

Korea Brain Initiative: Integration and Control of Brain Functions

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This article introduces the history and the long-term goals of the Korea Brain Initiative, which is centered on deciphering the brain functions and mechanisms that mediate the integration and control of brain functions that underlie decision-making. The goal of this initiative is the mapping of a functional connectome with searchable, multi-dimensional, and information-integrated features. The project also includes the development of novel technologies and neuro-tools for integrated brain mapping. Beyond the scientific goals this grand endeavor will ultimately have socioeconomic ramifications that not only facilitate global collaboration in the neuroscience community, but also develop various brain science-related industrial and medical innovations.

Introduction

In 1998, the Korean government enacted the “Brain Research Promotion Act” to promote the importance of brain science and enhance the public’s welfare by facilitating the industrialization of developed technologies in what has recently been referred to as “the fourth industrial revolution” (Schwab, 2015). This act reinforced the government’s active investments in basic and clinical neuroscience, cognitive science, and neuro-engineering. The main content of the Act consists of the establishment of basic annual plans to foster brain research, which are published in annual reports; the installation and operation of a biotechnology comprehensive policy deliberating committee; and the expansion of investments through collaborative efforts of four ministries of the Korean government: the Ministry of Science, ICT and Future Planning (MSIP); the Ministry of Education (MOE); the Ministry of Trade, Industry and Energy (MOTIE); and the Ministry of Health and Welfare (MOHW). Based on the first (1998–2007) and the second (2008–2017) Brain Research Promotion Basic Plans, the Korean government has analyzed the working plans, which are publishing annual reports. The decade-

long 21st Century Brain Frontier Project (2003–2013) contributed to advancing brain science. This government-led project largely focused on R&D for brain functions and diseases, with research studies conducted by joint teams from the private and public sectors. Due to these two decades of promotional effort by the Korean government, Korea’s brain research has been able to grow and prosper continuously.

Along with growing international efforts in the area of brain mapping, there has been emerging interest in formulating nationwide brain science projects in Korea. It has been considered a challenging and timely endeavor to launch a flagship initiative prior to another national basic plan for a decade-long development of brain science (2018–2027), and the Korean government has developed a bold and ambitious plan for advancing brain science and stimulating the interaction between the scientific community and industry. To further promote brain research at the government level, the Korea Brain Research Institute (KBRI) was established in 2011 based on Article 17 (Establishment of Research Institutes) of the Brain Research Promotion Act. This national institute plays an important role in con-

ducting national brain research while also maintaining and developing a system for enhancing cooperation among academia, research institutes, and industries. In the same year, the Korea Institute of Science and Technology (KIST, founded in 1966) launched the Brain Science Institute to facilitate brain science in convergence with brain engineering. In 2013, the Institute for Basic Science (IBS) also began contributing to the development of basic neuroscience research, creating three research groups: centers for cognition and sociality, neuroscience imaging research, and synaptic brain dysfunctions.

With the advantage of these ongoing investments and a strong environment for research, Korean neuroscience has made remarkable progress. Macroscale brain imaging studies are now supported by over 400 MRIs across the country and also by a dedicated IBS center. The Brain Science Institute of KIST focuses on neural and glial mechanisms in the diseased brain and the developing programs for the diagnosis, prevention, and treatment of such diseases. KBRI, on the other hand, has launched a collaborative research project focusing on perceptual decision-making by multiscale circuit analysis of the posterior parietal cortex.

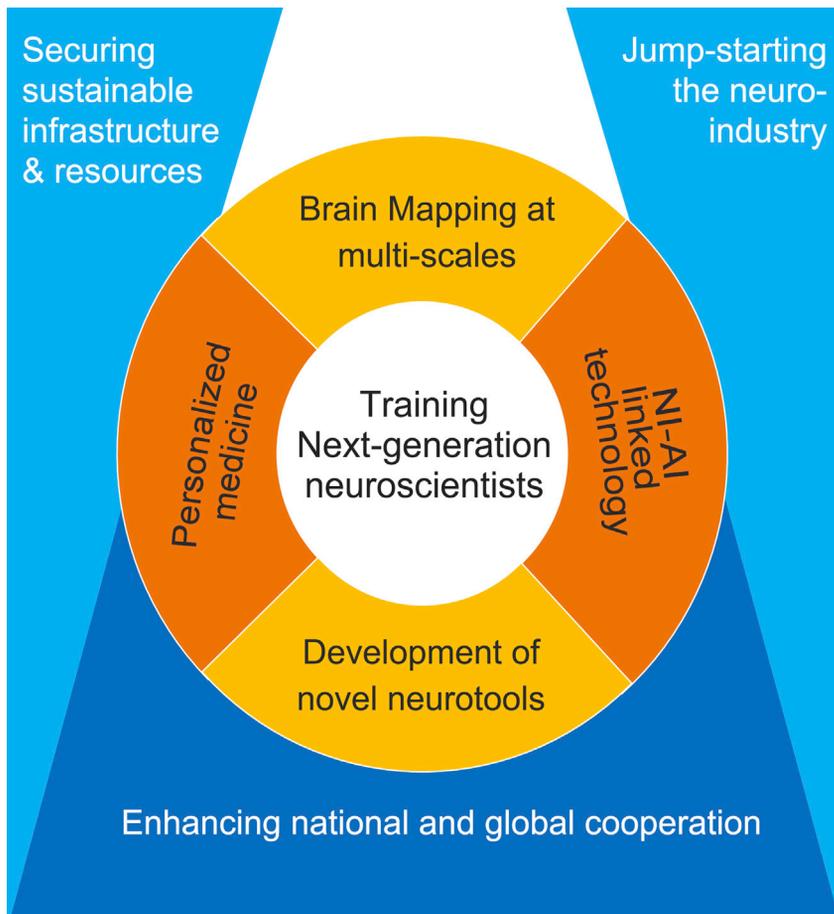


Figure 1. Korea Brain Initiative: Dual-Track Strategy of R&D and Ecosystem

Announcement of the Korea Brain Initiative

Recently, MSIP formed an advisory committee composed of experts from academia, research institutes, and business to develop a ten-year roadmap to revolutionize brain science. With this commitment, in-depth research on policies in neuroscience has been conducted, which resulted in the announcement of the “Korea Brain Initiative” on May 30, 2016. The overall plan features the development of novel neurotechnologies and the reinforcement of the neuroindustry with a vision to advance brain science by establishing and facilitating local, national, and global collaborative networks.

Toward Korean Neuroscience Development

It is essential for governments to invest in innovative approaches to solve today’s scientific challenges and prepare

for the future of an aging society. The launch of a sustainable, nationwide, flagship brain research project is important to confront the challenges that we face in a changing society and prepare for the future neuro-industry. The proposed Korea Brain Initiative is currently the subject of a comprehensive feasibility study and technological assessment, after which the grand project will be launched in 2018. Aligned with these scientific and infrastructure goals, it will also be important to consider the ethical and social issues in advancing neuroscience and neurotechnologies. Because of potential societal implications, it will be critical to undertake regular and comprehensive assessment of the developing R&D programs, as well as to work to promote strong public awareness in support of these initiatives. Open forums and symposia on the development of national brain science programs will serve as

communication channels for researchers and the public and provide opportunities to promote social harmony around the neuroscience community.

Aims and Scope of the Korea Brain Initiative

The primary goal of the Korea Brain Initiative is to foster neuroscience to enable scientific understanding of the principles of higher brain functions to produce a new dynamic picture of healthy and diseased brains. Additional goals are to develop personalized treatments for mental and neurological disorders by extrapolating the concept of precision medicine and to stimulate the interaction among scientific institutes, academia, and industry. To achieve such goals, the project adopts a dual-track strategy of innovative R&D projects, building a balanced neuroscience ecosystem.

R&D Projects

The R&D of the Korea Brain Initiative is focused on four core areas:

1. *Constructing brain maps at multiple scales.* The Korea Brain Initiative’s brain mapping plan employs a two-track strategy to understand how the brain works and how disease occurs. One track focuses on unraveling the structural and mechanistic bases of higher brain functions, such as decision-making, attention, and memory, while the other focuses on understanding the progression of neurological disorders, especially those related to aging. Two types of “specialized brain maps” are expected to be developed by 2023. Research in the area of functional connectomics will support the development and application of structural and functional mapping technologies applied at the micro-, meso-, and macroscales.
2. *Developing innovative neurotechnologies for brain mapping.* The initiative aims at advancing technologies for a better understanding of the full complexity of the brain, and especially of circuit-function relationship. The development of neuro-tools for multiscale brain mapping, circuit-mining, and high-resolution wide-field recording as

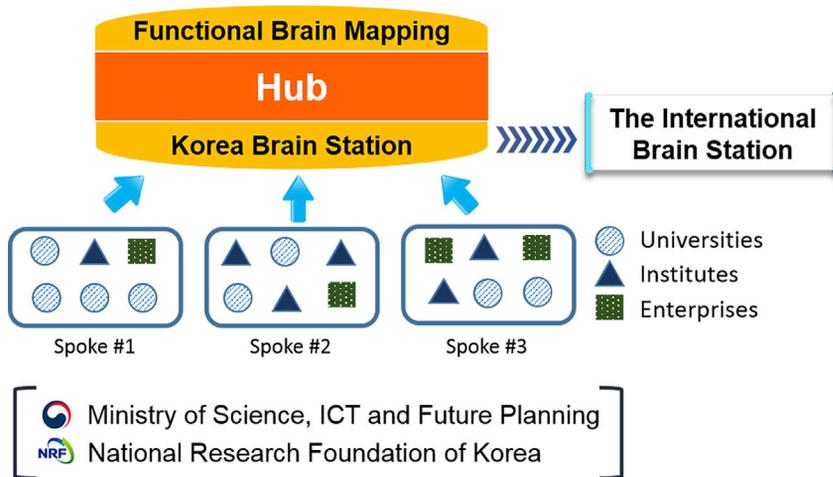


Figure 2. Operating Strategy of the Korea Brain Initiative: Hub-and-Spoke Model

well as new methods for modeling neurological diseases such as brain organoids are a few examples of innovative convergence R&D projects.

3. *Strengthening artificial intelligence-related R&D.* These initiatives are also intended to contribute to the development of new cutting-edge AI technologies. Neural circuit studies of higher brain functions such as sensory integration, perceptual decision-making, and natural intelligence are important for the advancement of AI, developing next-generation AI algorithms and models and neural devices.
4. *Developing personalized medicine for neurological disorders.* The initiative aims to develop cutting-edge precision medicine technologies to prevent and diagnose neurological disorders and to develop customized disease-prevention and treatment strategies for brain disorders.

Reinforcement of the “Neuroscience Ecosystem”

In order to create a favorable and collaborative research environment, the Korea Brain Initiative intends to provide a framework to embark on research activities in harmony by:

1. *Training next-generation neuroscientists.* The scope of neuroscience has broadened significantly over

the last decades, and researchers in the field need to be competent in a wider range of technical and analytical knowledge and skills. It is essential to push the limits of our knowledge and to adopt new approaches to train and develop a next generation of neuroscientists through various multidisciplinary training programs. The Korea Brain Initiative incorporates training plans into all of its various academic research institute collaborative projects. In this way, we hope to nurture experts competent in translating basic research into new treatments for brain diseases.

2. *Strengthening a sustainable infrastructure.* The Korea Brain Initiative aims at building a pipeline to facilitate collaborative research and exchange resources and research outcomes. For instance, the initiative plans to increase core facilities and expand the Korea Brain Bank Network (KBBN), and to construct an accessible data station to share and store data.
3. *Enhancing national and global networks.* Strengthening strategic interactions with neuroscience stakeholders, both at the national and international level, will be essential to solve the challenging issues in brain science. With regard to brain mapping, establishing a collaborative network by joining a global brain research consortium, including the

currently discussed project for creating an international brain data hub, would facilitate this task.

4. *Jump-starting the neuro-industry.* The Korea Brain Initiative plans to build a framework for the industrialization of cutting-edge neuroscience. To this end, it is essential to develop lab-to-bench bridge programs and establish neuro-industry clusters where research and business sectors can work together to create new value in the field of neuroscience (Figure 1).

Management Model: Hub-and-Spoke Strategy

The core infrastructure will feature a “hub-and-spoke” model in order to effectively operate the many projects of the Korea Brain Initiative. This model is expected to encourage multidisciplinary collaborations and create an open research environment. While the hub groups will have a role in providing research support from the core research infrastructure, standardizing brain mapping technologies, and developing the operating systems for data sharing, the individual spokes will undertake practical, bottom-up R&D activities and employ the systems that have been constructed and operated by the hub groups (Figure 2).

Uniqueness of the Korea Brain Initiative

The Korea Brain Initiative is unique in that it employs a dual-track strategy in pursuing goals of developing innovative neuro-technologies as well as fostering brain research environments. Through the implementation of this strategy, it is expected that the research ecosystem will function to bridge the gap between basic and applied neuroscience research. The reinforcement of this neuroscience ecosystem includes building and expanding neuroscience networks; allowing better access to research data, neuro-tools, and brain tissue samples; and fostering of a future-oriented neuro-industry.

Last but not the least, central to the overall strategy of the Korea Brain Initiative is the commitment to foster the development of next-generation neuroscientists. In order to have a valuable research outcome, it is essential to create a strong environment and training ground for more

Box 1. Funding Initiatives**GOVERNANCE**

The Ministry of Science, ICT and Future Planning (MSIP) is at the top of the national project's operating system. The research fund is managed by and provided to research groups through a fair and professional grant system operated by the National Research Foundation of Korea (NRF).

HISTORY

In 1998 the Korean government enacted the "Brain Research Promotion Act," and Korean neuroscience has made remarkable progress based on the first and second Brain Research Promotion Basic Plans. In order to lead the innovation of neuroscience, the Korean government decided to push for a ten-year national brain project prior to the third Brain Research Promotion Basic Plan (2018–2027). On May 30, 2016, the government of Korea announced the ambitious "Korea Brain Initiative" with the goal of advancing brain science and stimulating neuroscience-industry interaction.

MISSION AND SCOPE

To accelerate the impact of the national flagship brain research project, we plan to employ a dual-track strategy of R&D and infrastructure and to design targeted funding mechanisms to both strategies. It is expected that this new research ecosystem will function to bridge the gap between basic and applied neuroscience research.

The scope of R&D projects includes (1) constructing brain maps at multiple scales, (2) developing innovative neurotechnologies for brain mapping, (3) strengthening artificial intelligence-related R&D, and (4) developing personalized medicine for neurological disorders.

By creating a favorable environment for collaborative studies and laying the groundwork for excellent R&D activities, the Korea Brain Initiative introduces the reinforcement in neuroscience ecosystem as its second-track strategy, which includes (1) training next-generation neuroscientists through various multidisciplinary training programs, (2) strengthening a sustainable infrastructure, (3) enhancing national and international networks, and (4) jump-starting the neuro-industry by fostering lab-to-bench R&D.

ORGANIZATION AND OPERATIONAL STRUCTURE

In order to ensure fair and open competition among researchers nationwide, NRF will be responsible for monitoring and selecting individual research agencies through the Request for Proposal (RFP) process. For the efficient operation of the initiative, a hub-and-spoke model is introduced, where the hub serves as the infrastructure of the overall initiative while the spoke bodies proceed with the actual R&D activities.

and better-trained R&D manpower. The grand plan suggests cultivating the next generation of neuroscientists trained in multiple disciplines such as ICT, computer science, etc. through various programs involving institute-academia collaborations. This mission is crucial to recruit researchers for the brain mapping initiatives, and they will also contribute to an innovative research environment and will be better able to exploit the newly available data and information that will emerge from these big data resources.

Promotion of Global Collaboration

With the initiation of these neuroscience-focused mega-projects, Korea will not only boost its research competitiveness in the specialized fields of neuroscience but will also play a crucial role in contributing to impactful cooperation with the

other national and global neuroscience communities that are involved in related neuroscience projects, including, for instance, the MESO-BRAIN Initiative, funded by EC FET, which aims to replicate the brain's neural networks through 3D nano-printing (<https://www.icfo.eu/newsroom/news/3142-meso-brain-and-light-sheet-imaging-techniques>).

For regional collaboration at a wider level, Korea is in discussions about the creation of an "Asia Brain Initiative," a trilateral consortium between Korea, Japan, and China. By establishing a strategic East Asian brain research consortium, Korea is hoping to expand opportunities to conduct joint research projects and collaborate with international groups to tackle current challenges in the field of neuroscience, thereby contributing to the global neuroscience commu-

nity as a whole. For the upcoming Tenth International Brain Research Organization (IBRO) World Congress of Neuroscience, to be held in Daegu, Korea, in September 2019, we hope that the East Asian regional alliance will bring together stakeholders from the global neuroscience community, discuss pertinent issues, and promote large-scale brain research projects through cooperation.

Toward the goal of promoting effective, international collaboration, we hope to play an important part in the ambitious global-level plans toward establishing a comprehensive computational neuro-platform. A Korean delegation participated in a recent coordinating conference at Rockefeller University and a meeting that accompanied the 71st session of the UN General Assembly in September 2016, where there were official discussions on

the topic of international collaboration among governments and the private sector for the launch of an International Brain Initiative, termed “The International Brain Station (TIBS)” (Reardon, 2016; Underwood, 2016). By establishing a sustainable environment to build accessible databases, create core R&D facilities, and expand national brain bank networks, Korea is committed to expanding its role to the international level, embarking on various collaborative R&D tasks among national and global neuroscientists, and making significant contributions to the database initiative (Box 1).

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