EDITORIAL

Nano in the Brain: Nano-Neuroscience

As chemical communication and key biomolecular interactions in the brain occur at the nanoscale, the idea of exploiting advances in nanoscience to study brain structure and function has been gaining increasing attention. At the spring 2009 ACS meeting, we organized a symposium on the intersection of these fields, sponsored by the Kavli Foundation.[1] Last year, the Allen, Gatsby, and Kavli Foundations brought together scientists to identify opportunities in working across the fields of nanoscience and neuroscience. Planning of substantially greater efforts are underway.

One of the exciting topics under discussion is the idea of mapping the brain in its entirety so as to understand its function, and sometimes dysfunction. This is a daunting task given that there are 85 billion neurons[2] and estimated to be 100 trillion synapses in the human brain. Currently, three complementary approaches are under consideration. In one, snapshots of connections in the brain are obtained by making thin physical slices and stacking electron microscopy images of these slices. Missing from these data will be dynamic and chemical information. Both are believed to underlie plasticity, which is the basis of learning and memory, as well as other key brain functions. Another approach is to try to make a dynamic voltage map of the brain, essentially dealing with the brain as if it were a close relative of the computers we use every day.[3] One possibility is that emergent properties underlying information use and storage will become accessible by mapping network activity *versus* single or small numbers of multiple unit recordings currently available. A third approach is to try to obtain functional chemical maps of the *ca*. 100 not quite orthogonal chemical neurotransmitter systems in the brain. The genetic and chemical heterogeneity of the brain and the interactions between various neurotransmitter systems are major targets for investigation by neuroscientists and the pharmaceutical industry; nanoscience and nanotechnology have key roles to play in these efforts.

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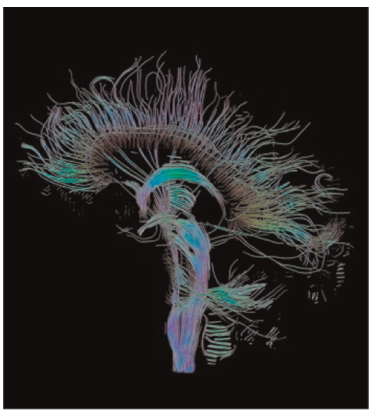

At larger scales than those considered here, the connections of bundles of neurons in the brain can be mapped with diffusion tensor imaging, a form of magnetic resonance imaging.[4] Shown here are reconstructed fiber tracts of the mid-sagittal plane of the brain. Image reproduced with permission from ref 4. Copyright 2006.

In all three cases, the key scales range from the centimeter scale in mapping brain regions and networks, to the micrometer scale of cells and local connectivity, to the 10 nm scale of synapses, to the single-molecule scale. There are thus tremendous opportunities at this intersection of the fields of nanoscience and neuroscience.

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Many techniques are now being developed to track single molecules dynamically at high spatial resolution.[5] In this issue, a novel method of three-dimensional tracking is described.[6] Yet, much remains to be done even in determining the function of the plethora of molecules that are found predominantly in the brain. Likewise, our ability to perform neurochemical and electrophysiological measurements needs to be miniaturized, sped up, and multiplexed. Electrical measurements at the relevant time scales (milliseconds) are straightforward, but getting to the 10 nm scale and making thousands, tens of thousands, or more measurements simultaneously *in vivo* remains challenging. Obtaining dynamic chemical maps at these scales will be an even greater challenge. Ultimately, the information handling problems in acquisition, analysis, interpretation, and visualization will also need to be addressed.

IMAGE COURTESY OF NATHAN DENNETTE/ CANADIAN PRESS

Professor Warren Chan of the University of Toronto joins *ACS Nano* as an associate editor.

There is much to do, and grand challenges lie ahead. We look forward to bringing you the developments at the exciting intersections of nanoscience and neuroscience on these pages and on those of our sister journals.

This month, we welcome Prof. Warren Chan, Canada Research Chair in BioNanotechnology at the University of Toronto Institute of Biomaterials and Biomedical Engineering as our newest associate editor. Prof. Chan is a leader in the area of developing and applying nanoscience methods to track the dynamics of abnormal cells and is a frequent contributor to *ACS Nano*.[7−9]

Finally, we congratulate Robert Lefkowitz of Duke University and Brian Kobilka on winning the 2012 Nobel Prize in Chemistry for their work on G-protein coupled receptors,[10] nanotransducers particularly important in neurotransmission in the brain.

Anne M. Andrews
ACS Chemical Neuroscience, Associate Editor

Paul S. Weiss
Editor-in-Chief

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