PRIORITIES FOR ACCELERATING NEUROSCIENCE RESEARCH THROUGH ENHANCED COMMUNICATION, COORDINATION, AND COLLABORATION

National Science and Technology Council

Committee on Science

Interagency Working Group on Neuroscience

EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL
WASHINGTON, D.C. 20502

Dear Colleagues:

We are pleased to transmit the report "Accelerating Neuroscience Research Through Enhanced Coordination." This report, prepared by the Interagency Working Group on Neuroscience of the National Science and Technology Council's Committee on Science, addresses the need for a broad and comprehensive approach to basic and applied neuroscience research, thereby improving scientists' understanding of how animals and humans respond and adapt to changing environmental conditions. In meeting this challenge, it is critical that Federal agencies investing in neuroscience research coordinate their efforts and work collaboratively to accelerate progress.

This report presents a set of recommendations to achieve this goal in neuroscience research through enhanced interagency coordination. These recommendations span five areas of research, policy, and communication, including: the brain's information processing capabilities; brain diseases, disorders, and trauma; interactions between the environment and the brain; translating research to practice; and communications and public engagement. The recommendations presented in this report are valuable additions to the coordination and collaboration efforts of Federal agencies in neuroscience research and President Obama's BRAIN Initiative.

Sincerely,

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Cora Marrett, NSF (Co-Chair, COS) — Date: 2/21/14

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About the National Science and Technology Council

The National Science and Technology Council (NSTC) is the principal means by which the Executive Branch coordinates science and technology policy across the diverse components of the Federal research and development enterprise. A primary objective of the NSTC is establishing clear national goals for Federal science and technology investments. The NSTC prepares research and development strategies that are coordinated across Federal agencies to form investment packages aimed at accomplishing multiple national goals. The work of the NSTC is organized through five committees: Environment, Natural Resources and Sustainability; Homeland and National Security; Science, Technology, Engineering, and Math (STEM) Education; Science; and Technology. Each of these committees oversees subcommittees and working groups focused on different aspects of science and technology. More information is available at http://www.whitehouse.gov/ostp/nstc.

About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976. OSTP's responsibilities include advising the President in policy formulation and budget development on questions in which science and technology are important elements; articulating the President's science and technology policy and programs; and fostering strong partnerships among Federal, state, and local governments, and the scientific communities in industry and academia. The Director of OSTP also serves as Assistant to the President for Science and Technology and manages the NSTC. More information is available at http://www.whitehouse.gov/ostp .

About the Interagency Working Group on Neuroscience

The Interagency Working Group on Neuroscience (IWGN) serves as part of the internal deliberative process of the NSTC and is charged to "coordinate activities in neuroscience research across the Federal government with a focus on identifying significant transformative opportunities to improve health, learning, and other outcomes of national importance." Representatives from over twenty agencies and departments participate in the IWGN, demonstrating the wide-ranging interest in neuroscience across the Federal government. The IWGN serves as a forum for exchanging and leveraging information and ideas among the participating agencies.

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INTRODUCTION

Despite major advances in neuroscience, understanding the brain remains one of the most important scientific challenges of our time. Increased knowledge of the brain and nervous system will enhance the scientific community's ability to promote and protect brain health; optimize learning strategies and educational paradigms; and develop treatments for the devastating disorders that afflict every age group and segment of society. A broad and comprehensive approach to basic and applied neuroscience research will also improve scientists' understanding of how animals and humans respond and adapt to changing environmental conditions.

To meet this challenge, it is critical that Federal agencies investing in neuroscience research coordinate their efforts and, when appropriate, work collaboratively to accelerate progress. The Interagency Working Group on Neuroscience (IWGN) was established in 2012 under the National Science and Technology Council (NSTC) Committee on Science (CoS) to "coordinate activities in neuroscience research across the Federal government with a focus on the fundamental understanding of learning, brain development and plasticity, and brain health and recovery." Further, the working group is charged with enhancing Federal efforts related to: "improving our understanding of learning and cognition and applying that to improvements in education and other areas; improving our understanding of a variety of neurological conditions and injuries; and developing appropriate resources, tools, techniques, interventions, and therapies to assist in research, treatment, and recovery."

The IWGN membership comprises more than twenty Federal departments and agencies. These organizations have highly diverse missions that include funding, conducting, and using research related to health, education, public safety, security, intelligence, defense, and other areas. Many agencies are already collaborating with each other and with private entities, advocacy organizations, and international partners. Current efforts involve encouraging and supporting scientific research, sponsoring workshops to set forward-looking agendas, developing and establishing common standards and guidelines, and sharing data and information.

Through a series of monthly meetings beginning in September 2012, the IWGN examined the landscape of basic and applied Federal research activities and investments related to neuroscience. The IWGN's analyses and deliberations resulted in a set of recommendations for accelerating progress in neuroscience through enhanced interagency coordination. These recommendations span five areas of research, policy, and communication:

1. Understanding and applying the brain's information processing capabilities;
2. Understanding and treating brain diseases, disorders, and trauma;
3. Understanding and optimizing interactions between the environment and the brain across the lifespan;
4. Translating research to practice; and
5. Improving communication and engaging the public.

The IWGN helps advance the White House Neuroscience Initiative, which is designed to identify significant, transformative opportunities across agencies and between the Federal Government and the private sector to increase the positive impacts of Federal neuroscience investments on health, learning, and other outcomes of national importance. The IWGN's deliberations took place concomitantly with, and were informed by, other ongoing activities related to the White House Neuroscience Initiative, including the National Alzheimer's Project Act and the Executive Order on Improving Access to Mental Health Services for Veterans, Service Members, and Military Families. In addition, on April 2, 2013, President Obama announced The Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative, intended to accelerate the development of cutting-edge technologies that will transform our understanding of the brain and its function.[1] The major funding agencies for neuroscience research, which are represented on the IWGN, serve as the lead agencies for The BRAIN Initiative, and this report includes several recommendations related to The BRAIN Initiative's goals.

[1] White House Blog: BRAIN Initiative Challenges Researchers to Unlock Mysteries of Human Mind; White House Fact Sheet: BRAIN Initiative; White House Infographic: BRAIN Initiative; DOD Press Release on White House BRAIN Initiative; NIH: Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative; NSF Participates in White House BRAIN Initiative

1. Understanding and Applying the Brain's Information Processing Capabilities

Recent and emerging technological advances in imaging, genetics, electronics, and materials science have created the potential for a transformation in experimental capabilities for understanding brain structure and function. Complementary developments in computer science and artificial intelligence have led to significant progress in the ability of scientists and researchers to discover patterns in large and complex datasets and to model functions of the brain. These methods can be used to shed light on neural activity patterns and to reveal structures that may underlie complex behaviors. Increased understanding of brain processing will also enable the scientific community to develop the next generation of therapeutic devices (e.g., neuroprosthetics) and create novel designs for computers and robotic devices.

The BRAIN Initiative is an exciting development in this area, aiming to accelerate the development and application of new technologies that will enable researchers to generate a dynamic picture of brain function, ultimately leading to a better understanding of how animals and humans think, learn, and remember. The following section outlines key priority challenges in research and technology development that, if addressed, would increase scientific understanding and applications of the brain's information processing capabilities.

Challenges

➢ Recording and Modulating Neural Activity Underlying Complex Behaviors

Emerging technologies have created the potential to record and modulate the brain's electrical activity with increased precision and on scales that have never before been possible. As highlighted by The BRAIN Initiative, progress in research and technology development aimed at understanding and applying the brain's information processing capabilities will be accelerated through focused investments and enhanced interactions among funding agencies. Through these interactions, agencies can establish mechanisms for sharing information and coordinating with relevant research communities. Agencies can also identify and focus on key technical, strategic, and collaborative goals for enabling significant advances in this area of neuroscience.

➢ Developing New Strategies and Standards for Data Mining, Data-driven Discovery, and Computational Modeling.

Efforts to monitor brain activity comprehensively and at large scales will generate massive amounts of data and thus present significant computational challenges. Effective and rigorous methods are needed to integrate across and identify patterns within such large and complex datasets and to enable collaborating research teams to efficiently build upon each other's work. Federal agencies can play a critical role in addressing this challenge by ensuring access to relevant data, enabling the development and deployment of new methods and tools, and encouraging the sharing of data and the development

of standardized software for visualization, analysis, and data mining. NSF and NIH funding of Big Data research is an example of a current effort that can support these goals.

- **Translating Brain Processing Research Results and Methodology Development into Applications**

Investments in research to understand how the brain processes information can be leveraged to accelerate progress in critical areas of health and technology. Of particular significance is the great potential for improving neurorestorative and neuroprosthetic devices so that they can be more seamlessly integrated into the nervous system and thus more responsive to the needs of the wearer. While this is a growing industry, the performance of such devices is currently limited – in large part due to scientists' limited understanding of how to optimize these devices to communicate directly with the nervous system and brain. Fundamental advances in understanding neural information processing will catalyze the development of the next generation of diagnostic and therapeutic strategies aimed at treating brain diseases and restoring nervous system function, as well as technologies for vision, robotics, and computing. Implementing these advances will in turn stimulate the growth of the industries involved in this effort.

Recommendations

1. Coordinate interagency efforts on neuroscience with The BRAIN Initiative to ensure that a broad range of projects are supported across the spectrum of species, technologies, and methods. Funding opportunities should encourage strong interdisciplinary and transdisciplinary interactions that capture the perspectives of diverse basic and applied scientific communities.

2. Support the development and establishment of methods for systematic description and quantification of behavioral, cognitive, and disease data. This is a critical issue for data integration, requiring the confluence of deep computational, neurobiological, psychological, and clinical expertise.

3. Through workshops and other collaborative mechanisms, encourage neuroscientists, computer scientists, mathematicians, statisticians, and researchers from other disciplines to identify key opportunities for progress in the organization and analysis of large-scale datasets. It will be particularly important to develop tools that span multiple levels of analysis as well as common data formats and ontologies.

4. Develop policies that encourage researchers to use and harmonize with existing data repositories and other resources, and to adopt common data standards or develop new standards, where needed, as part of their data management plans. Agencies should also work towards the coordinated implementation of current Administration and agency policies that support the standardization, availability, and sharing of data and that safeguard the privacy of human subjects.

5. Encourage the development of new data-analysis products and services by researchers, companies, and non-profit organizations, as well as public-private partnerships that facilitate transfer of the results of brain processing research into innovative clinical and technological applications.

2. Understanding and Treating Brain Diseases, Disorders, and Trauma

Rapid advances in neuroscience research are creating new opportunities for understanding and treating brain diseases, disorders, and trauma. Increased understanding of disease mechanisms is revolutionizing the abilities of scientists and medical professionals to diagnose these diseases and develop effective treatments.

Key Challenges:

➢ Neuroscience-based Disease Classification for Improved Treatment of Brain Disorders

Brain disorders are classified primarily on the basis of their clinical features. However, current neurobiological evidence suggests that there may be shared biological mechanisms underlying clusters of psychiatric, neurological, developmental, and substance use disorders. These mechanisms involve common genetic susceptibility factors, molecular pathways, cell biological phenomena, and higher level system properties. Incorporating such mechanistic information into the classification process could potentially improve diagnosis, advance treatment development, permit intervention earlier in the disease process, and ultimately improve prognosis.

➢ Development of Biomarkers and Assessment Tools

A biological marker (biomarker) is a characteristic that is objectively measured and evaluated as an indicator of normal biological processes, pathogenic processes, or pharmacological responses to a therapeutic intervention. Because biomarkers can differentiate among distinct biological states, their availability is critical in the clinical setting for early diagnosis, patient classification, and monitoring of disease progression and treatment. However, due to patient heterogeneity and a lack of quantitative measures for disease symptoms associated with brain disorders, biomarker discovery has been difficult and must be accelerated. A successful example that can serve as a model for future projects is the Alzheimer's Disease Neuroimaging Initiative (ADNI, see http://www.adni-info.org/).

➢ Understanding and Overcoming the Blood Brain Barrier

The blood-brain barrier (BBB) is a dynamic structure that protects the brain against invading organisms and other unwanted substances. The cells that comprise the BBB utilize a number of specific mechanisms to promote and maintain stability in the central nervous system (CNS). Disruption of the BBB and other blood-CNS interfaces has been implicated in a number of neurological, neurodegenerative, developmental, and psychiatric diseases. In addition, although the BBB protects the brain from many toxins, pathogens, and the body's own immune cells, it also limits the access of many potentially beneficial therapeutics to the brain. It is critical that researchers develop better models of the BBB, more sophisticated techniques for measuring its function, and strategies that enable therapeutics to cross it. These challenges will require engaging scientists from many disciplines, including cellular and molecular neuroscience, neurophysiology, brain imaging, biomedical engineering, biophysics, nanoscience, clinical pharmacology, and medicinal chemistry.

Recommendations:

6. Establish a working group under the IWGN to recommend how current neurobiological information can be incorporated in the classification of brain disorders. This working group should also discuss how to achieve more comprehensive phenotypic characterization of individuals both within and across related brain diseases and disorders. Precise phenotyping would help to define the overlap among groups of diseases.

7. Initiate a collaborative effort among relevant agencies to harmonize common data elements across clinical research studies; integrate information across large clinical datasets that exist or are being created; and, where legally feasible, enable and encourage the sharing of de-identified clinical data with the broader research community. Such harmonization and integration will generate larger cohorts and allow for finer analyses of genotypic and phenotypic information related to multiple brain disorders. For this integration to succeed, common approaches to defining and characterizing data (e.g., ontologies, metadata) must be developed.

8. Establish a working group under the IWGN, including both agency staff and outside experts, to evaluate biomarker efforts across agencies and consolidate and refine best practice guidelines. Key outputs of this effort should include:

    - Practice guidelines that can be applied across agencies for biospecimen collection, storage, and distribution;
    - Reference biospecimen sets and quality assurance measures associated with the guidelines; and
    - Mechanisms for facilitating pooling of recruitment efforts and subjects to promote biomarker development across agencies.

9. Through focused workshops and other collaborative mechanisms, encourage research communities and relevant agencies to identify the most promising strategies for delivering therapeutics across the BBB. It will be particularly important to identify the challenges that must be addressed for these strategies to be implemented and specific diseases that could serve as test cases.

3. Understanding and Optimizing Interactions between the Environment and the Brain across the Lifespan

Recent advances in neuroscience have led to sophisticated approaches to understanding the brain and how it functions within a naturalistic context. Many factors, ranging from diet to the physical environment to complex social relationships, affect brain and cognitive function across the lifespan of an organism. Fundamental research is needed to understand the basic neural mechanisms that begin to form during embryonic development and underlie decision-making, learning, and other higher order functions, and to determine how those mechanisms affect and are affected by complex social and environmental settings.

Challenges:

➢ Understanding and Promoting Adaptation and Resilience

During all phases of the lifespan, brain development, health, and function are affected by environmental factors. These include inadequate nutrition, the microbiome, natural and human-made disasters, changing ecosystems, environmental pollutants and toxicants, dangerous working conditions, social isolation, exposure to tobacco, alcohol and other drugs, and negative life events. These stressors can lead to different adverse outcomes at different points of the lifespan.

The naturally occurring processes of adaptation and resilience-building minimize the impact of environmental stressors on neural development. Exploring the basic neurobiological underpinnings of these processes in a wide variety of organisms is critical for attaining a general understanding of the basis of plasticity. Identification of factors that underlie adaptation and resilience can enhance individual, community, and population attributes that impact all aspects of health and brain function.

Specific topics that would benefit from greater interagency coordination and collaboration include:

- Effects of Environmental Change and Disasters **--** The direct and indirect effects of major environmental changes on varying timescales from slow (e.g., climate and land-use changes, invasive species, pollution) to rapid (e.g., natural and human-made disasters, predation) on organisms are poorly understood and have wide ranging consequences at the individual, group, and population/societal levels. These effects are important not only for humans, but also for animals both wild and domestic, leading to implications for environmental management and conservation.
- Genetic and Epigenetic Mechanisms of Response to Stressors -- The mechanisms that mediate the brain's response to stress are not well understood. Studies have revealed that inherited genetic variants and the microbiome affect an individual's ability to respond to stress. They have also shown that environmental factors can affect the individual epigenetically, through changes in gene expression that are heritable. The role of epigenetic mechanisms in normal and healthy brain development and evolution has not been studied extensively, particularly in terms of long-term effects on cognitive development, learning, and social behaviors.

- Nutrition -- Foods contain essential nutrients and bioactive components, which are required for normal brain function and for the ability of the brain to mitigate the effects of biotic (excess calories, bacteria, viruses), chemical (pollutants), and social stressors. During early development, nutrition can alter neuronal signaling pathways that underlie multiple brain functions, including the satiety signaling that is central to the maintenance of healthy weight. Disruption of eating behaviors and cellular pathways can result in the development of life-long unhealthy eating patterns that lead to malnutrition/obesity and associated co-morbidities and mortalities. Similarly, nutritional and/or dietary patterns influence childhood development and learning abilities, and epigenetic changes may carry the effects of nutritional influences forward into future generations.
- Individual Differences in Self-Control and the Response to Stress -- Recent findings in diverse species are reshaping our understanding of self-control, suggesting that many of its neural substrates and functional dynamics are already present at a very young age. In humans, underdeveloped self-control mechanisms are related to a range of risky decisions and behaviors, such as gambling, addiction, and negative academic outcomes. Understanding the behavioral components of self-control (e.g., smart decision-making, accurate risk assessment, coping with social pressures), together with identifying the neural correlates of self-control, will lead to improved strategies to optimize the success of children and other at-risk populations.
- All of the above influences on stress and resilience are in turn shaped by the microbiome. Emerging evidence indicates that the gut microbiome influences depression, mediates stress, and responds to human behavior and emotion. The effect of stress on the microbiome is transgenerational in mice. Stressors can change the mother's microbiome resulting in exposure of the offspring to an altered inoculum during birth.

➢ Understanding and Optimizing Learning

Although there is significant interest in the neuroscience of learning and pedagogy, evidence-based applications are still lacking in this domain. Given the importance of learning to an organism's fitness – and, in particular, the importance of education to success in human society – building an in-depth understanding of the neural correlates of learning processes is imperative. Great progress has been made in determining the major operations that underlie various aspects of learning and identifying where in the brain these operations are carried out in animals and humans. However, the relationship between an individual's learning performance and the underlying specific brain processes remains insufficiently understood, especially with regard to informing effective learning and teaching strategies.

Greater cooperation among Federal agencies is needed to enhance studies of the cognitive processes and the underlying neural mechanisms associated with learning and performance, particularly in the area of brain-environment interactions. Research examining these processes and mechanisms should utilize multiple methods and levels of query, including behavioral studies, neuroimaging, comparative analyses across species and other experimental and analytic approaches to explore the many social and biological influences on specific learning behaviors. Interagency collaboration would also enhance the

linkage between research and practice. It would allow us to identify research gaps and apply current knowledge in neuroscience and cognitive science to improve education outcomes. These outcomes would include innovations in instructional strategies and curricula, as well as evidence-based training protocols and practices.

Recommendations:

10. Develop mechanisms to strengthen interagency collaboration, coordination, and support of the diverse scientific community studying the brain and behavioral responses, resilience, and adaption to a broadly defined range of environmental inputs and change factors. Short- and medium-term goals would include identifying research priorities, defining areas where cross-agency initiatives would have high impact, and developing Federal, public and private partnerships, communications strategies, and funding strategies to respond to those priorities and support those initiatives. Key research areas where more collaboration and exchange would be particularly beneficial include:
    - Elucidating the basic molecular, physiological, and psychological mechanisms through which diet, both adequate and inadequate nutrition (under and over) affect brain development function, behavior, and dietary selection;
    - Determining the short- and long-term effects on brain function and behavior of exposure to toxic agents and of major environmental change including disasters;
    - Identifying the factors that distinguish between individuals who adapt to and recover from environmental challenges effectively and those who do not; and
    - Elucidating the mechanisms through which paternal and maternal behavior, positive and negative life experiences, and environment factors affect offspring characteristics, including cognitive development, social behavior, and physical and mental health.
11. Develop an interagency research agenda on self-control and response to stress that focuses on:
    - Exploring behavioral components of self-control and developing standardized animal models of delayed gratification to inform effective interventions; and
    - Formulating strategies for determining the genetic/epigenetic/microbial and neurobiological basis of response to stress and the relationship of this to poor self-control.
12. Through interagency workshops and potentially joint funding announcements, focus and coordinate Federal efforts to:
    - Understand the neuroscientific basis of learning and skill acquisition;
    - Strengthen research methodology for studying the complex interactions among the environment, cognitive processes, and learning outcomes;

- Study brain and cognitive changes across the lifespan and determine how they influence learning and are, in turn, influenced by learning;
- Encourage interdisciplinary, multi-method, and multi-scale research approaches to optimize learning outcomes; and
- Explore new learning technologies and how these interact with the brain to influence outcomes.

4. Translating Research to Practice

Challenges:

➢ Facilitating Clinical Translation of Basic Neuroscience Research

Many Federal agencies involved in neuroscience research have a vested interest in the clinical translation of advances resulting from basic research. The overall pathway, beginning with discovery and continuing through preclinical and clinical testing, is complex. It involves the expenditure of considerable resources to sustain therapy development efforts over protracted periods of time. Developing new tools and approaches to assess the safety, efficacy, quality, and performance of products intended for consumer or other uses could prove valuable with respect to the efficiency of the clinical translation process. Regulatory oversight provided by the FDA is a critical element in the product development and approval process. Agencies involved in clinical translation of research activities will mutually benefit from an exchange of experiences facilitated by interagency dialogue and opportunities for interagency resource sharing.

➢ Facilitating Translation of Neuroscience and Cognitive Science Research into Educational Settings

The translation of research discoveries in neuroscience and cognitive science into strategies for enhancing learning and teaching needs to be improved. Of particular interest are the identification and dissemination of specific findings that are ready for testing in classroom contexts. Enhanced partnerships among Federal agencies and with other state, local, and private organizations would accelerate the identification of promising research findings to implement and development of methods and metrics for assessment.

Recommendations:

13. Establish a working group to bring together Federal agencies interested in promoting the application of neuroscience research in applied settings (e.g., clinical, educational) and its potential commercialization. This group should include basic and clinical researchers, as well as regulatory officials. It would formulate best practices that ensure an efficient therapy development pipeline.
14. In conjunction with this working group, develop a publicly accessible Federal clearinghouse of resources and information for facilitating translation, with the goals of accelerating the translational process, ensuring timely and cost-effective translation of products moving through the regulatory review process, and minimizing redundancy.

5. Improving Communication and Engaging the Public

Challenges:

➢ Improving Communication and Information Sharing Among Agencies

It is imperative that Federal agencies share information related to their neuroscience resources and programs. Optimizing sharing among agencies will leverage existing activities and prevent duplication of research efforts. It has become clear that developing new research collaborations is difficult or impossible without a baseline awareness of existing programs and interests. It is also difficult for any single agency to have the deep diversity of expertise needed to span basic, translational, and clinical neuroscience. Enhanced communication would enable more efficient application of cutting-edge neuroscientific findings to clinical interventions, as well as educational and training curricula. Enhanced sharing of knowledge and skills would enable each agency to attain its goals more effectively and efficiently and accelerate progress in neuroscience research.

➢ Improving Communication with the Public and All External Stakeholders

The public has a vested interest in progress to understand the devastating neurological, psychiatric, and substance use disorders that affect many Americans. It is important that Federal agencies act in a coordinated fashion to inform and educate the public about the neuroscientific research that they conduct and support.

➢ Exploring Potential Areas for International Engagement

The IWGN has worked to identify concrete opportunities to leverage and accelerate the impact of Federal investments in neuroscience to improve health, learning, and other outcomes of national importance. Some of these opportunities have also been recognized by our international partners. For example, the European Commission identified the Human Brain Project as a flagship project, and leveraging mutual interests would have significant effects on advancing the frontiers of neuroscience. While the present report is focused on national priorities in neuroscience, the recommendations developed here will be explored by the IWGN going forward within the context of furthering opportunities to engage with international partners.

➢ Neuroethics

The IWGN is a part of the White House Neuroscience Initiative, which includes the area of neuroethics. The President's Commission for the Study of Bioethical Issues is engaged in these efforts and will advise the President on bioethical issues that emerge from advances in neuroscience in general and The BRAIN Initiative in particular. The President has directed this group to explore the "ethical, legal, and societal implications raised" by recent advances in neuroscience as a part of The BRAIN Initiative in keeping with broader policies and practices that ensure scientific research, health care delivery, and technological innovation are conducted in an ethically responsible manner.

Recommendations:

The IWGN should continue to serve as a forum that brings program officials and senior staff from diverse agencies together to share their priorities in neuroscience and encourage coordination and innovation in related funding areas. Priority activities in the near term would include:

15. Establishing a Federal neuroscience research portal (e.g., through Research.gov) that provides single-point access to agency and cross-agency programs, awards databases, and program officials and other experts across the Federal government. Features of such a portal could include:
    - A customizable notification system that alerts interested users when an agency is planning a new research initiative;
    - Lists of agency contacts for specific areas of neuroscience; and,
    - Links to searchable publication databases.
16. Developing strategies to enhance communication with the public about neuroscience research and brain diseases. This effort would include:
    - Developing communications about major investments in basic neuroscience research and resulting breakthroughs and important outcomes across Federally-funded activities.
    - Sharing relevant communication materials among IWGN agencies.
    - Working to improve the coordination, frequency, and content of neuroscience-research-related communications across the Federal sphere and with members of the public, press, academia, and other groups.
    - Employing social networking and online collaboration platforms to facilitate topical discussions within relevant communities and to enable broader participation in research and development projects.
17. Ensure that Administration priorities across the neuroscience spectrum, including those in areas such as neuroethics and military and veterans' health are included in the planning of individual Federal agencies.

RECOMMENDED SHORT-TERM STEPS

Of the recommendations proposed in this report, below the authors highlight a subset for which implementation can begin relatively quickly:

- Strengthening the Federal neuroscience framework, including projects initiated through The BRAIN Initiative. This includes sponsoring workshops that bring together neuroscientists, computer scientists, mathematicians, statisticians, and other researchers who analyze large datasets to: (a) encourage the development of data resources and experimental and computational tools that span multiple levels of analysis and facilitate modeling and analysis

across levels, (b) develop common data formats and ontologies, and (c) identify key opportunities and challenges associated with analysis of large datasets. (Recommendation 3)

- Initiating a federally led effort to build translational bridges between neuroscience, cognitive science, and learning across the lifespan. Conducting an interagency workshop bringing together federal experts and outside scientists and practitioners to discuss how current research discoveries in neuroscience and cognitive science can be used to inform the development of more effective educational and training paradigms, interventions, and supportive technologies that enhance learning across the lifespan. Workshop participants will identify effective translation strategies to scale from laboratory interventions to effective classroom practices and ways in which translational work may feed back into new lines of basic neuroscience and cognitive science research. (Part of Recommendation 12)
- Establishing a working group to recommend how current neurobiological information can be incorporated in the classification of brain disorders. This working group should also discuss how to achieve more comprehensive clinical phenotypic characterization of individuals both within and across related brain diseases and disorders to help identify shared co-morbidities and overlapping mechanisms. Ultimately this knowledge will advance treatment development, permit intervention earlier in the disease process, and potentially improve prognosis. (Recommendations 6 and 13)
- Supporting sustained efforts across Federal agencies to improve coordination and collaboration of research and development agendas in neuroscience, with an emphasis on identifying significant transformative opportunities to improve health, education, and other outcomes of national importance. These efforts might include the establishment of a research portal that provides single-point access for those in the Federal government to information about ongoing agency programs in neuroscience and expert staff contacts for these programs. One function of this portal would be to alert agencies to neuroscience research initiatives under development by other agencies to facilitate partnerships and to minimize potentially redundant efforts. (Recommendation 15)
- Establish a working group to focus on the impact of over- and under-nutrition on brain development, including identifying research needs relevant to the 0-24 age group project and pre-birth project. This should include the role of epigenetics on brain function.

These short-term activities would help to establish greater information sharing and cooperation among agencies and accelerate progress across multiple areas of neuroscience research.

CONCLUSIONS

The opportunity to understand better the inner workings of the human brain has never been greater. Such advances in understanding will ultimately be accompanied by breakthroughs that help the science, research, and innovation communities meet national priorities such as improved treatments for brain injuries and disorders, improved education strategies and learning outcomes, and the promotion of healthy brain development and function. To help our country address these priorities, this report presents a series of recommendations for accelerating progress across a broad spectrum of federally funded neuroscience research activities. Implementation of the recommended activities will also contribute to enhancing the level and quality of communication and collaboration among Federal agencies, and thus positively affect all federally funded research in neuroscience and beyond.

The strategies and activities recommended in this report range from those that can be easily achieved in the short-term without additional funding to those that would require significant investments of time, effort, and additional funds across multiple agencies. This report, however, makes no funding recommendations. Support for such activities is contingent on the availability of appropriations and/or reallocation of existing resources. Each IWGN member agency will determine how and when to engage in these proposed interagency activities according to its own mission and resources.

The recommended activities presented herein encompass a broad spectrum of neuroscience research, yet they are united by several common themes. First and foremost, enhanced communication among agencies will be critical to identifying shared interests and goals and resources that can be leveraged. Second, it will be important, through workshops and other forums, to bring together investigators from multiple scientific communities to determine research priorities to effectively move the frontiers of neuroscience in the future. Finally, when planning new research initiatives, the IWGN recommends that Federal agencies coordinate their efforts and promote potential collaborations where appropriate.

National Science and Technology Council

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