NIH and the BRAIN Initiative

Brain Research through Advancing Innovative Neurotechnologies

Greg Farber

Director, Office of Technology Development and Coordination

NIMH

NIH

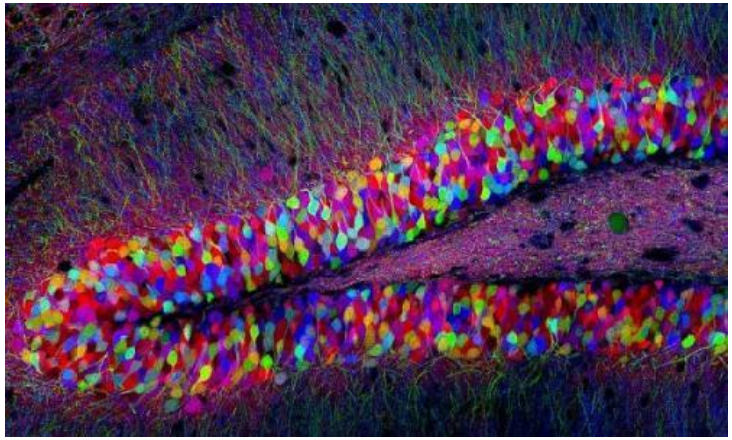
National Institute of Mental Health

“The Next Great American Project”

“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.”

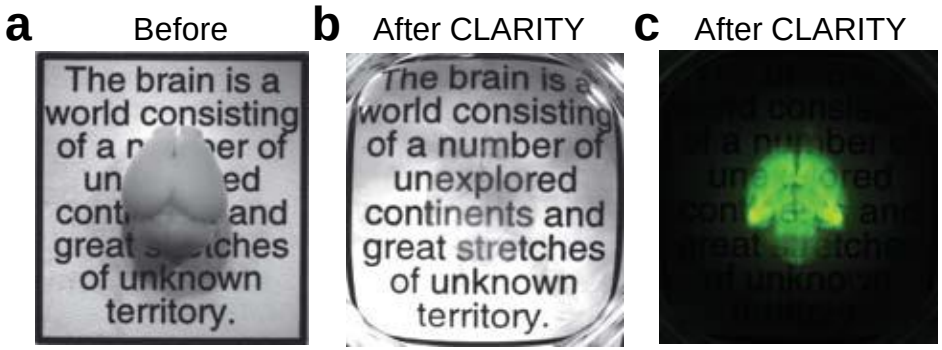
~President Obama, April 2, 2013

Advances in Understanding Brain
Structure



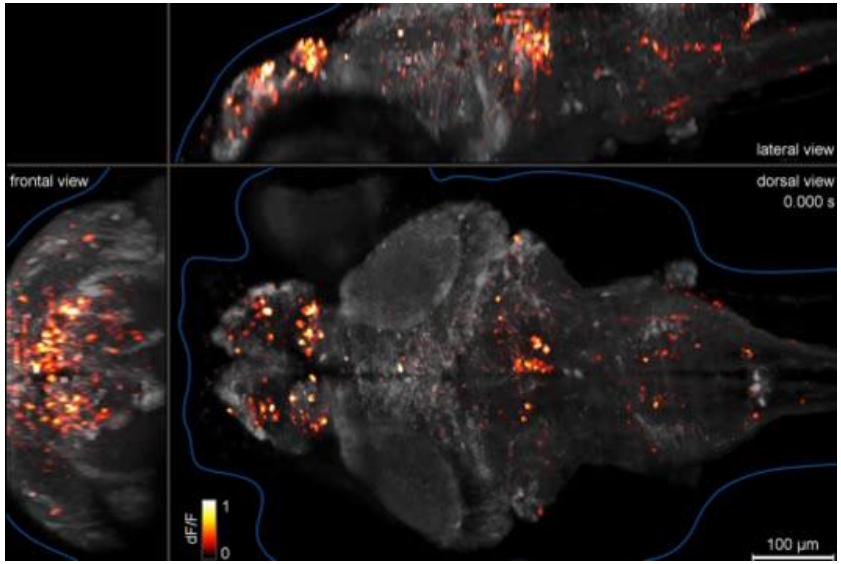
Brainbow (Livet et al., 2007)

Human Connectome (Wedeen et al., 2012)

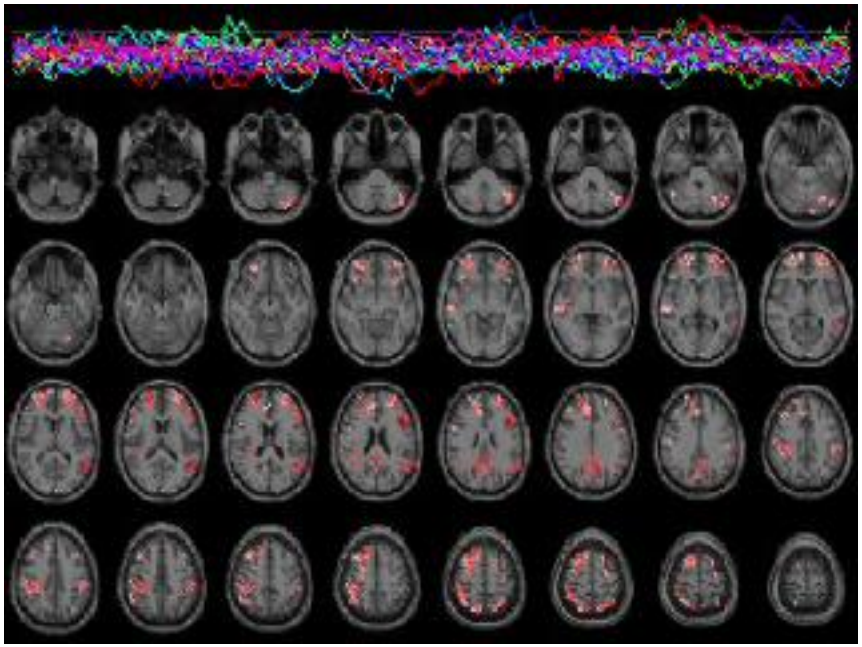


CLARITY (Chung et al., 2013)

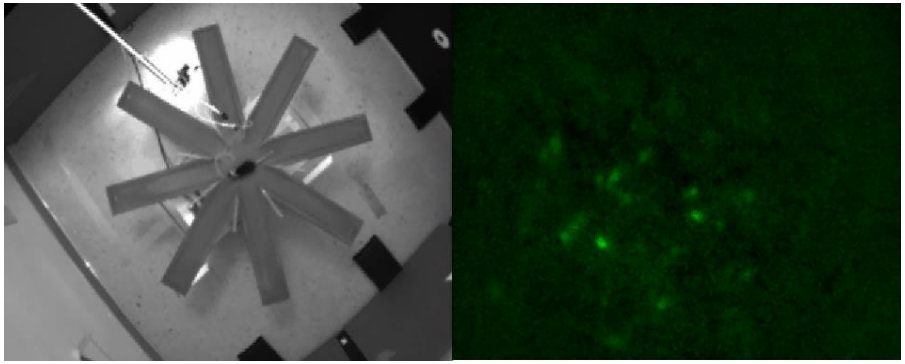
Advances in Understanding Brain *Function*



Zebra fish larvae (Ahrens et al., 2013)



21 transient co-activation networks (U-Minn/Was U)



Hippocampal neurons (Schnitzer laboratory)

BRAIN Initiative

“a public and private effort”

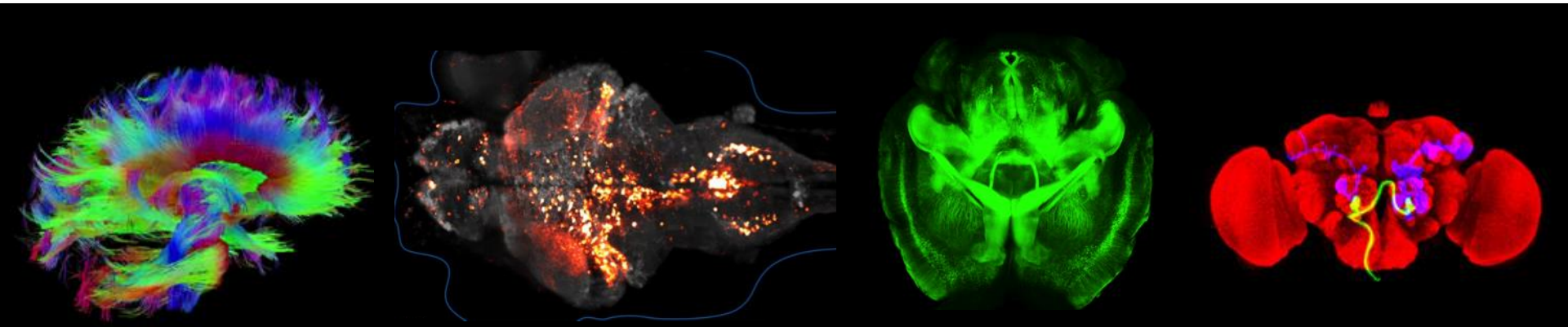
+

Private Investments

SIMONS FOUNDATION

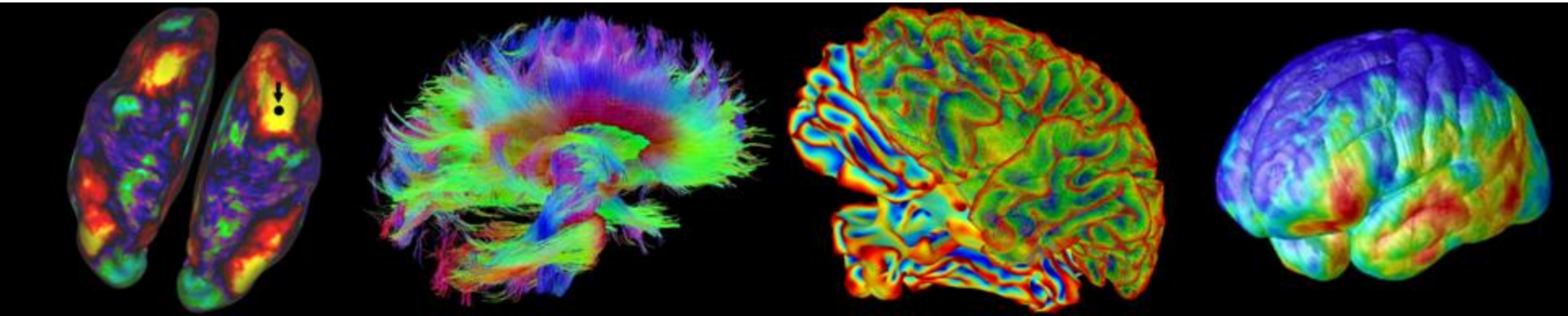
BRAIN Initiative: Challenges

- Map the circuits of the brain
- Measure the fluctuating patterns of electrical and chemical activity flowing within those circuits
- Understand how their interplay creates our unique cognitive and behavioral capabilities



BRAIN Initiative: Approach

- Accelerate development, application of innovative technologies to construct dynamic picture of brain function that integrates neuronal and circuit activity over time and space
- Build on growing scientific foundation – neuroscience, genetics, physics, engineering, informatics, nanoscience, chemistry, mathematics, etc. – to catalyze interdisciplinary effort of unprecedented scope
- Pursue experiments in simpler model systems and in humans.



The Working Group's Process

Spring/Summer 2013

- Reviewed neuroscience landscape
- 4 workshops, 48 expert participants, public commentary
- Presented interim report with FY2014 research priorities

Autumn/Winter 2013

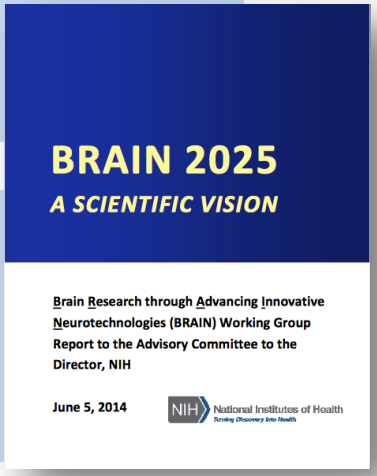
Conversations, presentations, feedback:

- Society for Neuroscience leadership and general membership
- Presidents of major clinical neuroscience professional societies
- NAS neuroscience members, NAS general membership, AAAS
- Public partners and private participants (NSF, DARPA, HHMI, AIBS, Kavli)

Spring/June 2014

Deliverables, milestones, implementation, budgets

BRAIN 2025, A Scientific Vision



Seven High Priority Research Areas

1. **Discovering diversity:** Identify and provide experimental access to the different brain cell types to determine their roles in health and disease.

2. **Maps at multiple scales:** Generate circuit diagrams that vary in resolution from synapses to the whole brain.

3. **The brain in action:** Produce a dynamic picture of the functioning brain by developing and applying improved methods for large-scale monitoring of neural activity.

4. **Demonstrating causality:** Link brain activity to behavior with precise interventional tools that change neural circuit dynamics.

Seven High Priority Research Areas

5. **Identifying fundamental principles:** Produce conceptual foundations for understanding the biological basis of mental processes through development of new theoretical and data analysis tools.

6. **Advancing human neuroscience:** Develop innovative technologies to understand the human brain and treat its disorders; create and support integrated human brain research networks.

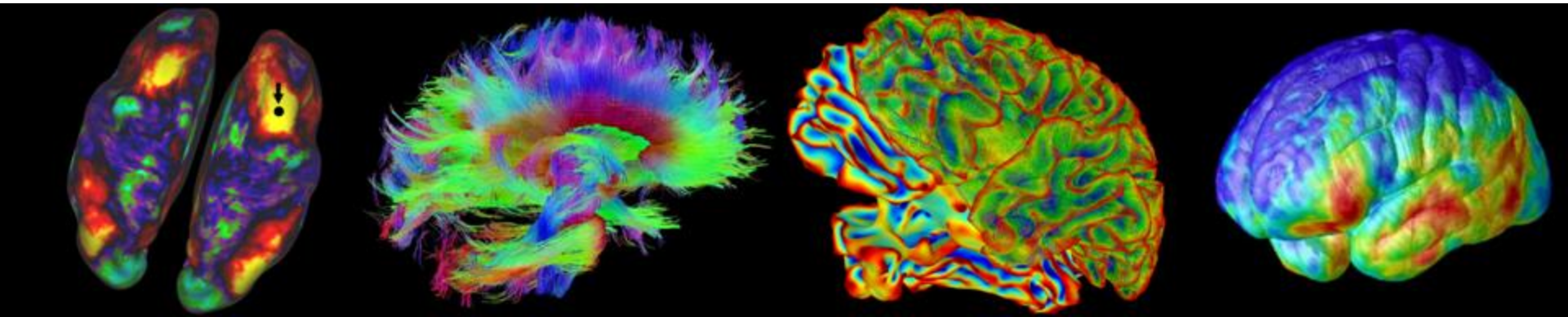
7. **From BRAIN Initiative to the brain**: Integrate new technological and conceptual approaches produced in goals #1-6 to discover how dynamic patterns of neural activity are transformed into cognition, emotion, perception, and action in health and disease.

Overview: 6 RFAs in FY14

- 2 RFAs focused on the cells in the vertebrate brain
  - Cell type classification
  - Development and validation of novel tools to analyze cell specific and circuit specific processed in the brain
- 3 RFAs focused on circuits in the brain
  - New technologies and novel approaches for large-scale recording and modulation in the nervous system
  - Optimization of transformative technologies for large-scale recording and modulation in the nervous system
  - Integrated approaches for understanding circuit function in the nervous system
- 1 RFA focused on humans
  - Planning for next generation human brain imaging

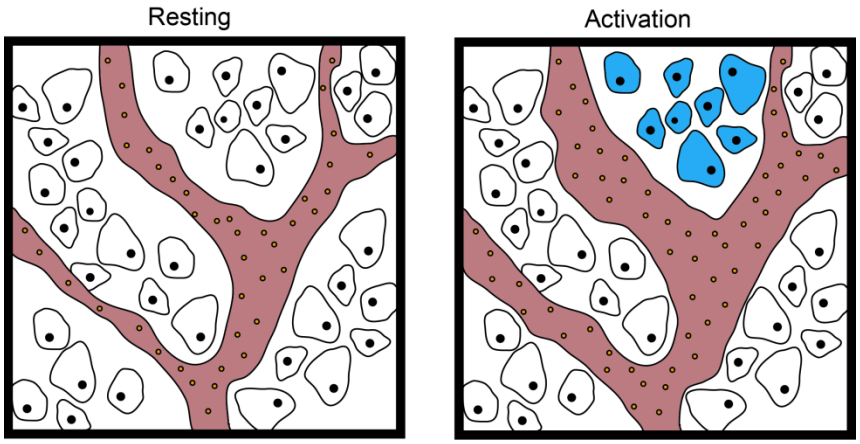
Details: FY14 Awardees

- 58 awards made for $46M
- More than the allocated $40M was spent because of the high quality of the awards.
- Awards and subcontracts made to foreign institutions and to business.
- The interdisciplinarity is clear



New Classes of Imaging Technology

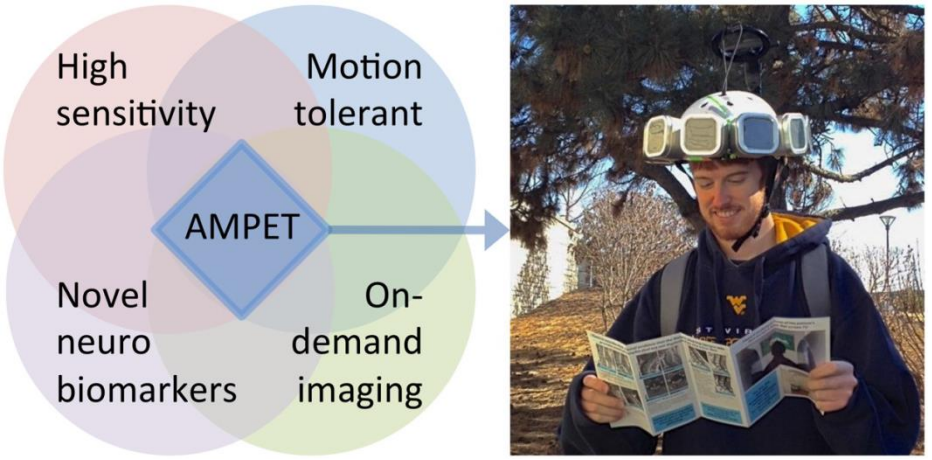
- **Larry Wald (R24MH106053, MGH) Magnetic Particle Imaging for Functional Brain Imaging in Humans**
- Their plan is to detect the activation-induced and resting-state changes in the iron-oxide concentration in the cerebral capillary network by monitoring the local iron oxide concentration (and thus local Cerebral Blood Volume)
- They envision replacing BOLD fMRI in the same way BOLD fMRI replaced O15 PET brain studies in the 1990s.



Cartoon of the brain capillary structure at rest (left) and during activation (right). The vessels swell under increased flow (in demand for O2) producing an increased CBV (by ~25%). Thus, the amount of the iron-oxide contrast agent in the voxel is increased 25% during activation. With MPI they plan to detect the concentration of the Fe directly and therefore expect the signal to increase with activation.

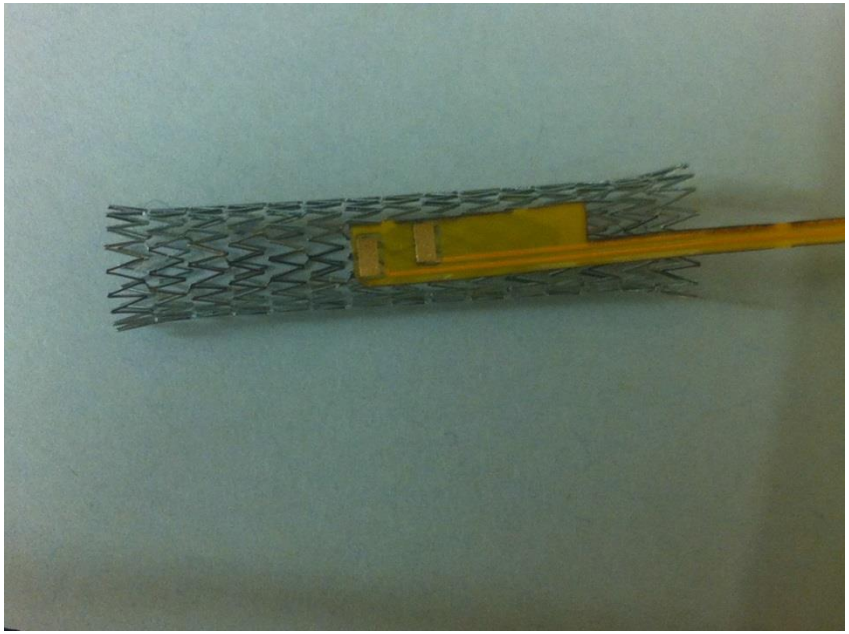
Imaging in More Natural Environments

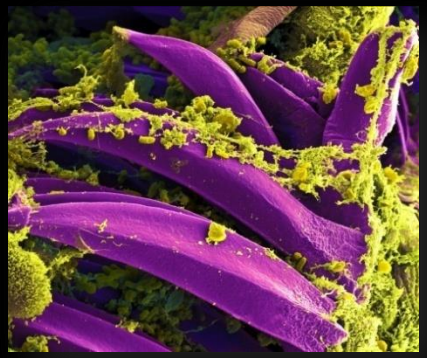
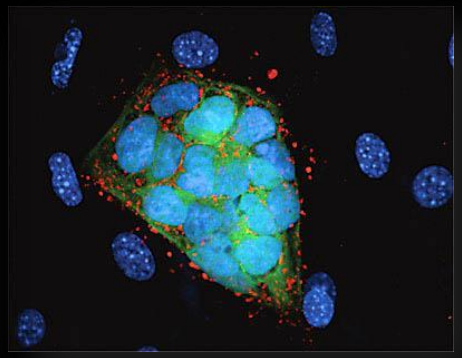
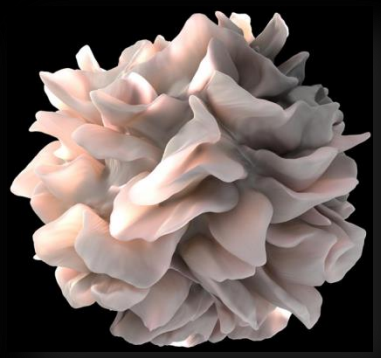
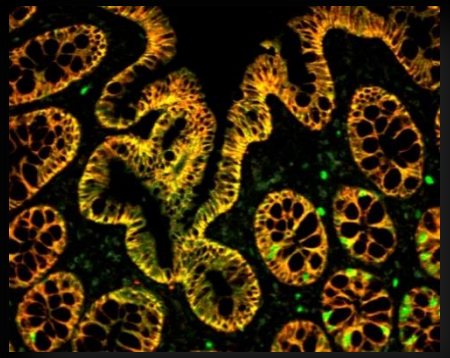
- **Julie Brefczynski-Lewis (R24MH106057, West Virginia) Imaging the brain in motion: the ambulatory micro-dose wearable PET brain imager**
- A wearable mobile molecular PET brain imager will be a unique new tool to safely provide never attained before detailed insight into the metabolism and cellular processes of the human brain during activities such as walking, playing a piano, meditating, and socializing.



Dramatic Improvements in SNR/CNR for Existing Imaging Technologies

- **Bob Desimone (R24MH106075, MIT) Vascular interfaces for brain imaging and stimulation**
- Vascular access offers a less-invasive, safer and more scalable means to deliver recording devices to the vicinity of neurons buried inside the brain parenchyma.
- Desimone and colleagues propose to create a vascular platform for brain imaging, stimulation, electrical recording, and molecular access, aiming for devices that will work at least in large blood vessels, and also paving the way towards capillary-resolution neural access through vasculature.



NIH…

Turning Discovery Into Health