Written Statement
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Subcommittee on Commerce, Justice, Science, and Related Agencies
Appropriations Committee, United States Senate
In support of the FY2014 Appropriations for the National Science Foundation
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Mr. Chairman and Members of the Subcommittee, my name is Larry Swanson, Ph.D. I am the Milo Don and Lucille Appleman Professor of Biological Sciences at University of Southern California. Over the past 30 years, my work has focused on the structure and organization of neural structures involved in motivated and emotional behaviors, as well as the development of a wiring diagram of the nervous system more generally. This statement is in support of increased funding for the National Science Foundation (NSF) for fiscal year 2014.

On behalf of the nearly 42,000 members of the Society for Neuroscience (SfN), thank you for your past support of neuroscience research at NSF. SfN's mission is to advance the understanding of the brain and the nervous system; provide professional development activities, information and educational resources; promote public information and general education; and inform legislators and other policymakers.

This is an exciting time to be a neuroscientist. Advances in understanding brain development, imaging, genomics, circuit function, computational neuroscience, neural engineering, and many other disciplines are leading to discoveries that were impossible even a few years ago. Many of these discoveries are being made by neuroscientists who can trace their first grant back to NSF on their way to becoming independently funded investigators.

SfN is appreciative that President Obama recognizes brain science as one of the great scientific challenges of our time. The recently announced Brain Research through Application of Innovative Neurotechnologies (BRAIN) Initiative will enable NSF and other federal agencies to develop initial tools and conduct further planning that will help accelerate fundamental discoveries and improve the health and quality of life for millions of Americans.

The field of neuroscience is poised to make revolutionary advances thanks to decades of global investment and path-breaking research. However, realizing this potential means today's critical seed funds must be backed by sustained, robust investment in the scientific enterprise, and SfN is encouraged by the President's request for an increase to the budget of NSF.

Resources provided to NSF support the nation's best and brightest researchers at the forefront of promising discoveries, graduate students at the start of their careers, and the development of scientific tools and infrastructure that will be available to researchers. These researchers are the ones who will be answering some of the vexing questions facing the field of neuroscience: what are the genetic, cellular, and molecular mechanisms responsible for brain development? How do biology and our external environment and stimuli intersect to affect the way our brains function? How will new tools such as brain-machine interfaces, computational models, and advanced imaging techniques enhance the effectiveness of the field, deepen scientific capacity for inquiry, and contribute to better health and quality of life in the years ahead?

Now is the time to take advantage of scientific momentum, to pave the way for improved human health, to advance scientific discovery and innovation, and to promote America's near-term and

long-range economic strength. These goals require robust investments in NSF that reverse the tide of stagnant and shrinking funding. Virtually every directorate at NSF supports neuroscience research. NSF continues to search for new ways to encourage and incentivize creativity and integration across disciplines when it comes to neuroscience. This is evident in the recent NSF "Dear Colleague Letter" aimed at "Accelerating Integrative Research in Neuroscience and Cognitive Science." SfN is very grateful for NSF's continued recognition of and support for cross-disciplinary approaches, and we believe neuroscience is an exceptional example of ways the life and physical sciences intersect and complement one another.

Seizing this moment can only happen if labs are able to pursue promising leads and innovative ideas can move forward. A constricted fiscal environment—compounded by sequestration—could stand in the way of that progress. It's impossible to say what breakthroughs will go undiscovered, but there is no doubt that this fiscal environment will result in delayed discoveries, with potentially huge opportunity costs for human health and the creation of new technologies based on models of neural network computation.

Fiscal Year 2014 Budget Request

SfN supports President Obama's request of $7.626 billion for NSF, an 8.4% increase over FY 2012. Let's work to put research on a trajectory of sustained growth that recognizes the promise and opportunity for improving the lives of Americans and as a tool for economic growth.

Sustained growth in funding will enable the field to serve the long-term needs of the nation by continuing to advance science, improve lives, and promote America's near-term and long-range economic strength by investing in the proven economic engine of discovery. Continued investment in basic research at NSF is essential to laying the groundwork for discoveries that will inspire scientific pursuit and technological innovation for future generations.

As noted above, NSF is a primary catalyst for understanding the connection between life sciences and physical sciences. Whereas the National Institutes of Health (NIH) may focus on basic research with an orientation toward a disease or health-related focus, NSF-supported neuroscience research is more likely to focus on specific functions of the brain, not necessarily tied to a specific disease or disorder. What's more, the "physical sciences" work supported by NSF has enabled the development of new technologies that have revolutionized neuroscience research in recent years.

Aggressive investment in technology and scientific research is crucial to ensure America sustains its global leadership and competitiveness. Science is now a truly global enterprise that has the potential to revolutionize human knowledge, health, and wellness—the question is whether the U.S. will maintain its role leading the next generation of scientific advances.

As the committee works to set funding levels for critical research initiatives for fiscal year 2014 and beyond, we ask you to help establish a national commitment to advance the understanding of the brain and the nervous system—an effort that will transform the lives of millions of people living with diseases and disorders of the nervous system and perhaps inspire the next generation of computing devices. Help us to fulfill our commitment to overcoming the most difficult obstacles impeding progress and to identifying critical new directions in basic neuroscience.

Neuroscience and NSF

SfN supports an increase in the budget of NSF because NSF-funded research is at the forefront of improving our understanding of neuroregeneration and rehabilitation, neuroimaging, and

brain-computer interface to name but a few.

The power of fundamental science unlocks the mysteries of the human body by exploring the structure and function of molecules, genes, cells, systems, and complex behaviors. Every day, neuroscientists advance scientific knowledge and medical innovation by expanding our knowledge of the human brain. Basic (also known as fundamental) research funded by the NSF continues to be essential for discoveries that will inspire scientific pursuit and medical progress for generations to come. Due to federally-funded research, scientists and health care providers have a much better understanding of how the brain functions.

NSF-supported work is essential for the future of neuroscience. For example, the "brainbow" uses complex genetic engineering to label neighboring neurons in different colors, making them easier to differentiate and trace their connections. Such advances have only been possible within the last decade. But being able to trace these connections also highlights an increasingly common and complex problem—how to handle vast amounts of data that are collected. To store the images necessary to form a picture of 1 cubic millimeter of a mouse brain—about the size of the eye of a needle—would require the equivalent of 212,000 DVDs. NSF is leading the way in such computational research.

We cannot rely on private industry to fund these ideas. Given the long-term path of basic science and industry's need for shorter-term return on investment, private industry depends on federally-funded research to create a strong foundation for applied research. As noted in a report issued by NSF in November 2012, research and development through universities, much of it driven by NSF, totaled more than $65 billion in fiscal year 2011. The life sciences were a primary driver of that growth. This demonstrates how investment in basic research acts as a "force multiplier," and why increasing investment in research—from the most basic to the translational—is so essential.

The following are just two of the many basic research success stories in neuroscience emerging now thanks to strong historic investment in NSF and other research agencies:

The "Connectome"

Current knowledge about the intricate patterns connecting brain cells (the "connectome") is extremely limited. Yet identifying these patterns and understanding the fundamental wiring diagram or architectural principles of brain circuitry is essential to understanding how the brain functions when healthy and how it fails to function when injured or diseased. Recent research suggests that some brain disorders, like autism and schizophrenia, may result from errors in the development of neural circuits. This research suggests a new category of brain disorders called "disconnection" syndromes.

While connectome research is primarily supported by NIH, key tools developed through NSF-sponsored research are essential to the project's success. The development of advanced technologies, along with faster and more data-efficient computers, now make it possible to trace the connections between individual neurons in animal models providing us with greater insight into brain dysfunction in mental health disorders and neurological disease. Scientists have already used these technologies to examine disease-related circuitry in rodent models of Parkinson's disease. Their findings helped explain how a new treatment called deep brain stimulation works in people, and are being explored for treatments of other diseases.

Brain-Machine Interface

NSF supported research on human-centered computing (HCC) has played a critical role in efforts to restore motor control to the almost 2% of the US population affected by some sort of

paralysis, be it a result of stroke, spinal cord or brain injury or other causes. Paralysis occurs when the link between the brain and a part of the body is severed, eliminating the control of movement and the perception of feeling in that area. Previous research has focused on understanding the mechanisms by which the brain controls a movement. Research during which scientists were able to record the electrical communication of almost 50 nerve cells at once showed that multiple brain cells work together to direct complex behaviors. However, in order to use this information to restore motor function, scientists needed a way to translate the signals that neurons give into a language that an artificial device could understand and convert to movement.

Basic science research in mice lead to the discovery that thinking of a motion activated nerve cells in the same way that actually making the movement would. Further studies showed that a monkey could learn to control the activity of a neuron, indicating that people could learn to control brain signals necessary for the operation of robotic devices. Thanks to these successes, brain-controlled prosthetics are being tested for human use. Surgical implants in the brain can guide a machine to perform various motor tasks such as picking up food to eat. These advances, while small, are a huge improvement for people suffering from paralysis. Scientists hope to eventually broaden the abilities of such devices to include thought-controlled speech and more. Further research supported by NSF is working on developing non-invasive interfaces for human-machine communication as well as providing tactile feedback. Understanding how neurons control movement has had and will continue to have profound implications for victims of paralysis.

A common theme of both these examples of basic research success stories is that they required the efforts of basic science researchers discovering new knowledge, of physician scientists capable adapting those discoveries into better treatments for their patients, and of companies willing to build on all of this knowledge to develop new medications and devices.

The Future of American Science

As the subcommittee considers this year's funding levels, please consider that significant advancements in the biomedical sciences often come from young investigators. The current funding environment is taking a toll on the energy and resilience of these young people. America's scientific enterprise—and its global leadership—has been built over generations. NSF alone has awarded over 46,500 Graduate Research Fellowships since 1952. Many young scientists receive their first grants from NSF on their way to having careers as independently funded investigators. Without sustained investment, we will quickly lose that leadership. The culture of entrepreneurship and curiosity–driven research could be hindered for decades.

We live at a time of extraordinary opportunity in neuroscience. A myriad of questions once impossible to consider are now within reach because of new technologies, an ever-expanding knowledge base, and a willingness to embrace many disciplines.

To take advantage of the opportunities in neuroscience we need an NSF appropriation that allows for sustained, reliable growth. We have entered an era where knowledge of nerve cell and circuit function has brought us to the threshold of a more profound understanding of behavior and of the mysteries of the human mind. This understanding, in turn, will have profound benefits for the American public and will help maintain American leadership in science worldwide. Thank you for this opportunity to testify.