as the composition of mineral nutrients and trace elements in the body and is an inorganic component of cellular and organismal systems.

ITER (International Thermonuclear Experimental Reactor) - International Experimental Thermonuclear Reactor.

Cybersecurity - information security of computer information and control systems, ensuring their high reliability and functional stability in the conditions of modern information warfare. It is part of military and dual-use products, used in banking and other areas.

Magnetar - a neutron star with an exceptionally strong magnetic field (up to 10 ^ 11 T)

Energy storage - a device that stores and releases energy for use without converting its type.

Neuroplasticity of the brain - a property of the brain, due to which the properties of neurons and neural networks can change under the influence of new experience, as well as restore lost connections.

Producer - organisms capable of producing organic substances from inorganic ones, that is, all autotrophs.

Generation NEET – a generation of young people who do not have an education, employment, or training (Not in Education, Employment, or Training)

Pyragogy (from English – peeragogy) is a theory of mutual learning and teaching using networks.

Relict/relics – a species (or other taxon) of living organisms that have survived in a given region from the flora or fauna of past geological eras and are in some discrepancy with modern conditions of existence

Real–Time Digital Simulator – a software and hardware complex designed for numerical simulation in real time of electrical, electromagnetic and electromechanical processes in a given virtual (numerical) model of the power system.

Decision support systems (DSS) – computer systems that, through the collection and analysis of a wide range of data (BigData), including also data coming from satellites of specialized sensors and sensors, and using various information management systems, allow influencing the decision-making process. which are based on the use of modern information technologies and have wide capabilities in the field of modeling and forecasting.

Supergravity is a generalization of the general theory of relativity (GR) based on supersymmetry or multidimensional supergravity is the name of physical theories that include additional dimensions, supersymmetry and gravity.

Space Situational Awareness (SSA) is when SSA data is used to predict dangerous approaches between objects and warn space operators about potentially dangerous close approaches in order to ensure the possibility of collision avoidance maneuvers.

CCUS (Carbon Capture Usage and Storage) is a process that involves the release of CO2 mainly from energy and industrial sources, its use, transportation and burial.

CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) are repeating fragments of the genetic code found in bacteria during sequencing. CRISPR – a system for precise DNA editing.

Time-domain astrophysics – astrophysical studies of time-varying objects.

Fine organic synthesis (FOS) is a huge number of chemical compounds: drugs, dyes, chemical additives, pesticides, surfactants, special polymeric materials, synthetic enzymes, etc.

FACTS (flexible alternating current transmission system) – a flexible alternating current transmission system used to transmit alternating current.

economic benefit, as well as sustainability of electricity production and distribution

Follow-up – observational support (“pickup”) of research objects by ground-based telescopes.

5G is the fifth generation of mobile communications, operating on the basis of telecommunication standards (5G/IMT-2020), following the existing 4G/IMT–Advanced standards. A new generation telecommunication standard. 5G technologies should provide higher bandwidth compared to 4G technologies, which will ensure greater availability of broadband mobile communications, as well as the use of device-to-device modes (literally "device to device", direct connection between subscribers), highly reliable large-scale communication systems between devices, as well as lower latency, Internet speed of 1-2 Gbit/s, lower battery consumption than 4G equipment, which will have a positive effect on the development of the Internet of Things (IoT).

Plant phenotyping is a procedure for assessing the phenotype of a plant by its size, shape, physiological and biochemical characteristics in specific environmental conditions and genome activity.

Eutagogy (from English - heutagogy) is the study of human self-education, including in the electronic environment.

12. ANALYSIS OF THE ACHIEVEMENTS OF YOUNG SCIENTISTS OF KAZAKHSTAN

For the first time, the Council of Young Scientists was created under the NAS RK under the President of the Republic of Kazakhstan, headed by Associate Professor, PhD Zhabagin M.G. (Head of the Laboratory of Human Genetics of the National Center for Biotechnology), the purpose of which is to unite young scientists of the country, protect their rights and promote their interests, as well as assist in their professional careers through the development of interdisciplinary research. In 2023, the number of young scientists engaged in research and development (R&D) was 11,703 people, of which 9,796 people worked as research specialists, which is 46% of the total number of employees engaged in R&D. The gender ratio among young scientists was 44% men and 56% women. Among young scientists with the highest scientific qualification (HSQ), there are 62 doctors of science, 232 candidates of science, 1745 doctors of philosophy (Ph.D.) and 15 doctors in the profile. For the first time, funding of scientific research of young scientists from the state budget in the form of grant funding began in 2020. By 2023, the completed grant funding competitions for young scientists are KMU 2020-2022 and KMU 2021-2023. An analysis of publication activity based on the results of projects within the framework of completed competitions is presented in Table 12.46:

Table 12.46 – Statistics on the number of articles and reviews in Web of Science and Scopus published with the indication of project numbers for grant funding for young scientists for 2021–2023, in various priority areas

Priority	Project number	Financing volume, Mio. tenge	Articles and reviews of the publicationss				The number of articles and reviews in the main WoS indices in terms of	
			Q1 WoS	WoS	WoS + Q1–Q2 Scopus	WoS+ Scopus	1 project	Financing 100 Mio.
RUWR	12	948	5	19	22	24	1,6	2,0
GEPMHR	35	1445	9	51	62	73	1,5	3,5
E&M	18	894	7	24	32	45	1,3	2,7
ICST	12	577	4	15	20	29	1,3	2,6
NS	17	763	34	72	79	98	4,2	9,4
SLH	21	1037	9	21	24	29	1,0	2,0
RE&S	5	247	1	1	5	5	0,2	0,4
RSHS	12	559	0	1	6	7	0,1	0,2
AIC	17	835	2	6	11	21	0,4	0,7
NS&D	2	108	0	1	2	4	0,5	0,9
Total	151	7413	71	211	263	335	1,4	2,8

Abbreviations: Rational use of water resources, flora and fauna, ecology; Geology, extraction and processing of mineral and hydrocarbon raw materials, new materials, technologies, safe products and designs; Energy and mechanical engineering; Information, communication and space technologies; Scientific research in the field of natural sciences; Science of life and health; Research in the field of education and science; Research in the field of social and humanitarian sciences; AIC: Sustainable development of the agro-industrial complex and safety of agricultural products; National security and defense: National security. Projects for official use and secret projects are not included. Journals: Q1 WoS – journals included in the 1st quartile by impact factor in Web of Science; WoS – journals included in Science Citation Index Expanded (SCIE), Social Science Citation Index

(SCIE) and/or Arts and Humanities Citation Index (AHCI) Web of Science; WoS+ Q1-Q2 Scopus – journals included in SCIE, SSCI and/or Arts and Humanities Citation Index and/or having a CiteScore percentile in Scopus of at least 50; WoS+ Scopus – journals included in SCIE, SSCI, AHCI Web of Science and/or indexed in Scopus.
Источники данных: Web of Science, Scopus, SciVal (апрель 2024 г.)

In 2023, the winner of the "Best Researcher" competition in the field of "Medicine and Healthcare" is the young scientist Tabynov K.K. (NCJSC "Kazakh National Agrarian Research University").

The State Youth Prize "Daryn" of the Republic of Kazakhstan in the nomination "Science" in 2023 was awarded to Kenzhina Inesh (NCJSC "Kazakh National Research Technical University named after K.I. Satpayev") and Utepov Elbek (NCJSC "Eurasian National University named after L.N. Gumilyov").

Based on the results of the scientific activities of young scientists in the period 2020-2023, the following achievements and promising scientific areas attract attention:

In the Department of Life and Health Sciences

Nurbek Nadirov (JSC "National Scientific Center for Maternal and Child Health of the KF "UMC"). In the "FSBI Children's Orthopedic Research Institute named after G.I. Turner National Medical Research Center (St. Petersburg, Russian Federation) developed a technique for surgical correction of scoliosis and introduced it into clinical practice within the framework of the project “Molecular genetic study of the basis for the occurrence and progressive course of congenital spinal deformity in children in Kazakh families using whole-exome sequencing”. A list of new pathogenic mutations in children with congenital spinal deformity in Kazakh families will be developed. The new pathogenic mutations discovered will contribute to understanding the genetic basis for the occurrence and progressive course of congenital spinal deformity. Thus, the basis for population genetic characteristics of congenital spinal deformity will be laid. This, in turn, will give a multiplier effect to the social and economic sphere of healthcare.

Ildar Fakhradiyev (NCO “Kazakh National Medical University named after S. Zh. Asfendiyarov”). He developed a unique device designed to prevent the formation of adhesions in the abdominal cavity after surgery. This device operates on the principle of transdermal electrical stimulation, which involves the use of weak electrical impulses to stimulate tissues through the skin. Thanks to this innovative device, the risk of adhesions is significantly reduced, which contributes to a faster and easier recovery of patients after abdominal surgery.

Mynzhylky Berdikhodzhaev (RSE on the Right of Economic Management " Medical Center Hospital of the President’s Affairs Administration of the Republic of Kazakhstan"). Practical medicine: the first private stroke center Akzhan in the city of Karaganda was jointly put into practice, with the achievement of maximum surgical tactics within 5 months.

Kaisar and Kairat Tabynovs (NCO "Kazakh National Agrarian Research University"). For the first time in the world, a new allergy vaccine has been created for an ultra-short regimen (only 4 subcutaneous injections at weekly intervals) of

immunotherapy for rhinitis and bronchial asthma caused by wormwood pollen, which is among the top 10 global respiratory allergens.

Yulia Safarova (JSC Nazarbayev University, Astana National Laboratory). A method for stimulating bone tissue regeneration in osteoporosis-associated fractures has been developed, based on the use of cellular therapy with mesenchymal stem cells. A Kazakhstan patent has been received for this method. Polymer hydrogel wound dressings based on amniotic membrane and platelet-rich autologous blood plasma have also been developed.

Ayaulym Nurgozhina (JSC Nazarbayev University, Astana National Laboratory). Concentrates of grape, lingonberry, cranberry, blueberry and bilberry polyphenols have been developed. Preclinical studies have established a high potential for cytoprotective action, providing cell protection. Two clinical trials are currently underway: one on patients after acute myocardial infarction, aimed at reducing the risk of recurrent infarction and mortality, and the other on phosphorus production workers, aimed at reducing the risk of occupational diseases. The results of these studies have been published in highly rated journals such as Scientific Reports, with 41 citations. In addition, a line of specialized nutritional gels for athletes based on polyphenols, which are adaptogens and actoprotectors, was released. Research is underway on transport systems for drugs based on exosomes from mare's milk, which allows for the delivery of drugs directly to the site of their action in the human body, including the brain. Based on scientific developments, active work is underway on commercialization projects funded by JSC "Science Fund". Biological fertilizers have also been developed to increase crop yields.

Fakhriddin Sarzhanov (International Kazakh-Turkish University named after Khoja Ahmed Yasawi). Developed and improved methods for diagnosing parasites (Blastocystis sp., Dientamoeba fragilis), which contributes to more accurate detection of infections. The research results are actively used in clinical practice to improve the diagnosis and treatment of parasitic infections, which helps improve the health of patients. Conducted important phylogenetic studies of frogs of the genus Pelophylax, revealing their genetic diversity and distribution in Kazakhstan and Northwest China. These data are important for the conservation of biodiversity and understanding of evolutionary processes.

In the Department of Earth, Space and Communications Sciences

Sariyev Bakytzhan (Astana IT University). A technology for surface modification of a titanium implant has been developed, which accelerates osseointegration with human tissues up to one month. This innovative technique is used in dental implantology, significantly improving the results and reducing recovery times. An innovative technology has been developed for the production of geopolymer concrete from thermal power plant waste, which is highly resistant to aggressive external environments, including water. This material is a promising alternative to traditional cement, replacing it by 80%, and contributes to more environmentally sustainable construction.

Sariyev B., Konkanov M., & Zhexembayeva A. (2024). Comparative Study of Rheological Properties of Fly Ash–Based Geopolymer Reinforced With PP Fiber For

3D Printing: An Experimental and Numerical Approach. A unique packer assembly has been developed for simultaneous separate injection of liquid into an oil well, which allows increasing the oil production coefficient up to 30%. This innovation opens up new opportunities for increasing the efficiency of oil production and improving the performance of field development. Sariev B., (2023). Results of pilot tests (PT) of the simultaneous-separate injection technology "2pkok-orz" in JSC "Ozenmunaigas". Hardware and software for satellite modems in Kazakhstan have been developed, which provides a reliable and secure satellite connection for transmitting data from / to critical locations anywhere in the world (especially in remote places where there is no 3-5G Internet or any communication). These solutions enable communication between personnel, computers, sensors and controllers located at facilities vital to the state and business. The system can be used to monitor the amount of precipitation and the current state of the soil in the steppe, which is important for predicting floods, as well as warn of earthquakes, ensuring safety and prompt response, or transmit data on field indicators located outside the network zone.

Rakhadilov Bauyrzhan Korabaevich (East Kazakhstan University named after S. Amanzholov). The technology of cathodic electrolytic-plasma surface hardening (CEPHS) of structural alloy steels has been developed. The developed CEPHS technology has been successfully implemented in the production of cultivator paws at PlasmaScience LLP within the framework of the commercialization project of the Russian Scientific and Technical Documentation "Production of Cultivator Paws Using Innovative Electrolytic-Plasma Technology" (AP15573873), funded by the Science Fund JSC. A linear plasma installation for studying the interaction of plasma with materials has been developed and manufactured, which is successfully used to study the effect of helium and deuterium plasma on the structure and properties of tungsten materials. A technology for producing gradient coatings using detonation spraying has been developed.

Shamoi Pakizar (Kazakh-British Technical University). An intelligent system for processing colors and color combinations in computer systems using artificial intelligence has been developed. In this area, the developments are truly pioneering; there are no similar systems in the world. The system imitates the perception and change of color similar to the human eye. At the same time, the intelligent computer system recognizes colors with any change in lighting and brightness. This development has proven to be in high demand and is cited by scientists in a variety of fields - from e-commerce to medicine. Thus, scientists from the USA have used this model to analyze endoscopic images for diagnosing diseases.

Akylbekov Nurgali Ikramovich (Korkyt Ata Kyzylorda University). Original methods for the synthesis of "hybrid" and heterocyclic compounds on the platform of benzofuroxans containing functional fragments of aliphatic and aromatic amines, ammonium salts and pyrrolidines have been developed. Water-soluble salts based on benzofuroxan were studied as stimulants and regulators of growth of agricultural crops (wheat, barley, rice, sweet sorghum, alfalfa, sweet clover). The antimicrobial activity and antitumor potential of phenol/benzofuroxan hybrids were studied. Most of the substances exhibited high cytotoxicity towards human duodenal adenocarcinoma cell

lines (HuTu 80), human breast adenocarcinoma (MCF–7), and human cervical carcinoma cells. The IC50 values of the obtained compounds for these lines ranged from 0.9 to 5.9 μM and were comparable to or superior to the activity of Doxorubicin and Sorafenib.

Torebek Berikbol Tillabayuly (Institute of Mathematics and Mathematical Modeling). Methods for studying evolution equations with critical nonlinearities were developed and qualitative properties of solutions of nonlinear equations of anomalous diffusion were studied. The obtained results solve a number of open problems of nonlinear analysis theory related to critical exponents of Fujita type. Based on the research results, 20 scientific publications were published in highly rated journals indexed by Scopus and Web of Science. Azat Seitkhan, PhD, associate professor (Satbayev University), Tauanov Zhandos, PhD, associate professor (Al-Farabi Kazakh National University), Baimenov Alzhan, PhD, associate professor (Physical and Technical Institute). A group of young scientists is engaged in the development of nanomaterials and new technologies for water purification from toxic pollutants. Having started joint research at Nazarbayev University as doctoral students and postdoctoral students in 2015, they continue to conduct joint research, working in leading universities and research institutes of the republic. In the period from 2021 to 2023, they published 40+ publications in high-ranking journals of the Q1-Q2 quartile indexed by the Scopus database, more than 20 articles in Kazakhstani journals, published 3 monographs on methods for synthesizing activated carbons and silicon from biomass, zeolites from fly ash and synthetic polymers for the adsorption of heavy metals and organic pollutants. They are the managers and executors of more than 15 projects, including the CLEANWATER project, sponsored by the European Union under the HORIZON 2020 MSCA program.

In the department of sciences "On agrobioresources and ecology."

Research in the field of agricultural sciences on the topic "Genetic marking of productive qualities of the Kazakh horse of the Jabe type based on SNP genotyping with broad genome coverage". Authors - the group of *I.S. Beishova* (West Kazakhstan Agrarian and Technical University named after Zhangir Khan). Results of the study: the genetic diversity of horses of the Kazakh breed of the Jabe type was studied. Comparison of the Jabe genotypes was carried out with foreign and domestic breeds (Adai and Naiman types, Kushum, Kostanay, Mugalzhar breeds). Based on the results of the study, an article was published in the Animal journal, which has quartile Q1 in the Web of Science database and percentile 96 in Scopus. The work was carried out within the framework of project No. AP14870614 under the competition for grant funding for scientific and (or) scientific and technical projects for 2022-2024 (MNVO RK).

Almanova Zhanna Sarsimbaevna (National Academy of Science of the Republic of Kazakhstan under the President of the Republic of Kazakhstan), PhD, scientist in the field of agronomic soil science and agrochemistry, head of the scientific and technical project within the framework of the PCF of the Republic of Kazakhstan 2021-2023. "Assessment of the agroecological state of agricultural lands from the impact of anthropogenic factors and determination of the degree of pollution of soils

and agricultural systems of the steppe and dry steppe zones of the Kostanay region." Engaged in the development of GIS-agroecological assessment of lands and the methodology for the formation and design of adaptive landscape farming systems. Agroecological groups and types of lands of Northern Kazakhstan have been developed for the design of the ALSZ.

Recommendations

Under the leadership of the Ministry of Science and Higher Education, develop a systematic information database of the activities of young scientists, in which it is possible to track qualitative and quantitative indicators in dynamics (the number of young scientists currently available in the NCSSTE database in the regions of Kazakhstan in terms of their academic degree: (Doctor of Philosophy (Ph.D.), Doctor of Science in the field, Doctor of Science, Candidate of Science) and academic title (professor, associate professor); young scientists holding the positions of deputy heads, heads of universities and scientific organizations; young scientists as part of scientific organizations, the number of completed projects, winners of competitions, etc.).

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