Brain Research through Advancing Innovative Neurotechnologies (BRAIN)
Perspectives from the National Science Foundation

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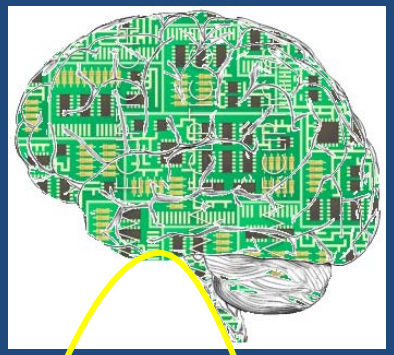
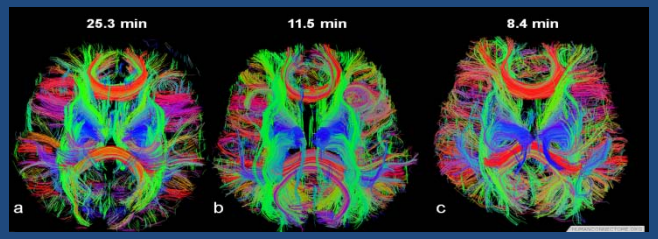
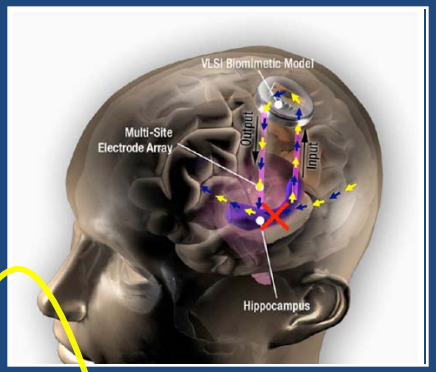
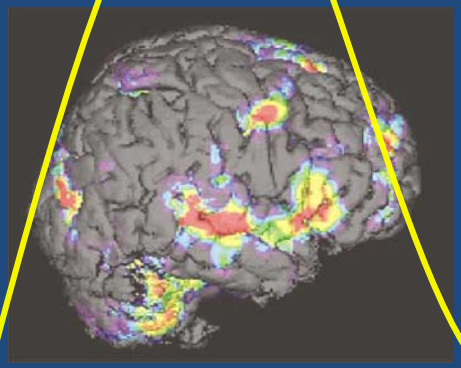
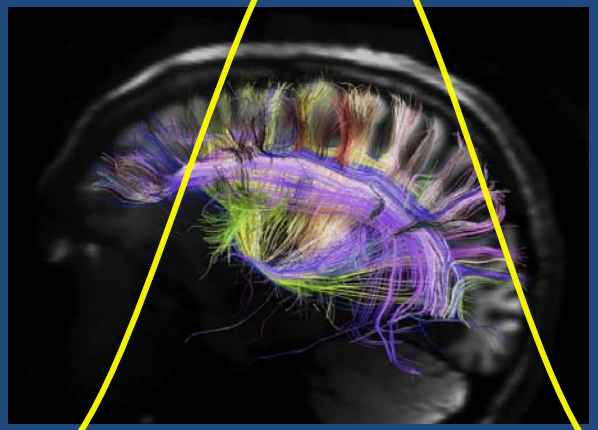
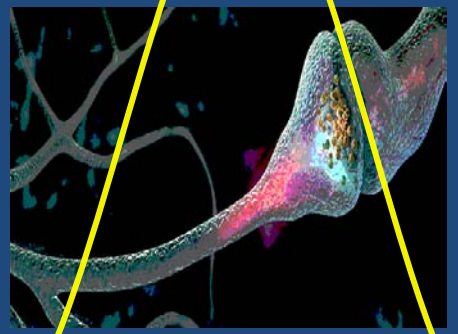


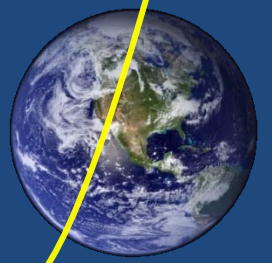












Basic Research Challenges Required to Achieve the BRAIN Initiative Goals

- Foundational knowledge
- Tools for high-resolution measurements
- Computational models and theoretical frameworks
- Data storage, management and analysis

The NSF Role

NSF is uniquely positioned to lead a multidisciplinary effort by scientists and engineers to advance the original research and tool development and educate the workforce needed for the BRAIN initiative to succeed.

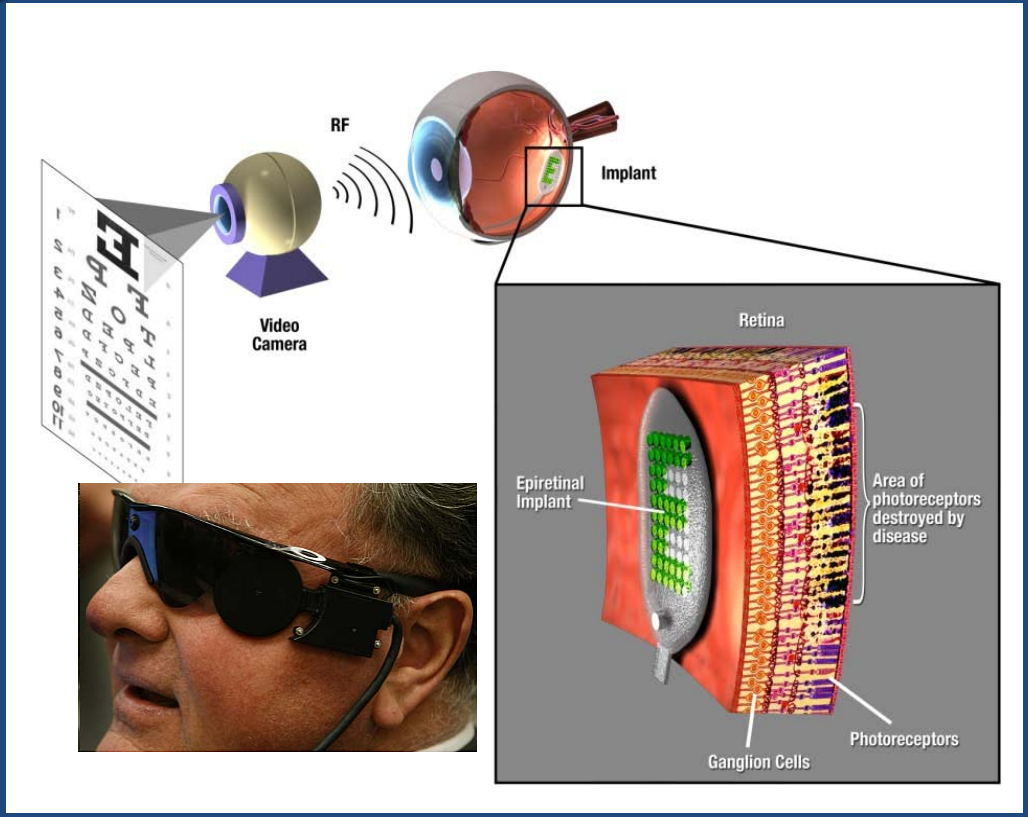
NSF Programs Support Research to:

1. Determine the genomic architecture, synaptic activity, and neural circuitry that gives rise to the emergent properties of the brain:
   - New molecular probes
   - Improved ability to sense and record neural network activity
   - New imaging and related nanotechnologies
2. Establish conceptual & theoretical frameworks to guide future research:
   - Link brain activity patterns to cognitive and behavioral functions in specific ecological, evolutionary, developmental and social contexts.
   - Apply social science theories and methods to link brain activity patterns to individual human behaviors.

Biomimetic Micro Electronic Systems (BMES) Engineering Research Center

- First FDA-Approved Retinal prosthesis (2013)
- First implanted device used to treat adult patients with advanced *retinitis pigmentosa*.
- Images from external video camera are transformed into electronic data that is wirelessly transmitted to the retinal prosthesis.
- Letter recognition, word reading, improved mobility, object localization, motion detection.

John L. Wyatt Jr., MIT
Co-Director, Boston Retinal Implant Project



Second Sight Medical Products Argus II

Video images captured by a miniature camera, housed in the patient's glasses are converted into a series of small electrical pulses that are transmitted wirelessly to an array of electrodes on the surface of the retina (epi-retinal).

Ethical Questions To Consider

- How do we manage or regulate rapidly evolving technologies?
- Do we need different principles to guide ethical policies relating to different uses of neurotechnology? (i.e. intelligence, defense, medical, personal)
- Should there be a distinction based on the intent of the use? (treatment vs. enhancement)
- Who will manage these policies?
- When and where should neuroethics education start?

Bioethical Concerns

- Dual Use Research of Concern (DURC)
  - National Science Advisory Board for Biosecurity housed at HHS
  - U.S. Government Policy for Oversight: http://www.phe.gov/s3/dualuse/Documents/us-policy-durc-032812.pdf
  - U.S. Government Policy for Institutional Oversight: http://www.phe.gov/s3/dualuse/Documents/oversight-durc.pdf
- Synthetic Biology
  - The Commission released a report in December 2010: http://bioethics.gov/sites/default/files/PCSBI-Synthetic-Biology-Report-12.16.10.pdf

Bioethical Concerns

- Animal Science
  - Guide for the Care and Use of Laboratory Animals: http://grants.nih.gov/grants/olaw/Guide-for-the-care-and-use-of-laboratory-animals.pdf
- Protecting Human Subjects (Moral Science)
  - The Commission released a report in December 2011: http://bioethics.gov/node/558

Bioethical Concerns

- Brain-Machine Interface (BMI) Issues
  - Invasive v. Non-invasive
  - Implants
  - Brain stimulation
  - Prosthetics
  - Mind control?

Future Steps

- Improving accountability
- Ethical underpinnings of regulation should be explicit
- Investigator obligations should be explicit in policies and regulations
- Promote engagement by the communities
  - Research
  - Industry
  - Students
  - Public-at-large

Additional Resource

- Nuffield Council on Bioethics's latest report: "Novel Neurotechnologies: Intervening in the Brain" published 24 June 2013

www.nuffieldbioethics.org/neurotechnology