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National Laboratory Astana: History, Mission, and Scientific Frontiers in Life Sciences

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Abstract The National Laboratory Astana (NLA) was established in 2015 under the auspices of Nazarbayev University and the Government of Kazakhstan, with the goal of advancing interdisciplinary fundamental and applied research to address pressing national scientific and technological challenges. Since its founding, NLA has grown into the most advanced research institution in Kazakhstan, hosting over 200 researchers across two main centers: the Center for Life Sciences (CLS) and the Center for Energy, Advanced Materials and Sensors (CEAMS). The Center for Life Sciences, founded in 2010, has positioned itself as a leading hub for biomedical research, pioneering work in genomics, bioinformatics, oncology, microbiome science, and bioengineering. Over the past decade and a half, CLS has established a broad international collaboration network spanning the United States, European Union, Asia-Pacific, and CIS regions, producing hundreds of peer-reviewed publications and filing numerous patents. This review traces the history, organizational structure, mission, and key scientific achievements of NLA and its Center for Life Sciences and outlines future directions for research in Kazakhstan's biomedical landscape.

Keywords: *National Laboratory Astana; Center for Life Sciences; Nazarbayev University; Kazakhstan; genomics; personalized medicine; biomedical research; bioinformatics; oncology; international collaboration*

Introduction

The development of world-class scientific infrastructure is an essential component of any knowledge-based economy. For Kazakhstan, this realization has driven significant investment in higher education and research since independence. Among the most consequential milestones in this trajectory has been the creation of Nazarbayev University (NU) in 2010 an autonomous, research-intensive university modelled on leading Western institutions and mandated to catalyze educational reform and economic diversification. As the research arm of NU, the National Laboratory Astana (NLA) was subsequently established in 2015, uniting leading scientists under a single institutional umbrella to address the country's most pressing scientific and technological challenges [1, 2].

The decision to establish a dedicated national research laboratory reflected a broader recognition that Kazakhstan's long-term prosperity would require more than resource extraction: it would demand the capacity to generate, apply, and export knowledge. NLA was designed to serve this purpose bringing together multidisciplinary teams, state-of-the-art infrastructure, and deep international partnerships. Today, it stands as Kazakhstan's flagship research institution, consistently ranked among the most productive scientific organizations in the country [3].

Central to NLA's scientific agenda is the Center for Life Sciences (CLS), which was established in 2010 initially as an independent entity and subsequently integrated within NLA's organizational structure.

CLS has focused on translating advances in genomics, molecular biology, and biotechnology into clinically meaningful insights for the Kazakh population. Given the unique genetic background of the Kazakh people shaped by centuries of nomadic migration and reflecting a distinctive blend of Western and East Asian ancestry the Center's work has particular significance for population-specific health strategies [4, 5].

This review traces the founding, mission, organizational development, and key scientific contributions of NLA and the Center for Life Sciences and discusses prospects for the coming decade.

National Laboratory Astana: Founding and Institutional Framework

The National Laboratory Astana was formally established in 2015 as a research organization within the Autonomous Organization of Education "Nazarbayev University." The decision to build NLA on the foundation of NU was deliberate: NU had already attracted internationally trained faculty and invested substantially in scientific infrastructure, providing NLA with an immediate platform from which to operate at global standards. The Government of Kazakhstan allocated dedicated funding and granted NLA the operational autonomy necessary to recruit internationally competitive researchers and pursue long-term research programs free from routine bureaucratic constraints [1].

NLA's founding mission was articulated clearly from the outset: to develop interdisciplinary fundamental and applied research addressing the nation's most pressing scientific and technological challenges, to generate and share new knowledge, and to become a world-class institution that contributes to Kazakhstan's green economic and technological development. This mission was underpinned by a commitment to international partnership from the earliest days, NLA sought to collaborate with leading research and educational institutions across the United States, European Union, Asia-Pacific, and CIS regions [1, 3].

Structurally, NLA comprises two principal research centers: the Center for Life Sciences (CLS), focusing on biomedical and biological sciences, and the Center for Energy, Advanced Materials and Sensors (CEAMS), focusing on energy technologies, materials science, and sensors. Each center encompasses multiple specialized laboratories. This bipartite structure allows NLA to address two of Kazakhstan's most strategically important domains: health and human capital on one hand, and sustainable energy and technological capacity on the other.

By 2024, NLA employed more than 200 researchers. In the 2024-2025 period alone, the institution completed 111 research projects, obtained 20 patents, and published 330 peer-reviewed scientific articles figures that reflect a research organization operating at genuine international scale [6].

Center for Life Sciences: Origins, Structure, and Research Agenda

The Center for Life Sciences (CLS) was established in 2010, predating the formal creation of NLA itself, and it has grown to become one of the most productive biomedical research institutions in Central Asia. CLS was co-founded by Almas Sharman (President of the Academy of Preventive Medicine of Kazakhstan) and Professor Zhaxybay Zhumadilov, who together laid the intellectual and institutional groundwork for the Center's distinctive focus on genomics and personalized medicine [6, 7].

Since 2012, CLS has been pioneering the application of next-generation sequencing (NGS) technology in Kazakhstan, using whole-genome sequencing to decode the genomes of Kazakh individuals and establish the first population-level genomic databases for the country. The Kazakh population presents a particularly compelling case study for genomic research: the historical combination of nomadic lifestyle, extensive migration routes spanning the Eurasian steppe, and admixture with both Caucasian and Mongoloid ancestry has produced a genetic profile that is distinct from those studied in large Western or East Asian cohorts. CLS research has helped reveal how this distinctive ancestry

shapes susceptibility to diseases such as breast cancer, cardiovascular disease, and infectious diseases including tuberculosis [4, 5, 8, 9].

CLS is organized into eight specialized laboratories, each targeting a distinct domain of biomedicine:

1. Laboratory of Genomic and Personalized Medicine focused on whole-genome sequencing, genetic risk assessment, pharmacogenomics, and population genomics of the Kazakh people.
2. Laboratory of Bioinformatics and Systems Biology developing computational pipelines and systems biology approaches for large-scale omics data analysis.
3. Laboratory of Bioengineering and Regenerative Medicine investigating cellular therapies, regenerative approaches, and next-generation biomaterials.
4. Laboratory of Molecular Oncology advancing the understanding of cancer biology and developing novel therapeutic strategies.
5. Laboratory of Microbiome characterizing the Kazakh gut and environmental microbiome and its links to health and disease.
6. Laboratory of Drug Discovery and Development identifying and developing novel therapeutic compounds, including candidates for clinical trials.
7. Laboratory of Biosensors and Bioinstruments engineering diagnostic devices and biosensors for medical and environmental applications.
8. Laboratory of Cell Motility studying cell migration and dynamics relevant to cancer progression and wound healing.

This multi-laboratory architecture enables CLS to engage in interdisciplinary projects that bridge computational biology, experimental science, and clinical translation the hallmark of modern translational biomedicine.

AI and Genomics Convergence: A Strategic Priority

Among the most significant recent developments at NLA and CLS has been the deliberate convergence of artificial intelligence methodologies with genomic and biomedical research. This trajectory reflects a broader global movement, but at NLA it has taken on particular urgency given the scale of data being generated by whole-genome sequencing projects and multimodal clinical studies.

AI tools have been integrated into several key research streams at CLS. In cancer research, machine learning approaches have been applied to the analysis of medical imaging data, helping to identify patterns that conventional diagnostic approaches may miss. In drug discovery, AI-assisted modeling of molecular structures has accelerated the identification of novel therapeutic candidates a process that, without computational support, would require considerably more time and resources. The Laboratory of Bioinformatics and Systems Biology has developed custom computational pipelines for processing terabytes of sequencing data, enabling the identification of millions of genetic variants across the Kazakh genome [7, 10].

The importance of this convergence was underlined at the ministerial level during the International Scientific Conference "Life Science Today 2025," where the Minister of Science and Higher Education of Kazakhstan highlighted AI's transformative role in both biomedical and pharmaceutical research, and specifically referenced CLS-based projects as exemplars of the national innovation agenda [6].

Of particular note is the project led by NLA General Director Professor Dos Sarbassov, which involves the development of a novel anti-tumor drug combining arsenic trioxide and a D-VC compound. AI assistance in analyzing large biological datasets and modeling molecular structures has contributed to accelerating this compound through clinical trials, with the research team currently engaged in determining maximum tolerated doses in collaboration with the Kazakh Research Institute of Oncology and Radiology [6].

International Collaboration and Scientific Networks

International partnership has been a structural priority for NLA since its inception. The Laboratory of Genomic and Personalized Medicine have established active collaborations with institutions in the United States, Finland (University of Helsinki), and across the CIS region. Collaborative studies on population genomics, tuberculosis genetics, cardiovascular genomics, and cancer biology have resulted in joint publications in high-impact journals, strengthening Kazakhstan's visibility in the global scientific literature [8, 9, 10, 11].

The Columbia Global Centers have featured CLS research in their "Logical Reasoning in Human Genetics" series, providing international academic audiences with a window into the unique genetic landscape of the Kazakh people and the research programs at CLS [4]. Such visibility contributes to attracting further collaborative partnerships and positions NLA as a knowledge hub for the Central Asian region.

The biennial conference series most recently "Life Science Today 2025 - Frontiers in Biomedicine: Infer, Innovate, Impact" has become an important mechanism for convening international expertise. The 2025 edition brought together more than 400 participants and featured over 40 presentations from scientists based in the United States, Europe, China, and Kazakhstan, covering genomics, personalized medicine, regenerative medicine, brain health, and cancer biology [6].

Current Challenges and Future Directions

Despite its significant achievements, NLA and its Center for Life Sciences face a set of challenges that are typical for research institutions in emerging economies, and several that are specific to Kazakhstan's context.

Building and retaining a pipeline of highly trained scientific talent remains a long-term institutional priority. While NLA benefits from its integration with Nazarbayev University and its ability to offer internationally competitive research environments, the broader ecosystem for scientific career development in Kazakhstan is still maturing. Expanding training opportunities for young scientists including competitive postdoctoral fellowships and structured PhD programs with international components will be important for sustaining research capacity over the coming decade [7].

The establishment of a comprehensive Kazakhstani Reference Genome and Reference Microbiome remains a flagship scientific objective for CLS. Progress toward this goal requires continued investment in sequencing capacity, computational infrastructure, and longitudinal cohort studies. The eventual completion of such reference datasets will provide an invaluable resource not only for CLS researchers but for clinicians and public health authorities across Kazakhstan [4].

Translating research findings into clinical practice and health policy remains a challenge across biomedical research globally. For NLA, building and strengthening the bridges between basic and applied research through partnerships with the Ministry of Health, clinical institutions, and the pharmaceutical industry will be critical for ensuring that scientific discoveries yield tangible benefits for patients and the population at large.

Conclusions

The National Laboratory Astana, established in 2015, has rapidly developed into Kazakhstan's premier research institution, leveraging the academic infrastructure of Nazarbayev University, strong government support, and a commitment to international scientific partnership. Over a decade of operation, its Center for Life Sciences has built a research agenda spanning genomics, bioinformatics, oncology, microbiome science, and bioengineering, generating hundreds of peer-reviewed publications, patents, and active research projects.

NLA's history illustrates the feasibility of building world-class scientific capacity in a rapidly developing country through strategic investment, institutional autonomy, and deliberate international engagement. As Kazakhstan continues to diversify its economy toward knowledge-intensive industries, NLA and CLS stand as critical assets not only for the advancement of biomedical knowledge, but for the training of a new generation of Kazakh scientists and the improvement of population health. The next decade will be defined by the convergence of AI with genomics, the completion of the Kazakhstani Reference Genome, and the translation of laboratory discoveries into clinical realities.

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Competing Interests

The author declares no competing interests.

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