Director's Blog: BRAIN – Creating the Next Generation of Tools

By Thomas Insel (http://www.nimh.nih.gov//about/director/bio/index.shtml) on June 11, 2014

Each year at this time, the Kavli Foundation announces its annual scientific prizes. In contrast to the Nobel Prizes, the Kavli Prizes cover three focal areas of science: astrophysics, nanoscience, and neuroscience. Fred Kavli, who died recently, described these prizes as recognizing those who work on "the biggest, the smallest, and the most complex." This year's awards in neuroscience, to Brenda Milner, John O'Keefe, and Marcus Raichle, continue the tradition of recognizing those who embrace complexity.

Complexity was also the theme of an extraordinary report released last week by the NIH Advisory Committee to the Director (ACD). Workgroup reports for advisory committees generally are not great summer reading, but this one, which captures not only the complexity but the excitement of brain research, is both insightful and inspiring. The report provides a 12-year plan for the BRAIN Initiative (BRAIN is an acronym for Brain Research through Advancing Innovative Neurotechnologies), what President Obama has called "the next great American project." We know much less about the brain than any other organ, and yet brain disorders, from autism to Alzheimer's, are increasing in prevalence, creating a national public health crisis. Recognizing both the urgency and the complexity, the BRAIN report calls for a broad approach, involving a $4.5 billion investment over 10 years beginning in fiscal year 2016, to decode the language of the brain by understanding its circuits.

Freeman Dyson, a leading astrophysicist, famously said, "New directions in science are launched by new tools much more often than by new concepts." This is true for neuroscience as much as astrophysics. The Rosetta Stone for the brain will require a new generation of tools that give us the vocabulary, the syntax, and the grammar of the brain. We still do not know the number or types of cells, the basic principles of encoding information, or the rules by which the brain stores and retrieves information. Our tools for recording from circuits capture, at best, hundreds of cells when circuits involve many thousands or millions. Our current approach has been compared to watching a television screen with only a handful of pixels, rather than the millions we require for HDTV. Modern imaging, which yields impressive color images, is also a coarse representation of brain activity. Even the highest resolution imaging scanner for the human brain captures the aggregate activity of about 100,000 neurons in each voxel (think of a voxel as a 3D pixel), when we really want to be measuring the activity of individual neurons or at least much smaller groups of neurons in each voxel. And these scanners work by measuring changes in blood flow or oxygen consumption, a process that is much too slow to monitor brain activity at the speed of thought.

The BRAIN report calls for a new generation of tools for neuroscience. Recognizing that current tools are focusing on the "micro-connectome" to map every connection of a small group of cells or the "macro-connectome" to map activity of the whole brain with neuroimaging, the report focuses on the "meso" scale, the in-between level that includes the circuit activity that may be the most critical for decoding the brain's language. Developing the tools for neuroscience at this scale will require teams of scientists from many disciplines, especially engineering, materials science, nanotechnology, and computational science. The first wave of grants for the BRAIN Initiative are expected to be awarded this September to launch projects on creating a cell census for the brain, creating new tools for monitoring circuit activity, and planning for the next generation of scanners for imaging the human brain.

In spite of the complexity and the urgency, the price tag of $4.5 billion may elicit sticker shock for some. This is, of course, the budget recommended by the ACD BRAIN working group, not a commitment from NIH. BRAIN funds would be “new money” that does not replace current funding for basic, translational, and applied research at NIH. These funds would need to be proposed by the President and appropriated by Congress. Even over the 10-year timeline, the $4.5 billion is less than what NIH currently spends on neuroscience research each year. And as Cori Bargmann, co-chair of the working group pointed out, $4.5 billion is still “less than the cost of a six pack of beer for every American.” Most of all, BRAIN is an investment in the future – giving us the tools to make progress on brain disorders and inform a deeper understanding of what makes us human.

As a glimpse into what this future might look like, last week brought two other notable neuroscience events from projects that preceded the BRAIN Initiative. The Human Connectome Project released data on the first 500 subjects who have received state-of-the-art brain scans and cognitive assessments. This massive amount of data, unprecedented in human neuroscience, along with the tools to explore it, have been uploaded to the Human Connectome Project website . Also last week, the International Neuroimaging Data-sharing Initiative (INDI) announced the public release of the “Consortium for Reliability and Reproducibility (CoRR)” via the 1000 Functional Connectomes Project. This effort has aggregated data from 1629 individuals across 38 cohorts collected at 18 institutions (over 5,000 resting state fMRI scans) to establish benchmark datasets for the evaluation of analytic methodologies, as well as to understand the range of variation for reliability across sites. Datasets will be made available via COINS an easily searchable informatics platform that was used for collecting the scans. BRAIN projects will follow a similar scenario, making tools and data available to the community as soon as possible.

What Freeman Dyson said about the importance of tools for new directions in science is critically important for NIMH. Biomarkers, new therapies, and preventive strategies for brain disorders, especially for the “connectopathies” that we call mental disorders, will require better tools. NIMH will be co-leading the BRAIN Initiative with our sister institute, the National Institute for Neurological Disorders and Stroke (NINDS). Whether you are a scientist working on synapses or a family member challenged by a mental disorder, the BRAIN Initiative represents a bold commitment by the NIH, offering hope for the development of better tools to enhance our understanding of the brain in health and disease.

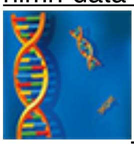
Publications by the Director

Selected publications by NIMH Director Thomas Insel (http://www.nimh.nih.gov//about/director/bio/publications/index.shtml)

Science News


NIMH Names Director for Translational Research (http://www.nimh.nih.gov//news/science-news/2015/lisanby-chosen-to-lead-nimh-division-of-translational-research.shtml)

Pioneering NIMH Data Sharing (http://www.nimh.nih.gov//news/science-news/2015/pioneering-nimh-data-sharing.shtml)


Disorders Share Same Gene Pathways (http://www.nimh.nih.gov//news/science-