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Chemistry and the BRAIN Initiative

On the evening of April 1, 2013, a group of scientists from diverse fields convened to celebrate the impending launch of a full-fledged national program motivated by a project they had initially conceived and proposed.[1,2] The following day, they would witness the kick-off by U.S. President Barack Obama of a nationwide multi-year project aimed at discovering how the collective actions of neurons produce brain function. Months of workshops involving individuals across disciplines had been convened to shape the ideas driving this initiative. Its essence would be the development of new tools and technologies to enable recording the activities of hundreds, then thousands of neurons (or more). The goals would be to understand how information arises from the emergent properties of neural circuits. That the initiative had captured the attention of the White House was cause for celebration.

The Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative embraces the concept that deciphering brain function will depend on new means of interrogating large numbers of neurons and making sense of the resulting data. Along with initiatives around the world, including the Human Connectome Project and the European Union Flagship Human Brain Project, the hope is to understand both how brains work and how they malfunction in disease states. In terms of cost, President Obama requested $100 million for the first year to be administered by the National Institutes of Health (NIH), the Defense Advanced Research Projects Agency (DARPA), and the National Science Foundation (NSF). To put this in context, the NIH alone spends greater than $5 billion/yr on neuroscience research at present.[3] Thus, substantial additional and sustained funding will be needed to enable the BRAIN Initiative to meet its goals.

Undoubtedly, the contributions of chemists have been and will continue to be central to these efforts.[4] As illustration and inspiration, we have assembled an American Chemical Society Virtual Issue highlighting advances of relevance to the BRAIN Initiative. The issue includes Articles, Letters, Reviews, Perspectives, and Editorials recently published in *ACS Chemical Neuroscience*, *ACS Nano*, *Analytical Chemistry*, and the *Journal of the American Chemical Society*.

At its essence, neuronal function is chemical in nature. Signaling along nerve cells depends on ion fluxes. Interneuronal communication relies on extracellular neurotransmitter fluxes. Articles in this issue and efforts globally illustrate how the chemistry community is investigating the properties of neurons in new and powerful ways. Information inherent in neuronal firing is being uncovered using dendrimer-based nanoprobes, ruthenium diimine nanoswitches, and semiconductor nanocrystals. These and other articles herein exemplify the nanoscale nature of neuronal architectures.[2] Optical imaging of neurotransmitter signaling is being enabled by sensors for GABA, glutamate, and dopamine. New sensors for imaging Ca^{2+} and exocytosis have also been developed. *In vivo* micro- and, increasingly, nanoscale neurotransmitter sensors will be used to decode information inherent in chemical signaling. The limits of mass spectrometry are being pushed to investigate large populations of neurons, as well as single cells, to produce information on highly heterogeneous and complex protein expression signatures in the brain. Many of these approaches take into account the massively parallel nature of neural circuits and work toward extracting information from these networks.

Investigating brains has been likened to entering a "final frontier". Much like the early days of space exploration, the BRAIN Initiative will rely heavily on revolutionary improvements in existing methods and, more so, on the development of new and transformative ways of investigating brain function. Unlike the recent Human Genome Project, the BRAIN Initiative will be less constrained by concrete milestones and largely characterized by technology development and exploration—ultimately reaching the unimagined shores and landscapes of the mind.

The editors and staffs of *ACS Chemical Neuroscience*, *ACS Nano*, *Analytical Chemistry*, and the *Journal of the American Chemical Society*, as well as the entire family of American Chemical Society journals, encourage chemical scientists and engineers to join in this journey. We eagerly await your discoveries and insights related to the BRAIN Initiative, the Human Brain Project, and the Human Connectome Project, and look forward to working with our authors, reviewers, and readers to bring you the latest results related to forays into this new and exciting territory.

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Notes

Views expressed in this Editorial are those of the authors and not necessarily the views of the ACS.

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