

# Advances in Neurotechnology and Neuroscience

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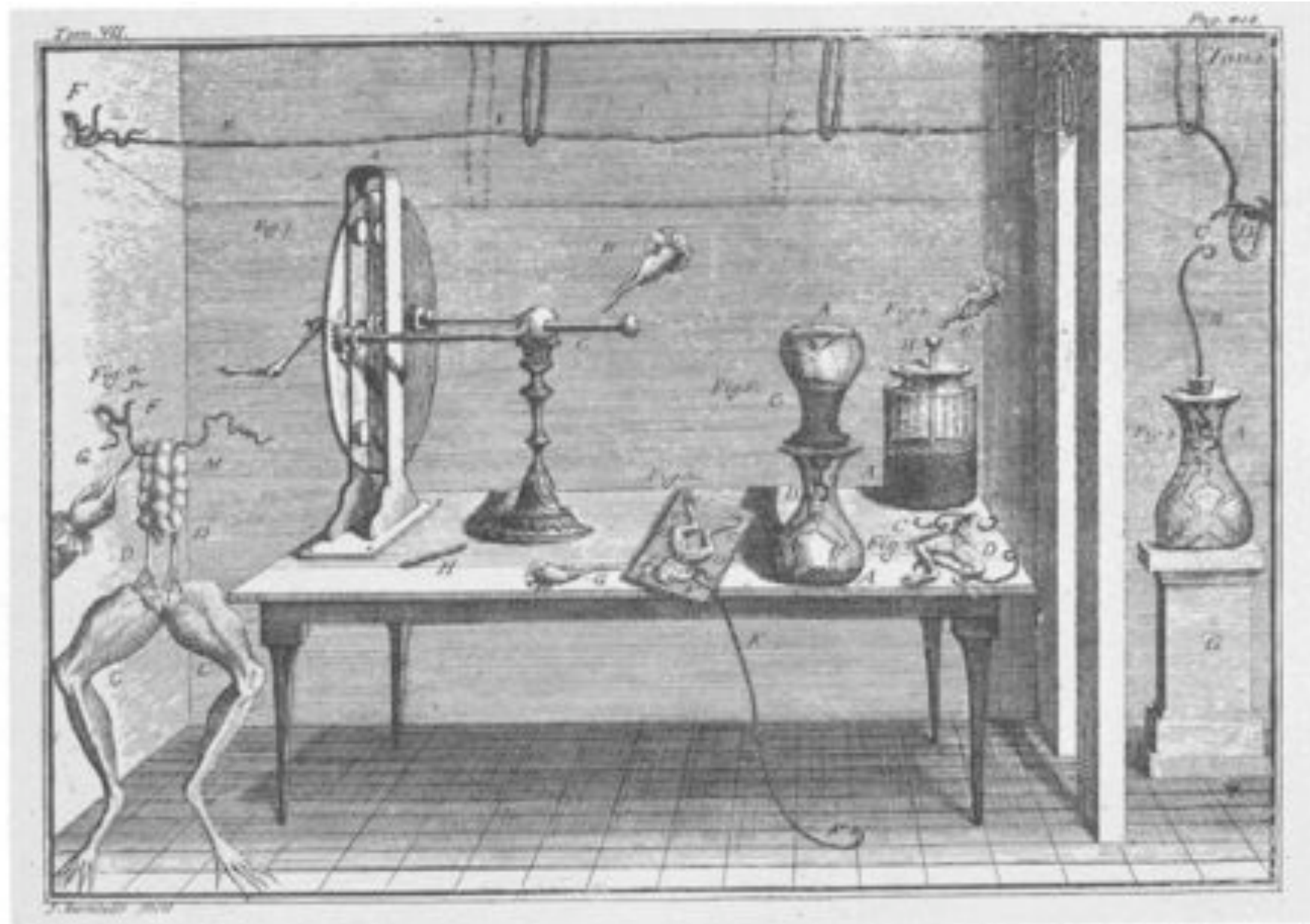
IEEE-EMB Boston/MIT-BMES  
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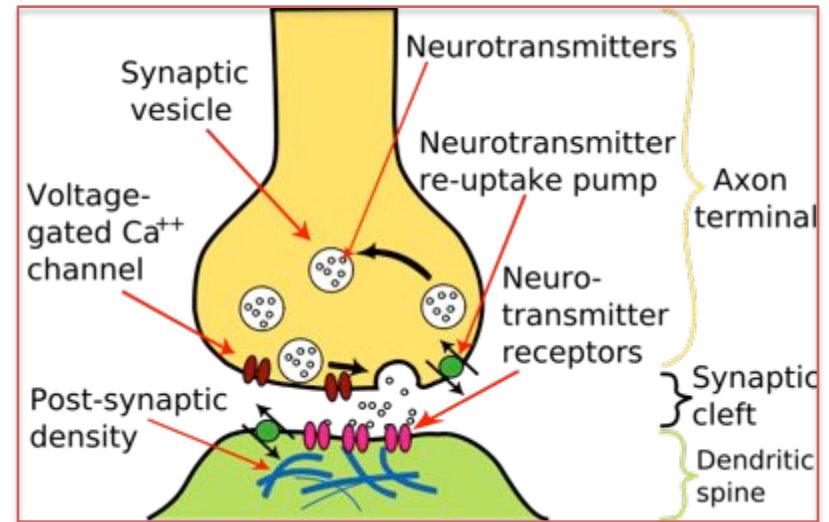
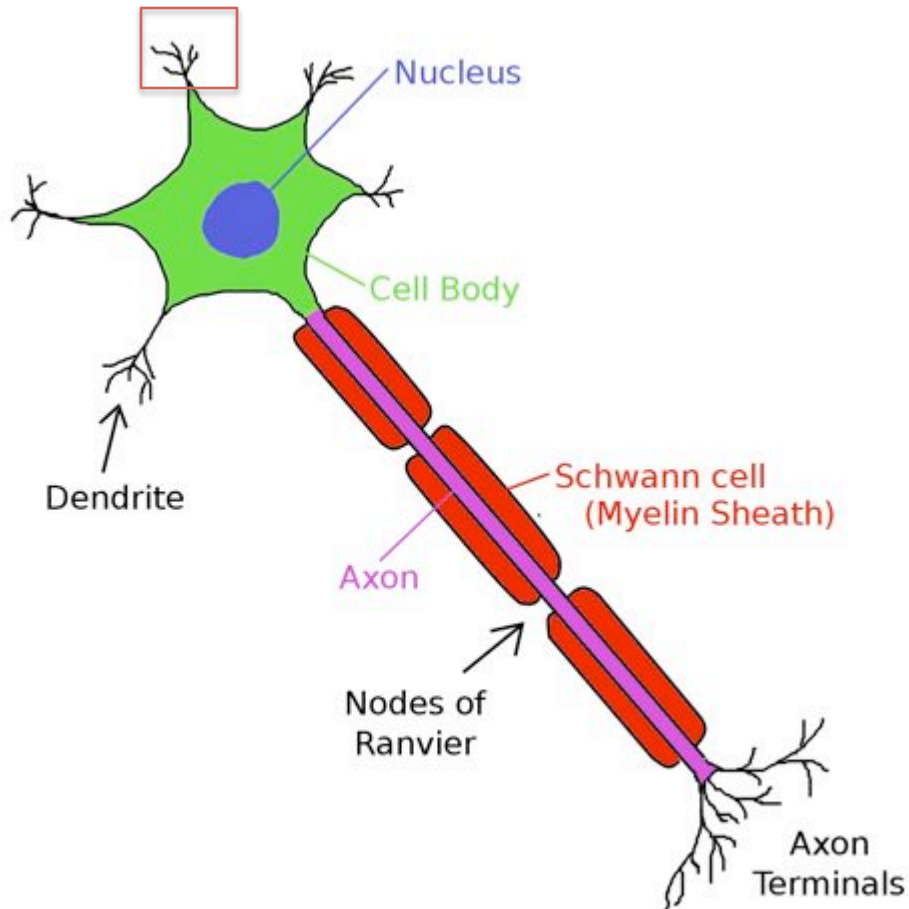
- “Neurotech industry revenues rose 10% to \$120.5 billion in 2006...”
- “Brain-related illnesses afflict more than two billion people worldwide and 100 million in North America...”
- “The annual economic burden of brain-related illnesses has reached more than \$1 trillion in the U.S. ...”
- “Aging populations are increasing the prevalence of brain-related illnesses creating unprecedented demand for treatments that delay, prevent and cure chronic neurological and psychiatric illnesses.”

- *The Neurotechnology Industry 2007 Report*, published by *NeuroInsights*



The first of the four engravings that illustrated Galvani's text in the original publication in 1791. In Fig. 2, the prepared frog's legs CC hang from the spinal stub by the crural nerves DD. When the electrostatic machine in Fig. 1 revolved, or the Leyden jar, Fig. 5, was discharged, Galvani observed that the legs jerked when a scalpel touched the nerve.

# Nerves and Neurons



# Action Potentials

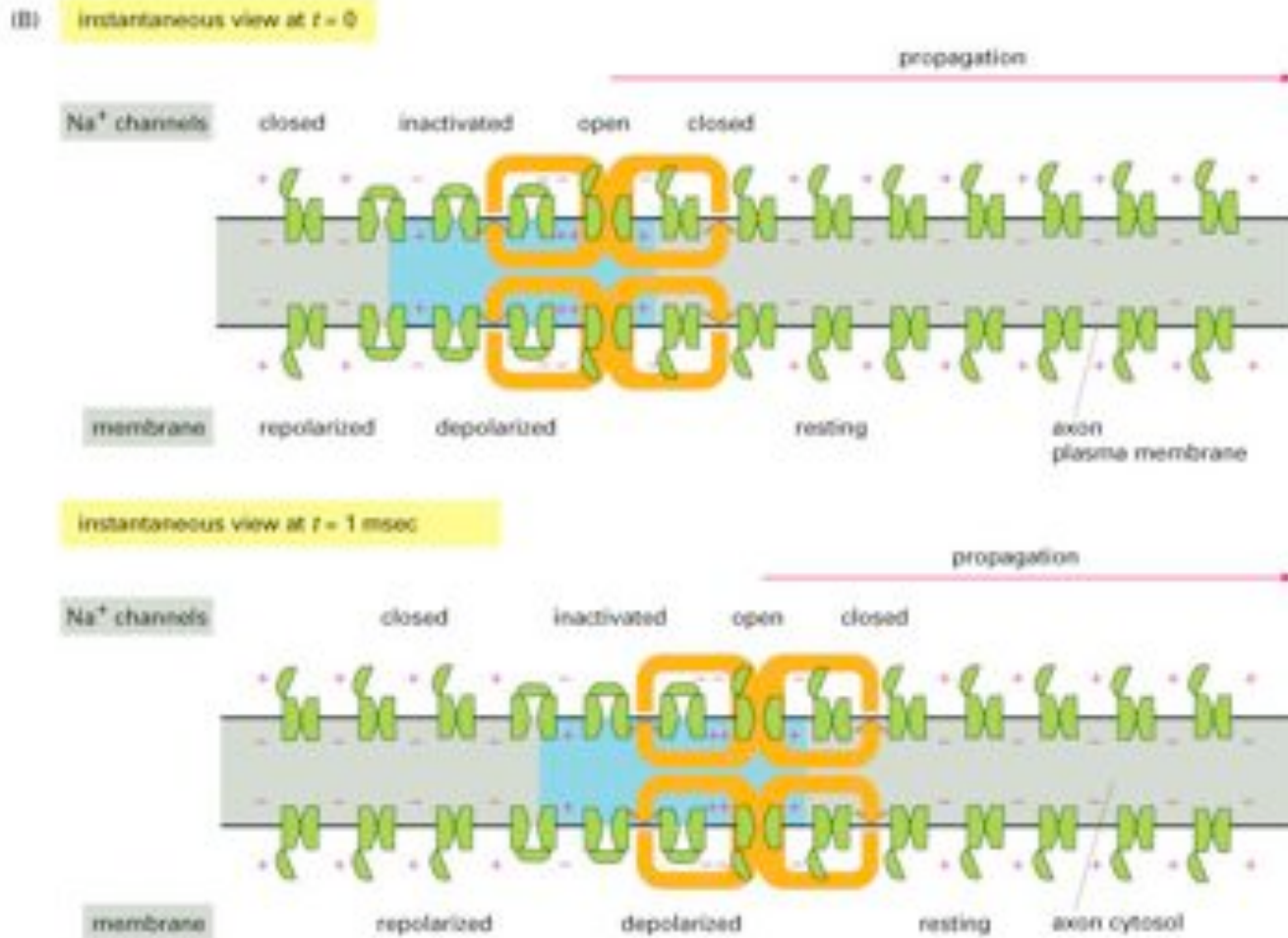
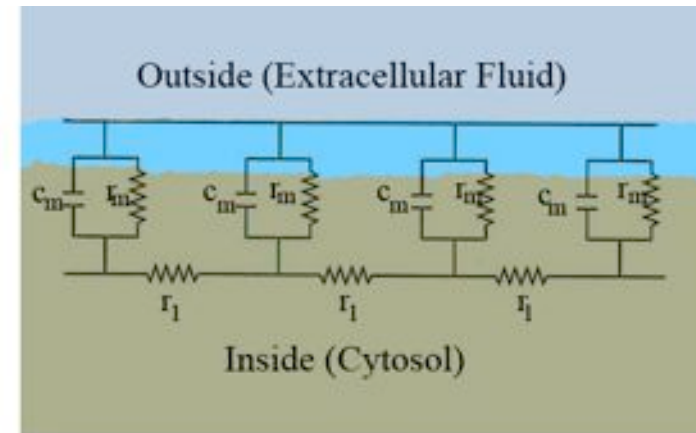
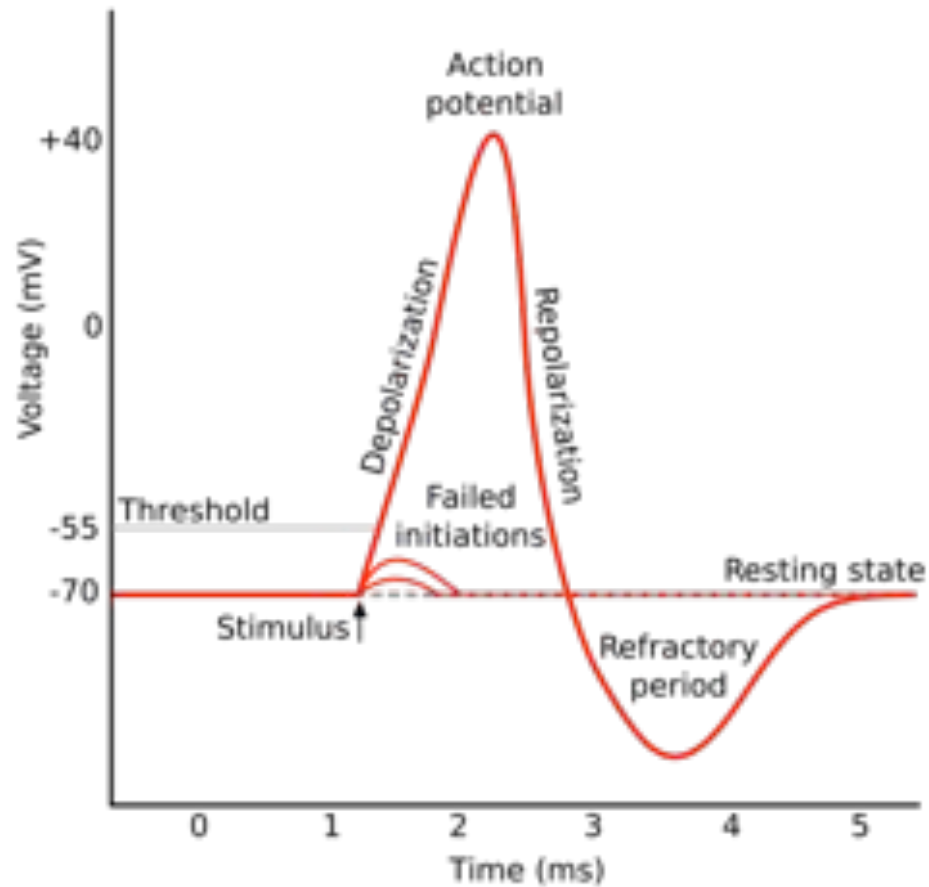


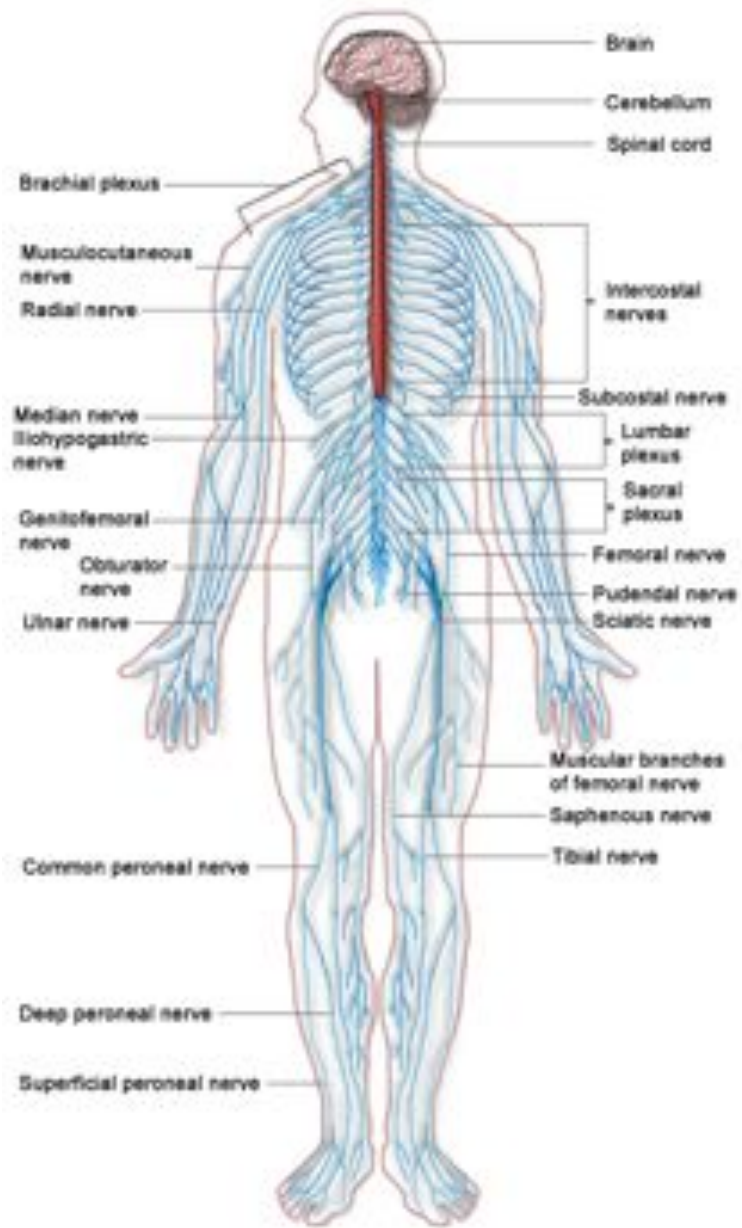
Figure 12-38 Essential Cell Biology, 2/e. (© 2004 Garland Science)

# Action Potentials



Capacitance      Resistance

$r_m$ : Membrane resistance  
 $r_l$ : Longitudinal resistance  
 $c_m$ : Capacitance due to electrostatic forces





Certain medical devices, such as this electro-magnetic machine for nerve stimulation, were used in specialized care hospitals.

W. H. Kemp, circa 1880-1890. W. H. Kemp

Hardwood W

As the war pr  
hospitals. Se  
renovated by  
Stout, NW



# Functional Electrical Stimulation

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- Stimulate muscle or motor nerve
- Directly cause muscle contraction
- Synchronize contraction to desired function



# Spinal Cord Stimulators

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- Approved for chronic pain management

# Vagus Nerve Stimulation

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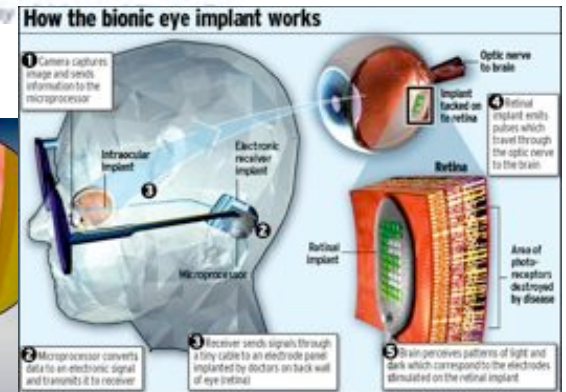
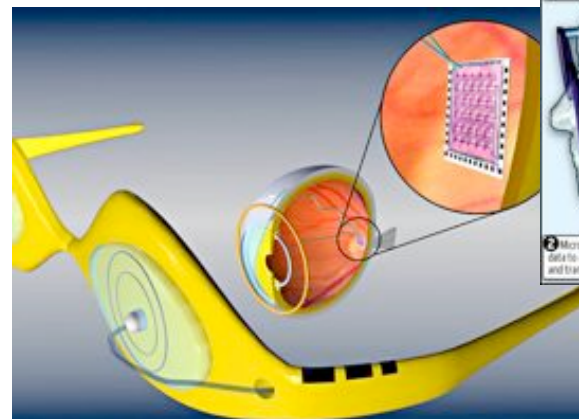
- Approved indication for treatment resistant epilepsy

# Sensory Prostheses

- Cochlear implant for hearing disorders
- Retinal implant for vision disorders

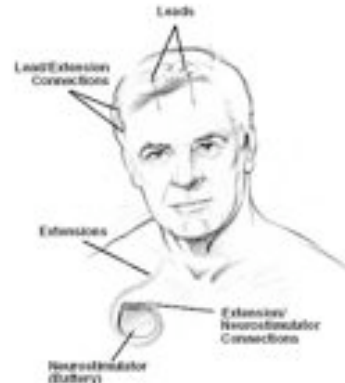


Courtesy



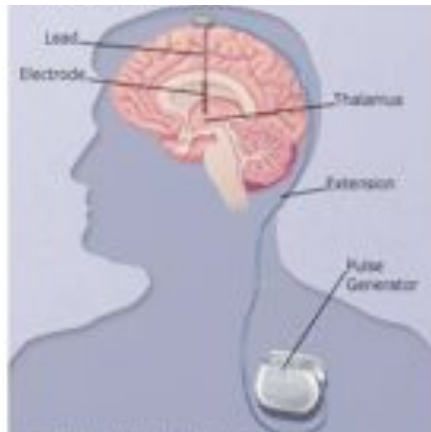
# Deep Brain Stimulators

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# Deep Brain Stimulation (DBS) and Parkinson's

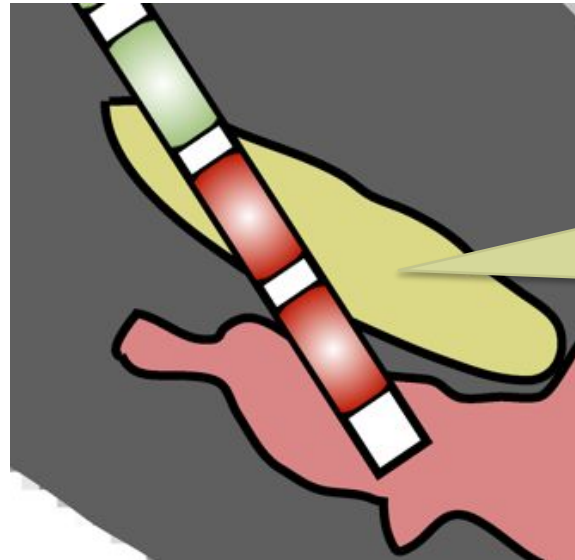
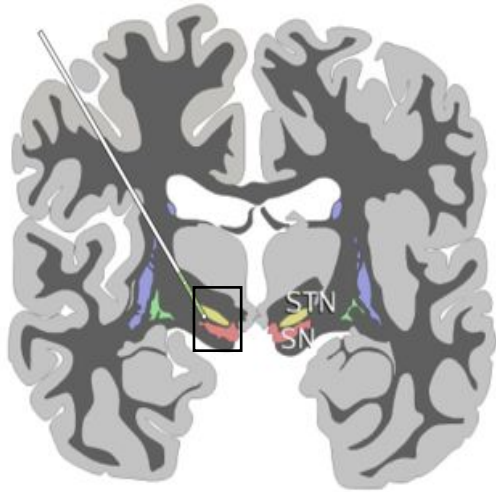
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DBS system

- No known drug cure for Parkinson's; levadopa loses efficacy after 5 to 7 years
- DBS approved for treatment of Parkinson's disease in 1997
- 50,000+ patients treated to date with Parkinson's and other movement disorders

# DBS Targeting



STN/  
Sub-Thalamic  
Nucleus



Existing DBS electrodes

Needs: Technology, Tools,  
Targets

# Limitations with Current Systems

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One-way stimulation – no feedback, measurements, control

Electrodes as large/larger than target regions

Limited signal modulation options

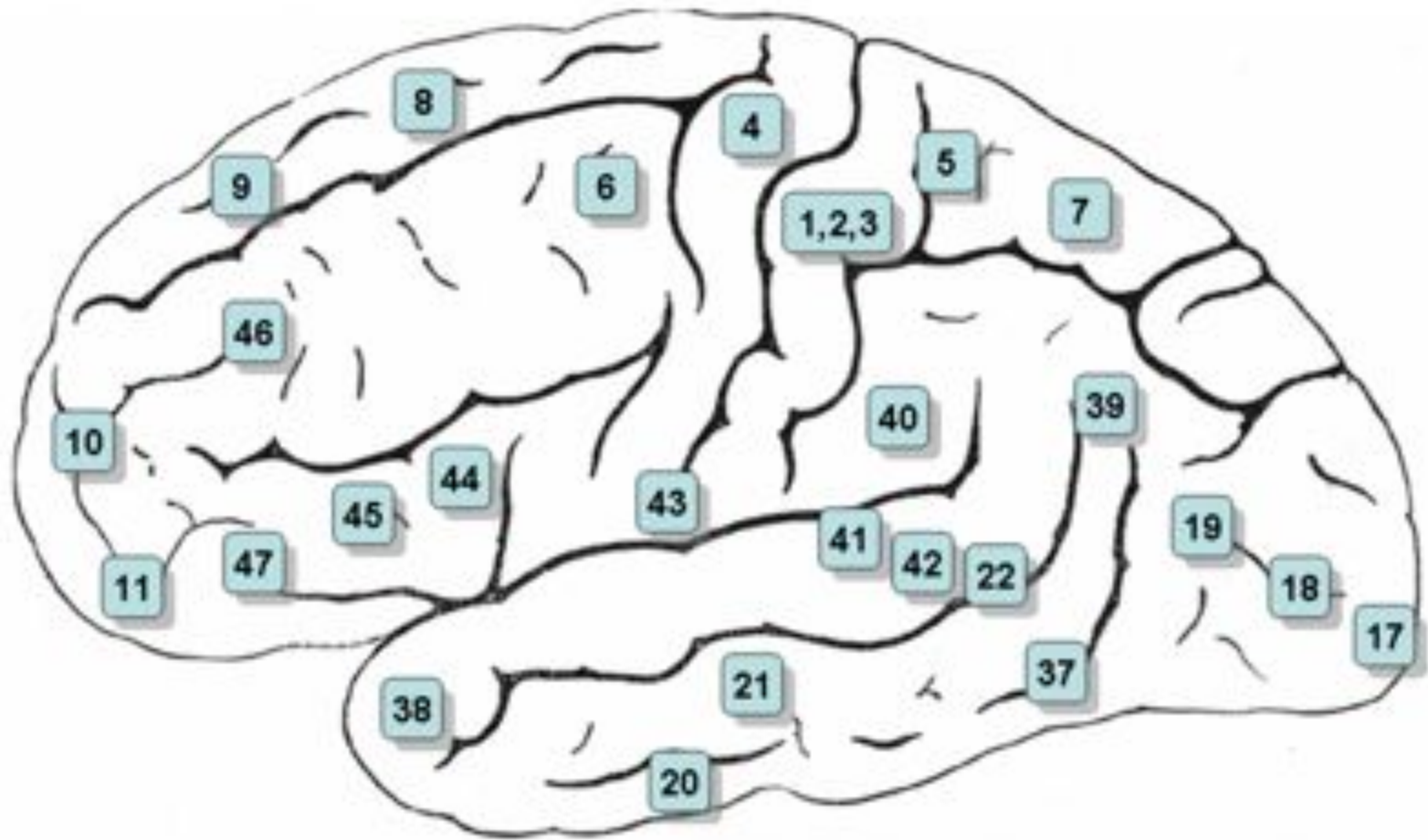
Limited adjustments post-surgery

# Neurosurgical Systems

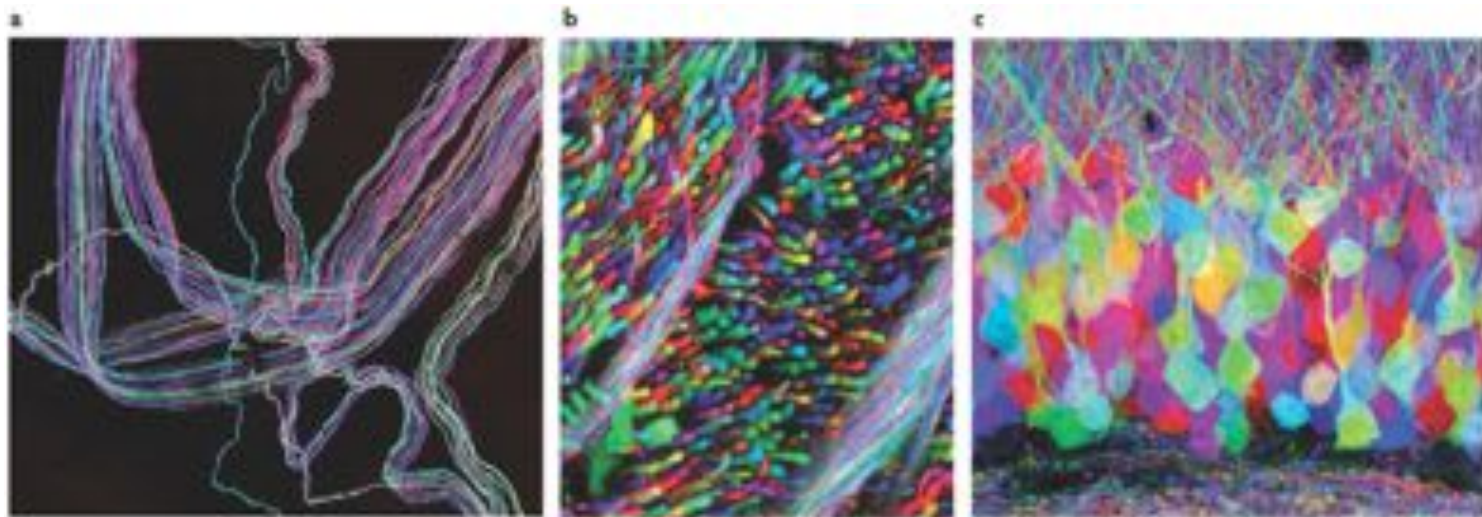
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# Brodmann's Brain Map

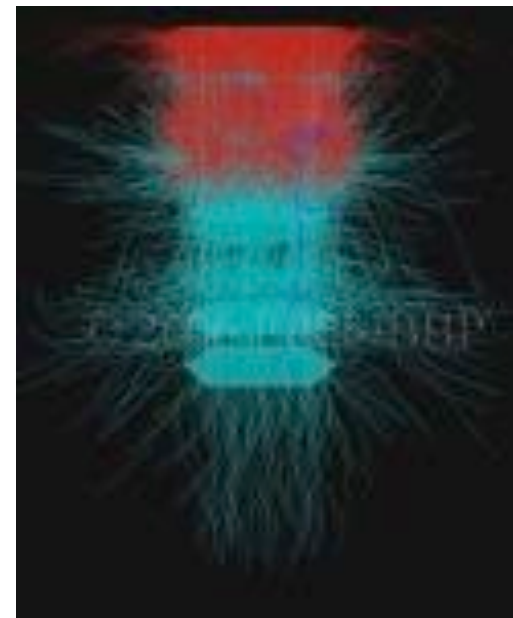


# Genetic Tools for Brain Mapping



Nature Reviews | Neuroscience

Jeff Lichtman, Harvard



# Recent Clinical Demonstrations in DBS

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Drug-resistant depression (St. Jude/ANS U.S. clinical trial enrollment)

Epilepsy (U of Lausanne, U of Leuven)

Memory recovery in Alzheimer's patients (U of Toronto)

Revival of patients in minimally conscious states (Cleveland Clinic, others)