G-Science Academies Statement 2016:

Understanding, Protecting, and Developing Global Brain Resources

The human brain is civilization's most precious resource. Investment in brain science is, therefore, an investment in the future of society, and nations must cooperate to understand, protect, and foster optimal development of the brain. To cultivate global brain resources, the G-Science Academies propose four Objectives, to be pursued in parallel, where strategic support for neuroscience will benefit society. (1) Fundamental research with international collaboration; (2) Global programs for the diagnosis, prevention and treatment of brain disorders; (3) Theoretical modeling of the brain and the development of brain-based artificial intelligence (AI); and (4) Integration of neuroscience with the social and behavioral sciences to improve education and life management as components of a brain-aware society.

Understanding the brain and how its functions are expressed in behavior is a complex scientific endeavor rivaling the search for the origin of the universe. The path to treating brain disorders, developing brain-based AI, and promoting a brain-aware society cannot bypass the difficult challenge of fundamental research on brain structure and function. Basic brain science has made spectacular recent progress built upon advances in genomics and protein chemistry to identify genes and molecules, optical and transgenic tools to observe and manipulate neural circuits, and multimodal functional brain imaging to study human cognition. However, a remaining bottleneck is the lack of technologies to study the brain at a resolution sufficient to enable understanding of its complex neuronal network in animal models and humans. Such technologies, in association with computational tools, would enable a clearer view of brain functions to facilitate a deeper understanding of cognition and reveal the core mechanisms of brain disorders. To achieve this goal, systematic approaches are needed to complement and extend research in single laboratories. Large-scale brain science projects are being initiated in many countries along with other biomedical research initiatives (e.g. next-generation sequencing, precision medicine, and biobanking) to develop new technologies, perform brain network mapping and recording, and establish neuroinformatics platforms [*1*]. However, these projects require extensive international coordination of technology, personnel, and data to economize and accelerate scientific progress. A successful example of a multilateral global research organization is the Human Frontier Science Program (HFSP) founded by the initiative of Japan.

Brain disorders represent a global threat to individual well-being, economic productivity, and intellectual capital [*2*]. Owing to pervasive social stigmas and therefore a lack of data, however, the adverse impact of brain disorders is often hidden. These disorders can be classified into five groups: [A] Neurodevelopmental disorders (e.g. mental retardation, epilepsy, and autism spectrum disorders); [B] Mental illnesses in adolescence and adulthood (e.g. major depression, bipolar disorder, and schizophrenia); [C] Degenerative diseases (e.g. Alzheimer's and Parkinson's diseases); [D] Brain injuries (e.g. stroke, traumatic brain injury, brain infection, and brain tumors); and [E] Chronic conditions (e.g. stress, addiction, malnutrition, headache, and sleep disorders). Eight million deaths each year are attributable to brain disorders [*3*]. In the last 20 years, their incidence has increased 41% and accounts for 1 in 10 years of lost health [*4*]. Brain disorders account for 36% of disability-adjusted life years (DALYs) in high-income countries (HICs) and 29% in low- and middle-income countries (LMICs) [*4*]. In particular, dementia (including Alzheimer's disease) and depression are urgent public health issues with enormous economic and societal costs. In order to produce successful therapies, new economic approaches to drug development are needed, including the use of cellular and animal models with predictive validity, and trilateral cooperation of government, academia and industry. Brain illnesses overburden society: in LMICs there is insufficient access to infrastructure, resources and funding, while in HICs research and clinical stakeholders are often fragmented. Addressing this problem will require international programs and centers that tightly integrate medical research, diagnosis, treatment, rehabilitation, and caregiving to combat the global epidemic of brain disorders.

The brain is the most complex biological system in the known universe. For example, the human central nervous system can easily perform complex decision-making after minimal learning, a feat surpassing the capability of the most efficient computers. Theoretical studies are essential for understanding the computational principles of brain function and for creating quantitative mathematical models. A fundamental understanding of brain circuits and their functions in behavior will require an approach that incorporates theory, experimentation, and computation as peer methodologies. Success will depend on a multidisciplinary quantitative approach that includes mathematics, statistics, information science, and computer science, as well as biological disciplines. An important component will be the acquisition and analysis of large data sets. The principles of open data, particularly as these apply to publicly funded research, should be recognized, in order to promote the widest possible sharing and analysis of data sets. Fundamental brain theories will also be essential for the development of applications in brain-based computing, AI, and information/communication technologies (ICT). While AI originated in computer science, recent advances in deep learning have been based on brain theory [*5*] and future AI will benefit from algorithms based on further brain research, which will also be useful for the design of brain-machine interfaces and brain activity-decoding machines. However, like other rapidly advancing technologies, AI raises concerns that need to be addressed by establishing a globally coordinated investigation of its social, ethical, and philosophical implications in the context of neuroscience and society.

Human culture is a dynamic concept that is created and renewed by diverse brain functions. Therefore, the role of neuroscience in the development of future society depends not only on studying the physical, biological, and computational basis of brain functions, but also on opening major research interfaces with the empirical social sciences. Collectively, these interactions will

orient neuroscience toward a greater impact in the global society and economy. Integration of the neurobiological, behavioral and social sciences will also create paths for the use of brain-based information in human applications with everyday use. A key example of this potential interdisciplinary convergence is in the science of learning. Emerging knowledge on how the brain acquires new information from biological, cognitive, and computational approaches could greatly improve the design of evidence-based education programs for children and adults [*6*]. Such knowledge also could provide a scientific basis for regulation of those approaches along with those based on pseudo-scientific claims. Likewise, the integration of brain science and the behavioral and social sciences will enable better predictive models of human behavior that will be useful for individuals in areas as diverse as economic decision-making, risk assessment, and social interactions. Collectively, evidence-based understanding of brain functions will transform the theory and practice of life management for individuals and brain-informed policies for organizations with broad utility for developing a sustainable, innovative global society. The integration of brain, behavioral and social sciences will provide a path for the science-based development of global brain resources.

In accord, the G-Science Academies recommend four Objectives:

1. Support Fundamental Research on Brain Principles and Technologies

- Support fundamental brain research from the molecular and genomic landscape of brain cells to neural circuit development and functional mapping to brain networks and behavior.
- Prioritize the development of novel brain recording and imaging technologies for high-resolution and large-scale analyses of brain structure and function, especially for human studies.
- Facilitate the international collaboration of large-scale brain and biomedical projects in technology development, data management, researcher training/mobility, and coordinated funding.

2. Address Brain Disorders with Next-Generation Integrative Programs

- Recognize that brain disorders constitute a global health crisis and support basic and applied research on their causes, prevention, diagnosis, and therapy including rehabilitation.
- Advance new economic and scientific platforms to develop therapeutics using valid biological models including animals, and promote cooperation between academia and industry.
- Support partnerships between higher and lower-middle income countries to strengthen research and clinical capacity for the study and treatment of brain disorders, and enhance public education.

3. Promote Theoretical Neuroscience for Creating Brain-Based Applications

- Support multidisciplinary research using theoretical, computational, statistical, and data sciences and mathematics to reveal fundamental principles for developing a unified brain theory.
- Promote international cooperation for sharing neuroscience data to accelerate research and the development of brain-based artificial intelligence and neuro-technologies.
- Launch a global dialogue on neuroethics spanning scientific, policy, regulation, and governance spheres to address the safety and efficacy of brain-based technologies and applications.

4. Integrate Brain, Behavioral, and Social Sciences for Education and Life Management

- Support fundamental and translational research that integrates principles, technologies, methods, and theories of brain science with those in the empirical social sciences.
- Promote multidisciplinary research on the biological and cognitive foundations of human learning for the creation of scientific programs and tools for child and lifelong education.
- Launch research and international cooperation on the development of programs and guidelines for brain-based life-management and social function for individuals and organizations.

References:

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