

NIH BRAIN Initiative

Brain Research through Advancing
Innovative Neurotechnologies

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Co-Chair, ACD BRAIN Working Group

Learning the Language of the Brain

the WHITE HOUSE

PRESIDENT OBAMA IS CALLING ON THE SCIENCE COMMUNITY
TO JOIN HIM IN PURSUING A GRAND CHALLENGE

BRAIN INITIATIVE

BRAIN RESEARCH
THROUGH ADVANCING
INNOVATIVE
NEUROTECHNOLOGIES



Brain disorders affect us all

Neurodegenerative disorders:

Alzheimer's, Parkinson's, ALS, Huntington's....

Annual cost of dementia care in the US is ~\$200 billion

Cognitive and affective disorders:

Schizophrenia, Bipolar disorder, Depression, Anxiety, OCD

Neurodevelopmental disorders:

Autism, Attention-deficit disorder, Epilepsy, Intellectual disability

Injury- and insult-induced disorders:

PTSD, Traumatic brain injury, Stroke, Addiction, Chronic pain

The Charge



“So there is this enormous mystery waiting to be unlocked, and the BRAIN Initiative will change that by **giving scientists the tools they need to get a dynamic picture of the brain in action** and better understand how we think and how we learn and how we remember. And that knowledge could be – will be – transformative.”

~President Obama, April 2, 2013

BRAIN Initiative Partners

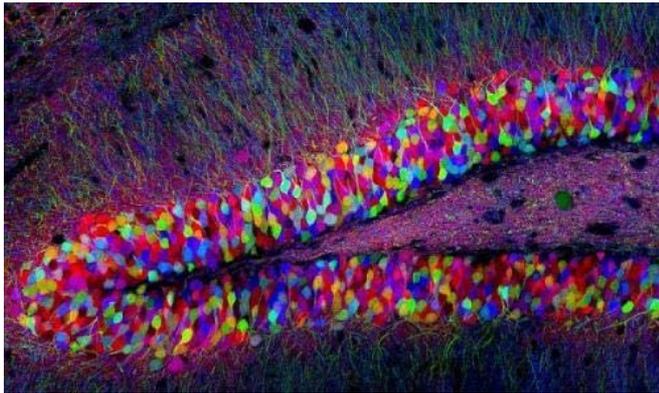
FY2014 Investments

Government Agencies	\$ in Millions
National Institutes of Health	\$40
Defense Advanced Research Projects Agency	\$50
National Science Foundation	\$20
Private Organizations	
Allen Institute for Brain Science	\$60
Howard Hughes Medical Institute	\$30
Salk Institute for Biological Studies	\$28
The Kavli Foundation	\$4

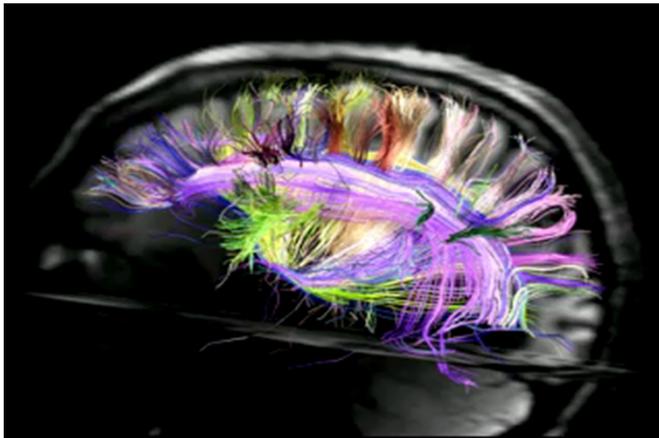


The Brain:

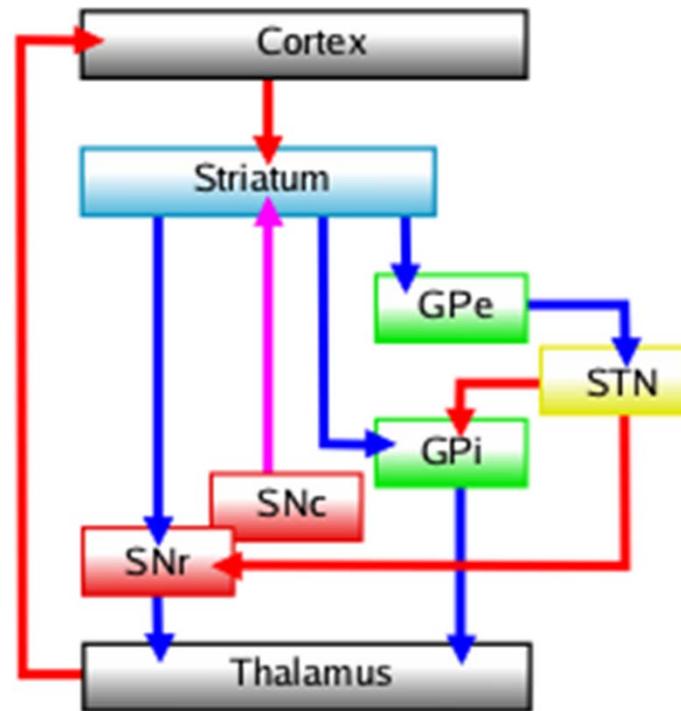
perceives, feels, thinks, remembers, plans, and decides via **circuits and systems** of interconnected neurons
~10,000/local circuit; 1 million/area; many areas/system



Brainbow (Livet et al., 2007)



Human Connectome (Wedgeen et al., 2012)



Why Now?

Progress in neuroscience is yielding new insights into brain structure, activity, and function

Advances in **genetically-encoded sensors** of neural activity

Advances in **optogenetics and pharmacogenetics**

Advances in **microscopy**: SPIM, sculpted light, multifocal

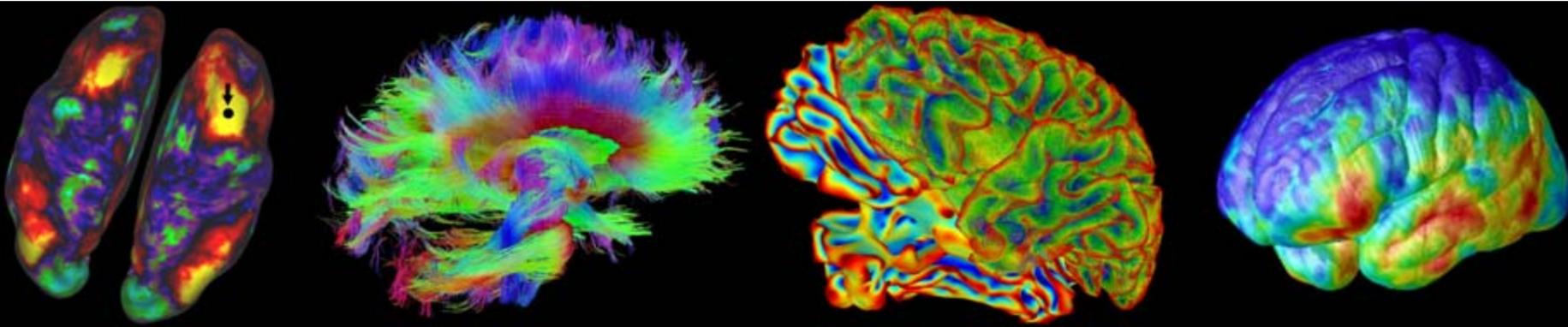
Advances in **multi-electrode design** and fabrication

Advances in **computation, theory**, analysis of big datasets

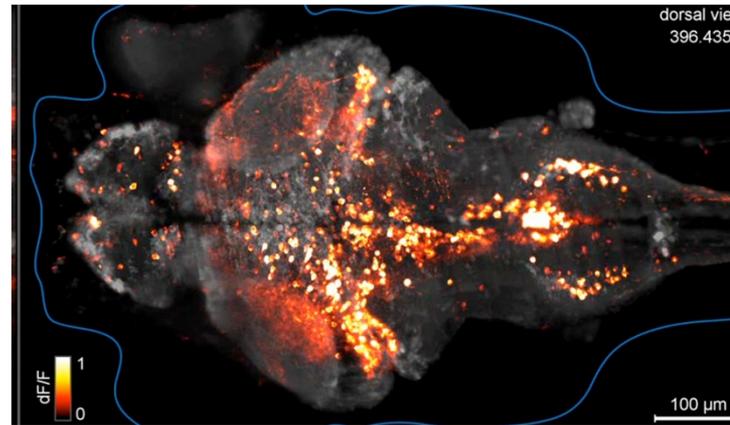
And the possibility of entirely new approaches

NIH BRAIN Initiative: Goals

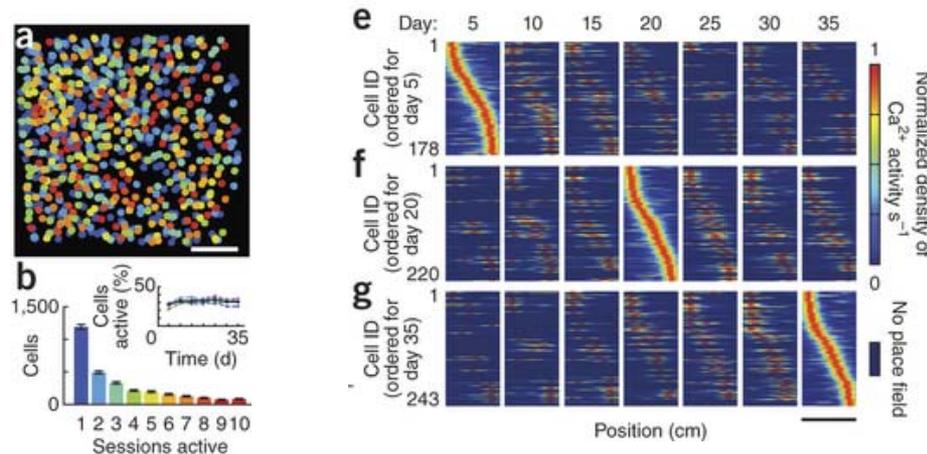
- Accelerate the development and application of **innovative technologies** to construct a **dynamic picture** of brain function that **integrates neuronal and circuit activity over time and space**
- Build on neuroscience, genetics, physics, engineering, informatics, nanoscience, chemistry, mathematics, to promote interdisciplinary efforts and advances



Monitoring Neuronal Activity at Large Scales, High Spatial and Temporal Resolution, and Across Time



Zebrafish, whole brain calcium imaging of neuronal activity (Ahrens...Keller, 2013)

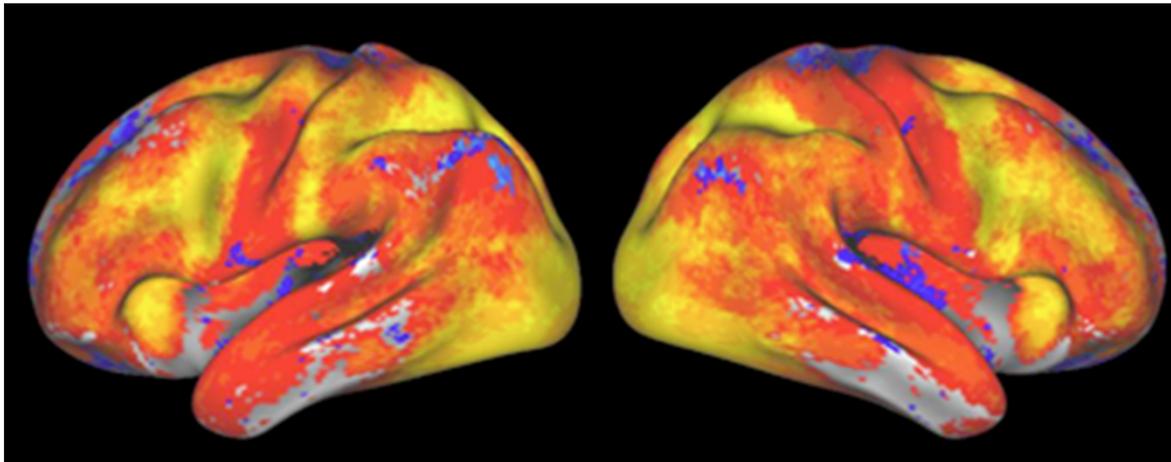


Behaving mouse, 826 CA1 hippocampal neurons, 30 days (Ziv... Schnitzer 2013)

Understanding Brain Circuits and Systems

How do distant parts of the brain work together to generate patterns of activity?

How are these patterns of activity translated into thoughts, behaviors, and emotions?



NIH BRAIN Initiative: Process

- Plan to be developed by a working group of the Advisory Committee to the Director, NIH
 - Selected for visionary leadership, expertise
 - Charged with articulating scientific goals, developing plan
 - Including timetables, milestones, costs

NIH BRAIN Initiative: Working Group

Cornelia Bargmann, PhD (co-chair)

The Rockefeller University

Bill Newsome, PhD (co-chair)

Stanford University

David Anderson, PhD

California Institute of Technology

Emery Brown, MD, PhD

Massachusetts Institute of Technology

Karl Deisseroth, MD, PhD

Stanford University

John Donoghue, PhD

Brown University

Peter MacLeish, PhD

Morehouse School of Medicine

Eve Marder, PhD

Brandeis University

Richard Normann, PhD

University of Utah

Joshua Sanes, PhD

Harvard University

Mark Schnitzer, PhD

Stanford University

Terry Sejnowski, PhD

Salk Institute for Biological Studies

David Tank, PhD

Princeton University

Roger Tsien, PhD

University of California, San Diego

Kamil Ugurbil, PhD

University of Minnesota

EX OFFICIO MEMBERS

Kathy Hudson, PhD

National Institutes of Health

Geoffrey Ling, MD, PhD

Defense Advanced Research Projects Agency

John Wingfield, PhD

National Science Foundation

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- Informed by experts across sectors and disciplines
 - Assisted by NIH Blueprint for Neuroscience Research
- NIH BRAIN Working Group will
 - Seek broad input; hold open meetings, workshops
 - Deliver interim report on high-priority areas for FY14 funding in summer 2013; final report, June 2014

NIH BRAIN Initiative: Working Group Summer Schedule

DATE	LOCATION	FOCUS
May 29-30	San Francisco, CA	Molecular Approaches
June 26-27	New York, NY	Large-Scale Recording Technologies
July 29-30	Boston, MA	Computation, Theory, and Big Data
August 29-30	Minneapolis, MN	Human Analysis and Measurements

Workshop discussions will also address appropriate experimental systems and questions, animal and human models, and behavioral approaches.

Public can receive updates, contribute to discussion, at

<http://www.nih.gov/science/brain/>

Posing the problems, not dictating the solutions

Create a space for the most original and compelling ideas to flourish “Open science” collaboration across labs and organizations

An initial focus on technology

Innovation, Validation, Application, Iteration, and Dissemination

Making a wider impact on neuroscience research

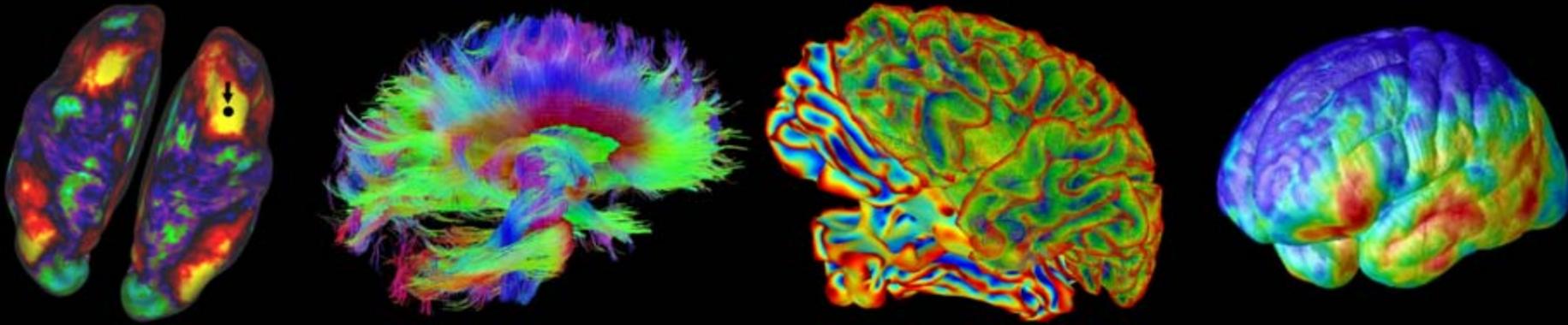
NIH spends approximately \$5.5B on neuroscience research
In 2014, BRAIN will be \$40M, or <1%

Potential for wide-ranging benefits

Tools to enhance many areas of research

Foundational knowledge and methods

for deeper understanding of all brain disorders



First workshop, May 2013:

Molecular tools

Nat Heintz, Rockefeller

Gerald Rubin, HHMI Janelia Farm

Hongkui Zeng, Allen Institute

Feng Zhang, MIT

Ed Callaway, Salk Institute

Liqun Luo, Stanford

Clay Reid, Allen Institute

Loren Looger, HHMI Janelia Farm

Alice Ting, MIT

Ehud Isacoff, UC Berkeley

Michael Stryker, UCSF

Second workshop, June 2013:

Large-scale recordings
and structural neurobiology

Gyorgy Buzsaki, NYU

Markus Meister, CalTech

Hongkun Park, Harvard

Florian Engert, Harvard

Kristin Scott, UC Berkeley

Karel Svoboda, HHMI Janelia

Winfried Denk, Max Planck

Jeff Lichtman, Harvard

Pavel Osten, Cold Spring Harbor

Ed Boyden, MIT

Rafael Yuste, Columbia

First workshop: Posing the problems, not the solutions

1. The parts list: a census of neuronal types
2. Genetic or chemical access to defined neurons
3. Tracing synapses in a circuit
4. Tracing circuits by common activity patterns
5. Monitoring different forms of neuronal activity
6. Manipulating neuronal activity
7. Experimental systems
8. “Open science” infrastructure