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Challenges and perspectives of brain science in Mongolia and Central Asian countries

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"What is the origin of the mind?", "What is the organ of intelligence?" The first answers to these questions trace to the scripts of ancient Sumeria and Egypt. It took almost 4000 years to understand that the brain is the main organ that controls other organs. The dawn of modern neuroscience lay in the 1890s when the pioneering works of Camillo Golgi and Ramon Cajal invented the structure of the nervous system using microscope techniques (Lopez-Munoz et al., 2006). Cajal's neuron doctrine, which hypothesizes that the functional unit of the brain is the neuron, has become the main concept that explains the mind and body interactions. Since 1906, starting from both until this year to David Julius and Ardem Patapoutian, no less than 42 laureates have been awarded the Nobel prize in Physiology and Medicine. Since 2000, 24% of the Nobel Laureates were neuroscientists, and research funding for neuroscience has significantly increased, indicating neuroscience as one of the frontier sciences in the 21st century. It may be associated with neuroscience being a platform for multidisciplinary research, including basic, clinical, and translational sciences. The United States of America (US) has more than 230 universities and colleges offering neuroscience degrees, more than 40 research institutes in neuroscience, and more than ten large industries involved in brain initiatives. The total neuroscience funding by the National Institutes for Health is more than US\$10 billion for 2021. This amount is more than twice the annual budget of Mongolia, which is US\$4.9 billion for 2021. Out of this budget expenditure, only 0.1% (~US\$50 million) is allocated for the science funding in Mongolia.

Despite the extremely scarce resources, Mongolian neuroscientists established the Mongolian Neuroscience Society (MNS) in 2014. The goal of the society is to develop and support brain science in Mongolia. In 2015, we became a member of the International Brain Research Organization (IBRO). IBRO, established in 1961, serves as the core organization to promote neuroscience globally, which comprises over 90 neuroscience societies across the globe. MNS belonged to the Asia-Pacific Region of the IBRO and was the first member organization from Central Asia. MNS organized the Honored Public Lectures supported by the IBRO in 2018 in Ulaanbaatar to increase the awareness of brain science in the Mongolian population. The lectures were held in the Parliament House under the Auspice of the President of Mongolia. The honoured world-renowned neuroscientists, speakers including the President of IBRO, Pierre Magistretti, the Chief-in-Editor of Neuroscience, Juan Lerma, and the

2014 Nobel Laureate Edvard Moser. The lectures were made possible by the essential support of the Directors of IBRO, Tasia Asakawa, Rebecca Hadid, and Stephanie de la Rochefoucauld. It attracted the whole nation to neuroscience, and decision-makers promised to support the development of brain science. As a result, the first research institution for neuroscience, Brain Science Institute, was established at the Mongolian National University of Medical Sciences (MNUMS) on April 24, 2019, in Ulaanbaatar. It was an excellent opportunity for Mongolian neuroscientists who graduated abroad and were eager to conduct studies in neuroscience in their labs.

Currently, the Brain Science Institute at MNUMS conducts a nationwide multicenter, interdisciplinary, prospective, population-based cohort study to investigate brain-related disorders in the general population of Mongolia. The current population of Mongolia is 3,357,542 based on the latest United Nations data, of which 1,597,290 of them live in Ulaanbaatar, the capital city, and the remaining of them live in 4 rural regions. Accordingly, the cohort consists of 64 sampling centres, including 30 primary health centres of 8 districts in Ulaanbaatar and 34 primary health centres of 4 rural regions (**Figure 1**).

The cohort team consists of five specialities: neurology, psychiatry, endocrinology, gynaecology, dentistry, and family medicine. The principal investigators are Byambasuren Dagvajantsan, Gantsetseg Tumur-Ochir, Oyuntugs Byambasukh, Batsuren Choijamts, Ganjargal Ganburged, and Myagmartseren Dashtseren, respectively. This cohort was initialized by Tsolmon Jadamba, the former President of MNUMS, and conceived by Battuvshin Lkhagvasuren, the institute director. Of note, there has been no study since 1989 that assessed the epidemiology of neurological and psychiatric disorders in the general population of Mongolia. The political transition from communism to democracy, rapid urbanization, air pollution, change of lifestyle, the shift of disease burden, and economic turbulence over the past three decades should have primarily impacted the brain health of Mongolian people. Including but not limited to these factors, the normative data of subjective surveys on stress level, quality of life, and other clinical characteristics in Mongolian people may deviate from international standards. However, before establishing the normative data, it is mandatory to determine the psychometric properties of the Mongolian versions of assessment tools for validity and reliability. Therefore, the first

cohort results highlighted in the special issue are mixed with validation studies.

Modern medicine was introduced to Mongolia in the early 1920s, and it took a relatively long time to have their first national experts in science due to the political turbulence. As Mongolia was a satellite country of the former Soviet Union, the first modern university was established in 1942 in Ulaanbaatar with the support of Soviet scientists. The first scientific article on brainrelated disorders was published in Sante Publique (Bucur) in 1970 by Prof. Dorjjadamba Shagj (Dorjjadamba, 1970). He was one of the founders of psychiatry and modern mental health service in Mongolia. His successor Prof. Byambasuren Sandag has led the first nationwide clinical and public health research on neuropsychiatric disorders (Byambasuren & Tsetsegdary, 2005). Professor Khairulla Jalel was the pioneer in neurosurgery who established the first neurosurgery department in Mongolia (Khairulla, 1980).

Historically, Mongolia has been part of Central Asia. The current Central Asian countries, including Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, and Turkmenistan, were autonomic republics of the Soviet Union until 1991. The first modern university was founded in 1918 in Uzbekistan as the Turkestan People's University, and the other universities were established in each republic by the Soviets afterwards. Therefore, the Central Asian countries have as short histories of neuroscience as Mongolia and share similar challenges to developing neuroscience. The fact that there is almost no national contribution from these countries to world science from the perspectives of neuroscience may be associated with many problems. The current autonomic regions of China, including Inner Mongolia, Xinjiang, and Tibet, were considered parts of Central Asia in the past. However, we will summarize the challenges in Central Asian countries here with reference to Mongolia only.

Although those are common problems in developing countries elsewhere, most challenges we currently face in Mongolia are as follows. The first problem is poor research funding which is inevitable in developing countries. Both the government members and scientists are pessimistic about the outcome of the allocations provided for science, less than 0.2% of the Gross Domestic Product in 2018 in Mongolia (UNESCO, 2021). The general population and governments in developing countries ask for valuable results from scientific research as if it helps solve local issues in society. However, basic science such as neuroscience increases



Figure 1. Sampling centres by geographical locations. The cohort consists of 64 sampling centres indicated by black balloons, including 30 centres in urban areas and 34 centres in rural areas. Urban areas are divided into eight districts of Ulaanbaatar city, whereas rural areas are into four regions. Orange designates the Western region, yellow the Mountain region, blue the Central region, and red the Eastern region, respectively.

knowledge, while applied science uses it to solve those specific problems. Currently, Mongolia is limited to understanding these facts and awareness of how important to support basic scientific research. Second, the competition for funding resources, which is already too scarce, is complicated due to the outdated and complex system. As for Mongolia, we have a similar approach to the former Soviet Union's academic system. However, it has not been updated adequately since the socio-political shift due to the number of economic recessions. It can be reflected in the absence of a principal investigator system, non-transparent funding procedure, uncoupled funding system with graduate studies.

Third, education and academic governance are under the persistent burden of political polarization, notably higher education governance. Political parties interfere with the independence, academic freedom, and financial stability of public universities by frequent changes in administrative employees, deans, and department heads based on their political orientations as soon as they start governing. They treat public universities as places to advance a political agenda and to recruit their members or followers. Boards of public institutions are mainly composed of government agency officers, which makes it possible to determine the mission and goal of the institutions or what should be studied, and who can do it. These frustrating threats of political intrusion significantly limit the development of science and cause cascades of negative consequences.

Fourth, the lack of human resources has become a severe problem in many scientific areas. As a country with no training and research program in neuroscience, training abroad is the only way to prepare national experts in Mongolia. However, the lack of career structure in neuroscience and low salaries make a significant problem in re-integration on return home. Most neuroscientists who graduated in developed countries had to abandon the techniques and knowledge they acquired by pursuing careers in medicine or education. It also distracts graduate students, and they seek to remain in the developed countries where they got trained. In the field of brain science and overall in science, this phenomenon called brain drain is negatively affecting the country's development. It is also reflected in a small portion of the educated population compared to developed countries, particularly at the graduate level.

Fifth, the high cost of research facilities makes it hard to renew the outdated technologies in research labs. Especially, multidisciplinary sciences such as

neuroscience are dependent on other disciplines' technologies and require multiple experiment setups. For example, establishing an fMRI facility requires a whole range of equipment and software, exceedingly far more than the current funds available in the country. There was an attempt to establish a shared facility with specialized equipment, including an electron microscope, mass spectrometry, and NGS technology for mission-oriented or applied research in Mongolia. However, it failed for many reasons, including corruption, lack of planning, efficient utilization, and maintenance.

Although there are many other problems, last but not least is the importation barrier. Like other Central Asian countries, Mongolia is a landlocked country that does not have access to the open sea. We are utterly dependent on imported products because every item necessary for a research lab, such as chemicals, vials, or animals, is imported. Therefore, not only the importation-associated high cost but also permission to import equipment and chemicals, custom duties, bank transactions, and a long period of permanent frost make the importation labour-intensive and time-consuming. These significant problems in the current academic system in Mongolia demonstrate how challenging is to develop a new discipline in a developing country.

On the other hand, we are now in much better condition than 30 years ago. During this period, the macroeconomic characteristics of Mongolia have been increased almost ten times, i.e., gross national expenditure jumped from US\$250 million to US\$5 billion; the gross domestic product per capita was US\$0.58 billion, and it is now US\$4.53 billion. Also, democracy allowed any Mongolian organization or individual to communicate with international or foreign organizations without political censorship for academic exchange or scientific purposes. A few decades ago, the Mongolian could not leave the country for any reason as we had to live under a strictly censored communist regime, like current North Korea.

We are aware that there is an urgent need to improve the current national scientific standings to keep pace with accelerated global development. There are several best practices on facilitating science with a high impact on global knowledge. For example, although Nordic countries have smaller GDPs, their outputs are relatively higher than the larger countries. They provided relatively marginal resources to public research funding out of their total expenditure, close to the globally recommended rate of 3% (King, 2004). Nevertheless, at

the same time, they strengthened their national infrastructure, decreased corruption and bureaucracy, improved the governance of academic organizations, and promoted internationalization. The alternative way can be maintaining the current system by closing the system gaps and intensifying direct financial support to the research institutions and specific projects, which have been successfully implemented in the People's Republic of China.

Nevertheless, emerging technologies, artificial intelligence, well-designed research, and innovative strategies are the core aspects of overcoming current challenges. Promoting neuroscience can be an ideal strategy for building multidisciplinary and more advanced research clusters that nurture all disciplines

from biochemistry to cognitive psychology. Therefore, neuroscience can be the central hub for cooperative projects and platforms in Mongolia.

To develop neuroscience in Mongolia, we have to establish a national research institute for brain science, integrate neuroscience as a discipline in the national education system, train national experts at the graduate level, develop a national program for brain science, facilitate multidisciplinary projects, incubate high-tech clusters, increase the public awareness of brain science, and contribute to science. In conclusion, "Can the brain study itself?" — we have much to do.

Conflicts of Interest: The authors declare no conflict of interest.

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