Written Statement
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Subcommittee on Commerce, Justice, Science, and Related Agencies Appropriations
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Introduction

Mr. Chairman and Members of the Subcommittee, my name is Susan Amara, PhD. I am the Thomas Detre Professor of Neuroscience and Chair of the Department of Neurobiology as well as Co-Director of the Center for Neuroscience at the University of Pittsburgh and President of the Society for Neuroscience (SfN). My major research efforts have been focused on the structure, physiology, and pharmacology of a group of proteins in the brain that are the primary targets for addictive drugs including cocaine and amphetamines, for the class of therapeutic antidepressants, known as reuptake inhibitors, and for methylphenidate, which is used to treat attention deficit hyperactivity disorders.

On behalf of the more than 41,000 members of SfN and myself, I would like to thank you for your past support of neuroscience research at the National Science Foundation (NSF). Over the past century, researchers have made tremendous progress in understanding cell biology, physiology, and chemistry of the brain. Research funded by NSF has made it possible to make advances in brain development, imaging, genomics, circuit function, computational neuroscience, neural engineering and other disciplines. In this testimony, I will highlight how these advances have benefited taxpayers and why we should continue to strengthen this investment, even as the nation makes difficult budget choices.

Fiscal Year 2012 Budget Request

SfN supports the President's request of $7.7 billion for NSF in FY 2012, a 13 percent increase over FY 2010. This level of funding will enable the field to serve the long-term needs of the nation by continuing to advance science, improve health, 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. Also, as reflected in the America COMPETES Act, 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 America will maintain its role leading the next generation of scientific advances.

Resources provided to NSF will go to support the nation's best and brightest researchers at the forefront of promising discoveries, to deserving graduate students at the start of their careers, and to developing advanced scientific tools and infrastructure that will be broadly available to the research community.

What is the Society for Neuroscience

SfN is a nonprofit membership organization of basic scientists and physicians who study the brain and nervous system. Its mission is to:

Advance the understanding of the brain and the nervous system by bringing together scientists of diverse backgrounds, by facilitating the integration of research directed at all levels of biological organization, and by encouraging translational research and the application of new scientific knowledge to develop improved disease treatments and cures.

Provide professional development activities, information and educational resources for neuroscientists at all stages of their careers, including undergraduates, graduates, and postdoctoral fellows, and increase participation of scientists from a diversity of cultural and ethnic backgrounds.

Promote public information and general education about the nature of scientific discovery and the results and implications of the latest neuroscience research. Support active and continuing discussions on ethical issues relating to the conduct and outcomes of neuroscience research.
Inform legislators and other policymakers about new scientific knowledge and recent developments in neuroscience research and their implications for public policy, societal benefit, and continued scientific progress.

<u>Neuroscience and NSF</u>
Neuroscience is the study of the nervous system. It advances the understanding of human thought, emotion, and behavior. Neuroscientists use tools ranging from computers to special dyes to examine molecules, nerve cells, networks, brain system, and behavior. From these studies, we learn how the nervous system develops and functions normally and what goes wrong in neurological and psychiatric disorders.

SfN supports the president's proposed increase for NSF because NSF research is indispensible to studying how the brain functions, how it controls behavior and health, and how to develop new tools to treat many debilitating diseases and disorders. The field of neuroscience is deeply interdisciplinary and interdisciplinary collaboration is the hallmark of NSF research. For example, NSF-funded biologists and neuroscientists are discovering fundamental mechanisms important to understanding how humans and other animals behave, develop, communicate, learn, and process information. Understanding the neuroscience of animal diversity is necessary as we confront environmental and agricultural changes in the future. Also, NSF-funded physicists, mathematicians, computer scientists, and engineers have conducted ground-breaking work that enables the analysis of EEG data, the development of advanced brain prosthetic devices, and other technologies that will assist in the rapid diagnosis and treatment of epilepsy and stroke. NSF-funded statisticians are developing new methods for analysis of the large amounts of genome data, on humans and other organisms, and developing better statistical tools for looking at the effects of the environment on human and animal populations. NSF-funded chemists have developed new methods that allow for the extremely accurate measurement of very small amounts of brain hormones.

As the committee works to set funding levels for critical research initiatives for FY 2012 and beyond we need to do more than establish a budget that is "workable" in the context of the current fiscal situation. We ask you to help establish a national commitment to advance the understanding of the brain and the nervous system – an effort that has the potential to transform the lives of thousands of people living with brain-based diseases and disorders. Help us to fulfill our commitment to overcoming the most difficult obstacles impeding progress, and to identifying critical new directions in basic neuroscience.

<u>Brain Research and Discoveries</u>
The power of basic 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 are advancing scientific knowledge and medical innovation by expanding our knowledge of the basic makeup of the human brain. In doing so, researchers exploit these findings and indentify new applications that foster scientific discovery which can lead to new and ground-breaking medical treatments.

Basic research funded by the NSF continues to be essential to ensuring discoveries that will inspire scientific and medical progress for future generations. We know from past experience that it is not always clear where the next critical breakthrough or innovative approach will come from—progress in science depends on imaginative curiosity-driven research that makes leaps in ways no one could have anticipated, and it is often identified through basic research funded at NSF. Where would neuroscience and cell biology be without a rainbow of fluorescent proteins from jellyfish? The original discovery of green florescent protein earned three researchers the Nobel Prize for Chemistry in 2008 and their work is now illuminating pathways of study for neurological diseases and disorders. Where would cutting edge work in systems neuroscience be today without research on channel rhodopsins from algae? This discovery has blossomed into the burgeoning field of optogenetics and now holds promise for novel, noninvasive treatments for brain disorders. More than ever is it important to support and fund research at many levels from the most basic to translational, from the biological to the physical, in pursuit of human understanding and scientific advances.

Indeed, many of the new findings in neuroscience can be traced back to fundamental work in diverse research fields that has contributed to new technologies of all kinds. This allows us to carry out new kinds of experiments not imaginable even 5-10 years ago. These discoveries have great potential to improve the lives of Americans and almost certainly would not have been made without the strong commitment to interdisciplinary research at NSF. The following are a few additional basic research success stories in neuroscience research:

Nicotine Addiction

Although tobacco has been used legally for hundreds of years, nicotine addiction takes effect through pathways similar to those involving cocaine and heroin. During addiction, drugs activate brain areas that are typically involved in the motivation for other pleasurable rewards such as eating or drinking. These addictions leave the body with a strong chemical dependence that is very hard to get over. In fact, almost 80% of smokers who try to quit fail within their first year. The lack of a reliable cessation technique has profound consequences. Tobacco-related illnesses kill as many as 440,000 Americans every year, and thus the human and economic costs of nicotine addiction are staggering. One out of every five US deaths is related to smoking.

Past federal funding has enabled scientists to understand the mechanisms of nicotine addiction, enabling them develop successful treatments for smoking cessation. The discoveries that lead to these findings started back in the 1970's, when scientists identified the substance in the brain that nicotine acted on to transmit its pleasurable effects. They found that nicotine was hijacking a receptor, a protein used by the brain to transmit information. This receptor, called the nicotinic acetylcholine receptor, regulates the release of another key transmitter, dopamine, which in turn acts within reward circuits of the brain to mediate both the positive sensations and eventual addiction triggered by nicotine consumption. This knowledge has been the basis for the development of several therapeutic strategies for smoking cessation: nicotine replacement, drugs that target nicotine receptors, as well as drugs that prevent the reuptake of dopamine have all been shown to increase the long-term odds of quitting by several fold.

More recently, using mice genetically modified to have their nicotinic acetylcholine receptors contain one specific type of subunit, scientists determined that some kinds of receptor subunits are more sensitive to nicotine than others, and because each subunit is generated from its own gene, this discovery indicated that genetics can influence how vulnerable a person is to nicotine addiction. Further research to spot genetic risk factors and to generate genetically-tailored treatment options is on-going. Other studies are also testing whether a vaccine that blocks nicotine's effects can help discourage the habit. Since people who are able to quit smoking immediately lower their risk for certain cancers, heart disease and stroke, reliable and successful treatments are clearly needed. Today's continued research funding can make it possible for these emerging therapies to ultimately help people overcome the challenges of nicotine addiction.

Brain-machine interface

The brain is in constant communication with the body in order to perform every minute motion from scratching an itch to walking. Paralysis occurs when the link between the brain and a part of the body is severed, and eliminates the control of movement and the perception of feeling in that area. Almost 2% of the US population is affected by some sort of paralysis resulting from stroke, spinal cord or brain injury as well as many other causes. 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 a glass of water. These advances, while small, are a huge improvement for people suffering from paralysis. Scientists hope to eventually broaden the abilities of such devises to include thought-controlled speech and more. Further research is also needed to develop non-invasive interfaces for human-machine communication, which would reduce the risk of infection and tissue damage. 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 Next Generation of Science – and Scientists

Finally, another key aspect of NSF is its support for science education and training. SfN recognizes the leadership role that NSF plays in driving innovation in science education. Investment in pre-college and collegiate science-technology-engineering-math instruction is vital to providing a strong pipeline of knowledgeable and motivated young people who will make future discoveries. Additionally, I must emphasize that NSF is a leading force in the development of the next generation of scientists through its support of training. Through NSF grants and cooperative agreements with colleges, universities, K-12 school systems, and other research organizations throughout the United States, neuroscientists can continue to conduct the basic research that advances scientific knowledge and leads to tomorrow's treatments and cures, while mentoring and training students of all levels.

As the subcommittee considers this year's funding levels and in future years, I hope that the members will consider that significant advancements in the biomedical sciences often come from younger investigators who bring new insights and approaches to bear on old or intractable problems. Without sustained investment, I fear that flat or falling funding will begin to take a toll on the imagination, energy and resilience of younger investigators and I wonder about the impact of these events on the next generation. America's scientific enterprise – and its global leadership – has been built over generations, but without sustained investment, we could lose that leadership quickly, and it will be difficult to rebuild.

Conclusion

The field of neuroscience research holds tremendous potential for making great progress to understand basic biological principles and for addressing the numerous neurological and psychiatric illnesses that strike more than 100 million Americans annually. While we have made great strides toward understanding molecules, cells and brain circuitry, scientists continue to unearth how these circuits come together in systems to do things like record memories, illuminate sight and produce language. We have entered an era in which knowledge of nerve cell function has brought us to the threshold of a more profound understanding of behavior and of the mysteries of the human body and mind. However, this can only be accomplished by a consistent and reliable funding source.

An NSF appropriation of $7.7 billion for fiscal year 2012 is required to take the research to the next level in order to improve the health of Americans and to sustain America's global leadership in science. Thank you for this opportunity to testify.