Electrophysiology & Neurochemistry Sensor for Stroke Studies

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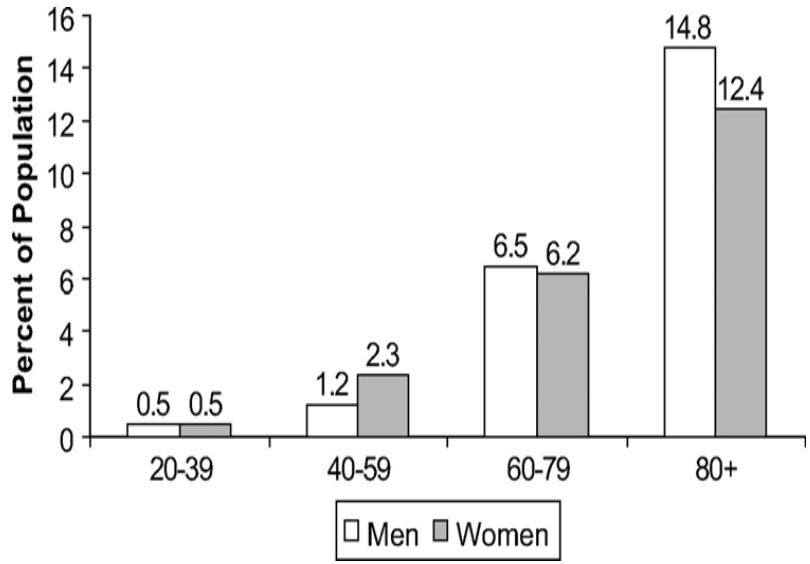
Purpose of Study

- To better understand the complex electrophysiological and neurochemical changes during stroke
- Developing a sensor that detects the various spatiotemporal changes that occur in neural tissue during and after stroke
- In the future the research will help with rehabilitation after stroke by possible electrical and chemical stimulation of neural tissue surrounding the stroke

I mpact of Stroke in the U.S.

American Stroke Victims

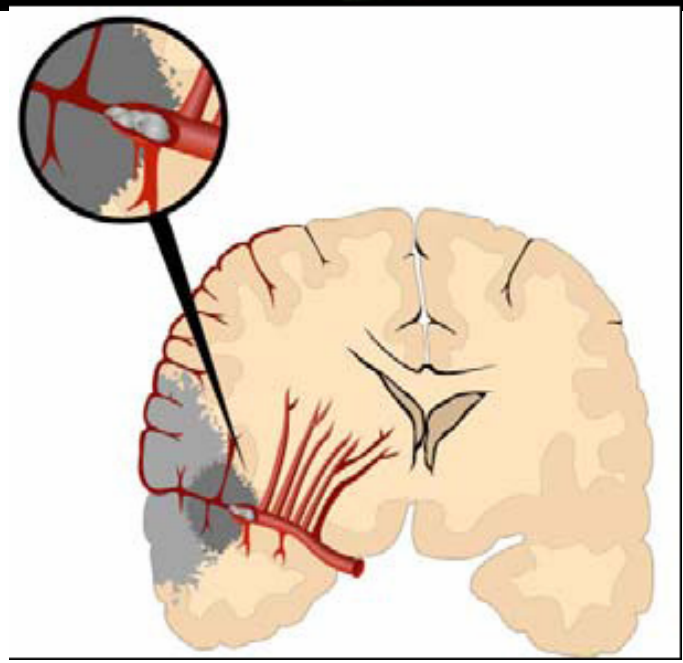
- 700,000 people suffer annually
- 150,000 people killed each year
- 3rd leading cause of death behind heart disease and cancer
- Annual economic burden of $62.7 billion



American Heart Association: Heart Disease and Stroke Statistics – 2007 Update; Rosamond, W. et al. Circulation 2007;115:e69-e171

What is a Stroke

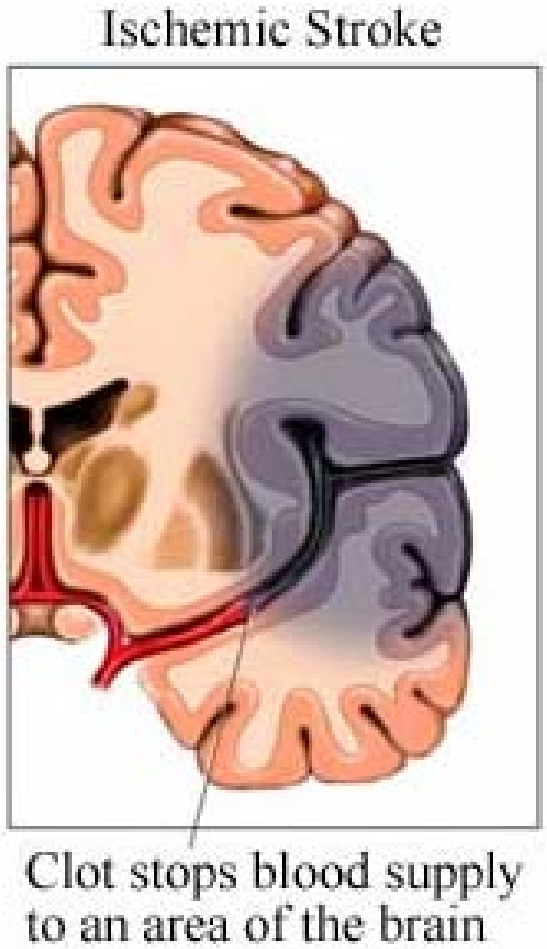
- Damage to the brain
  - Ischemic Stroke
  - Hemorrhagic Stroke
- Outcomes of Stroke
  - Death – 24%
  - Loss of one or more normal functions
    - Permanent – 15-30%
    - Temporary – 50-70%
- Focus on Ischemic Stroke



American Stroke Association, Stroke Treatment; http://www.massgeneral.org/vascularcenter/page.asp?id=stroke

http://www.hmc.psu.edu/neurosurgery/services/diseases/Stroke.htm

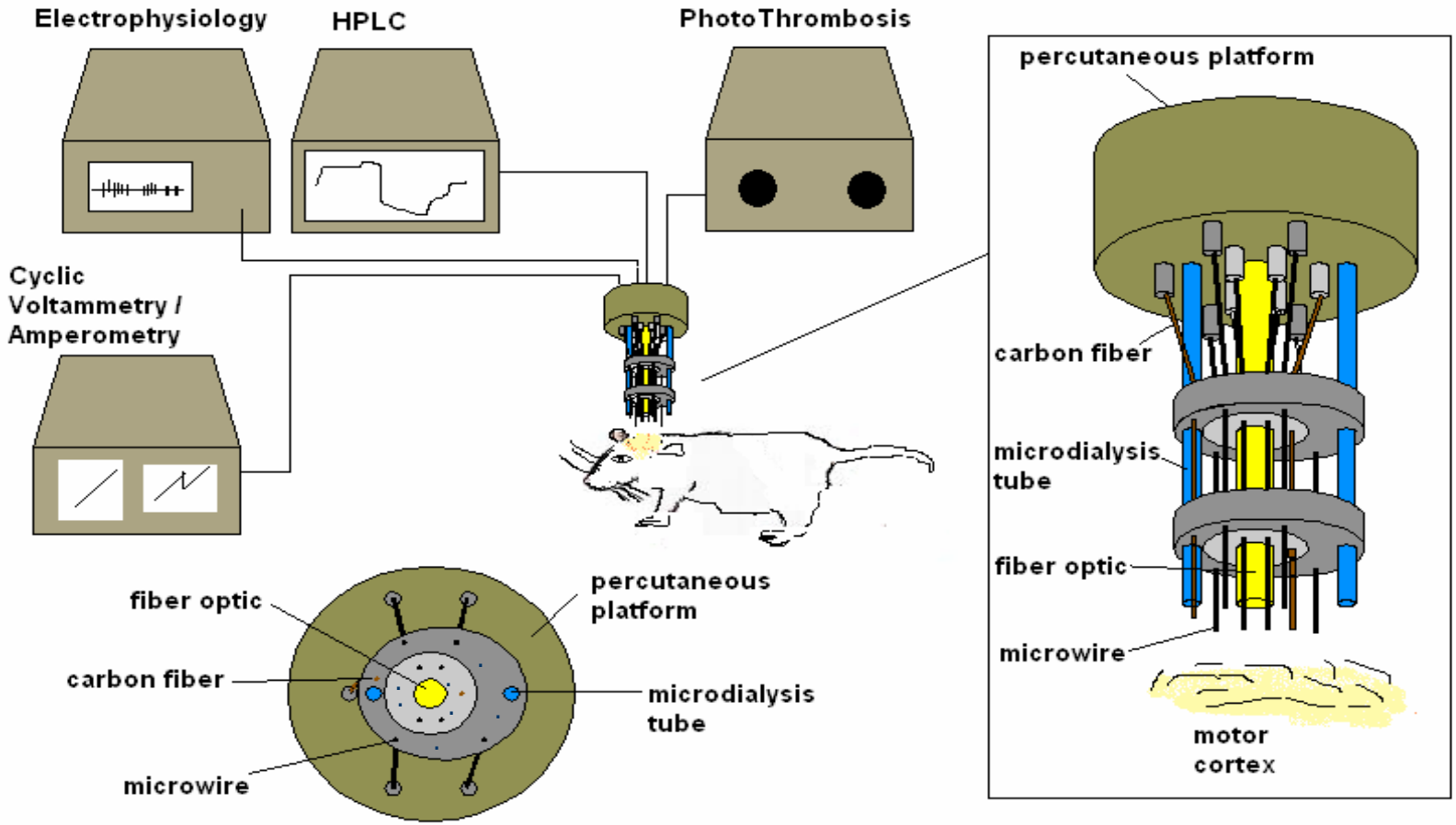
Stroke Treatment



- Tissue Plasminogen Activator (tPA)
- Thrombolytic drug: Dissolves clot & restores blood flow
- 1-3% of stroke victims are eligible
  - Therapy started within 3 hours of stoke onset
  - Increased risk of bleeding into the brain

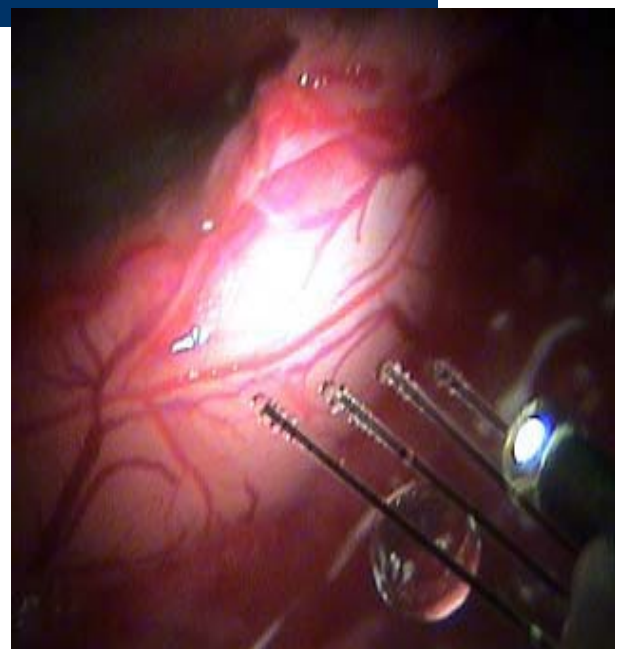
American Stroke Association, Stroke Treatment; http://www.massgeneral.org/vascularcenter/page.asp?id=stroke

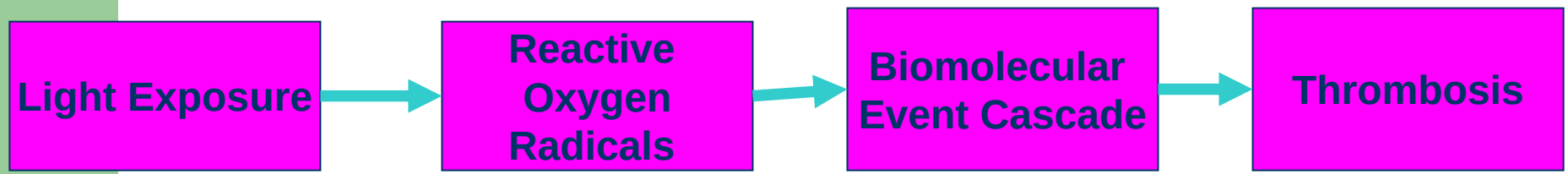
Proposed Device



Fiber Optic Probe to Induce Stroke

- Use micromanipulator to position fiber optic light probe
  - Precise target location
  - Ischemia size control
- Illumination for 20 min following dye injection

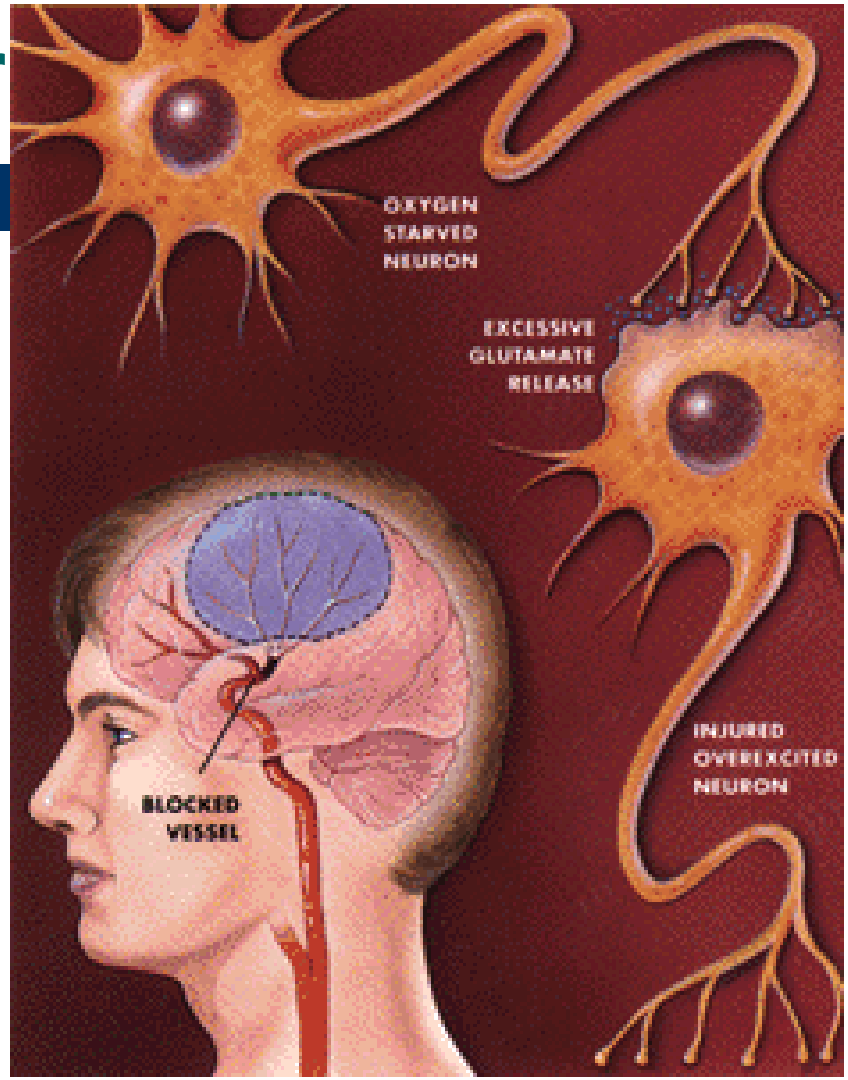




Comparative Electrophysiological Response Dynamics During Stroke, Terry C. Chiganos, PhD Thesis (2006)

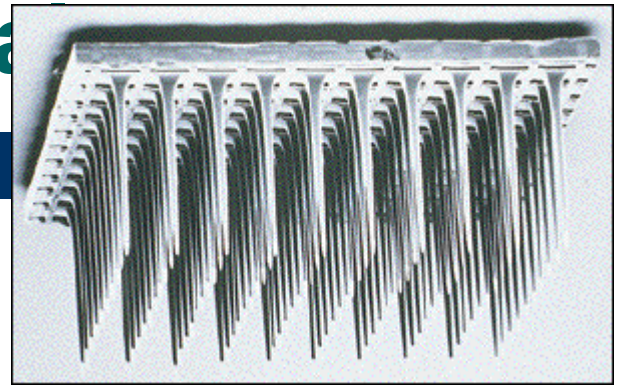
Neurotransmitter

- Microdialysis technique to collect samples
- HPLC technology to identify and quantify specific neurotransmitters
- Create a spatial and temporal “roadmap” of neurochemical changes

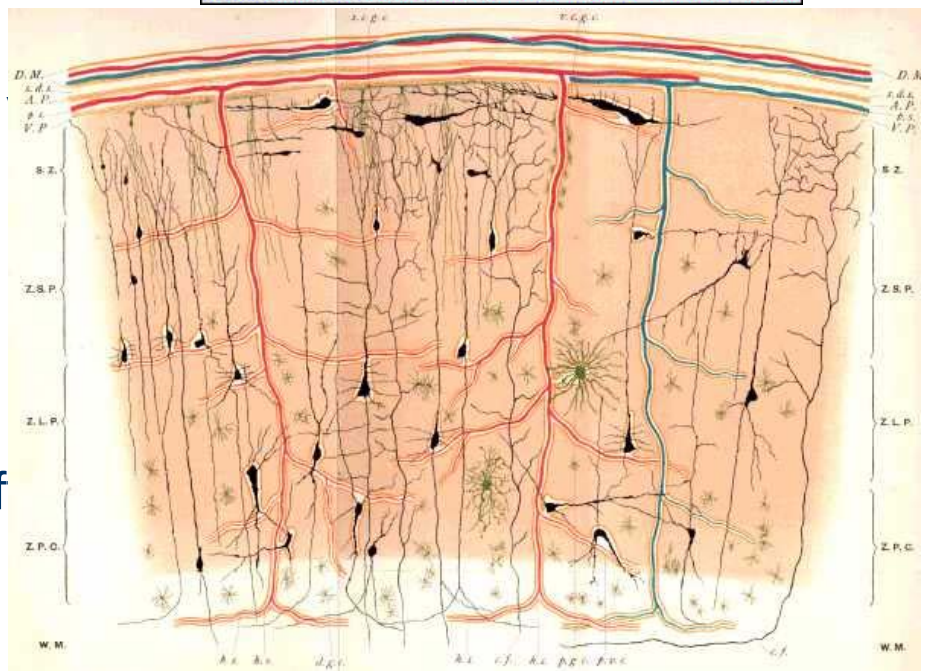


http://www.sfn.org/index.cfm?pagename=brainBriefings_nMDAReceptorBlockers

Electrophysiologica

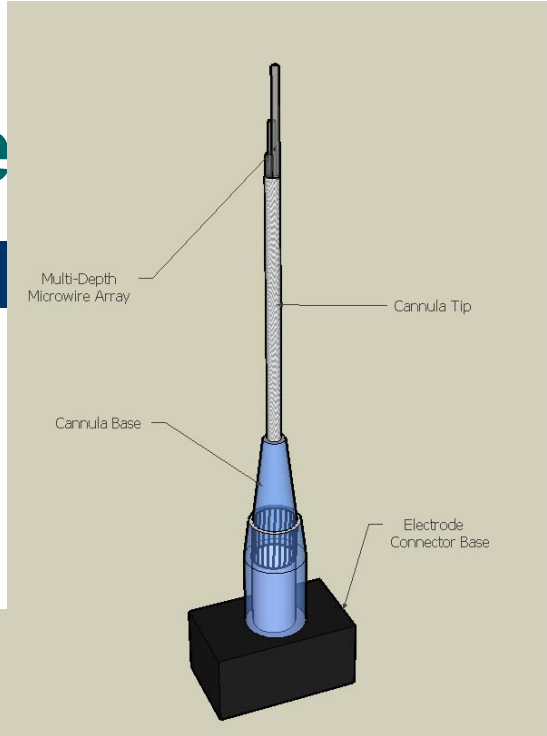


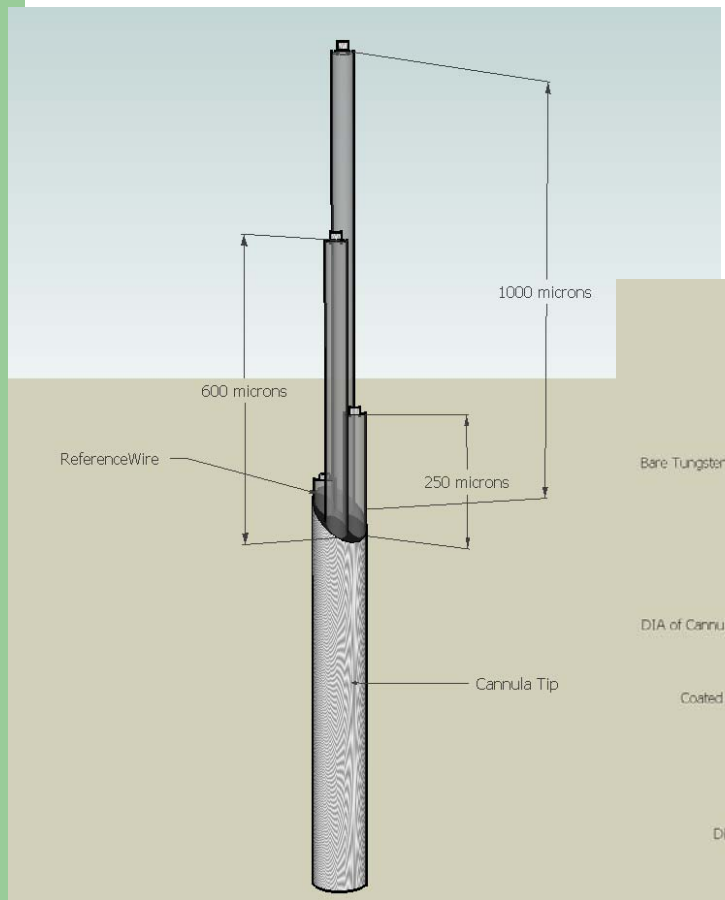
- Microwire electrodes
  - Multiple lengths
  - Different Brain Layers
    - II/II “integrating” and “output”
- Brain Signals
  - Amplified
  - Analyzed using TDT
  - Before, During, and Af Stroke

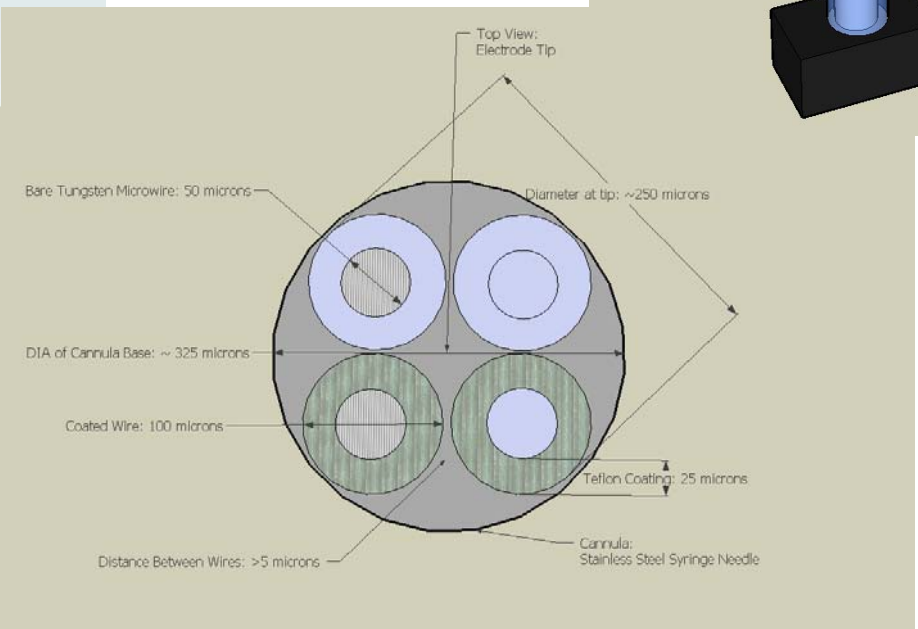


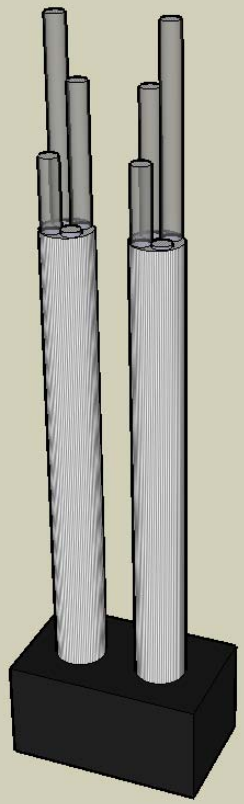
http://brain.web-us.com/brain/PhysiologyOrdinaryConsciousness.htm

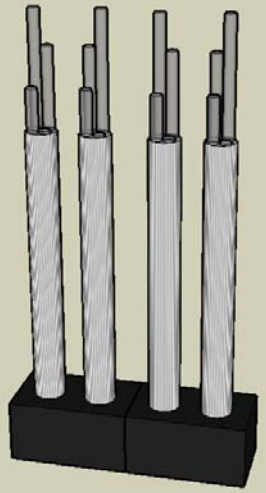
Prototype Electrode

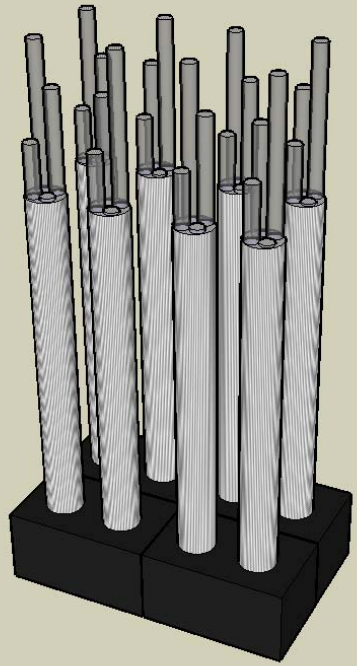


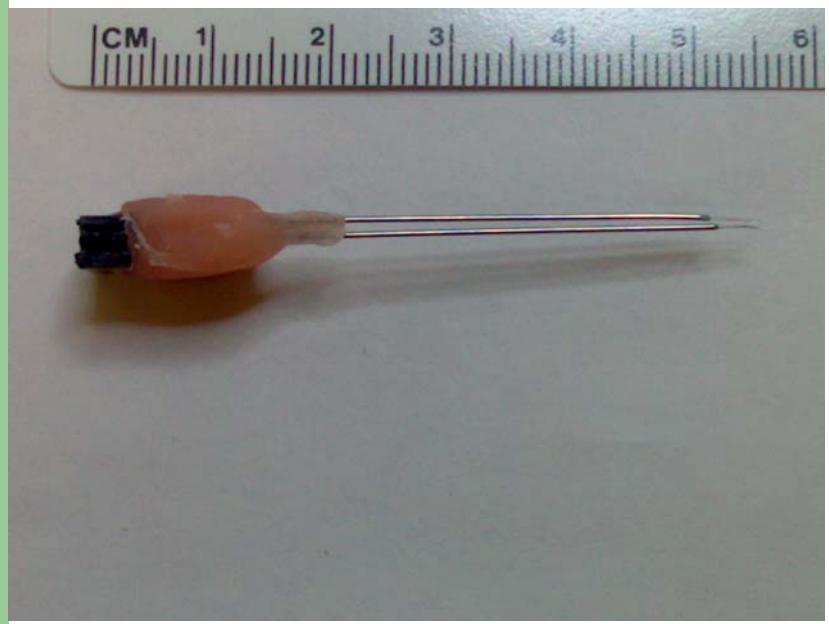








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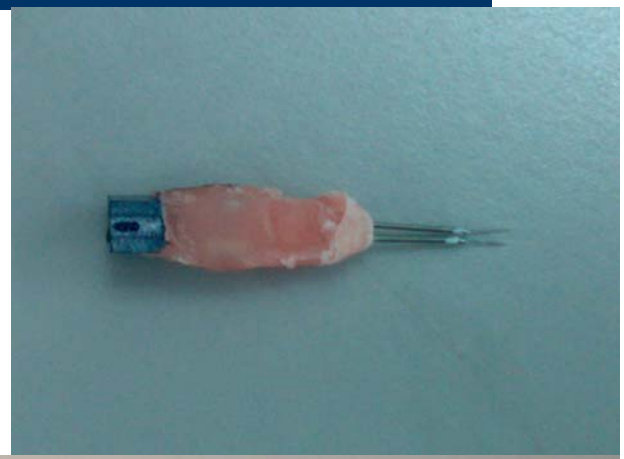
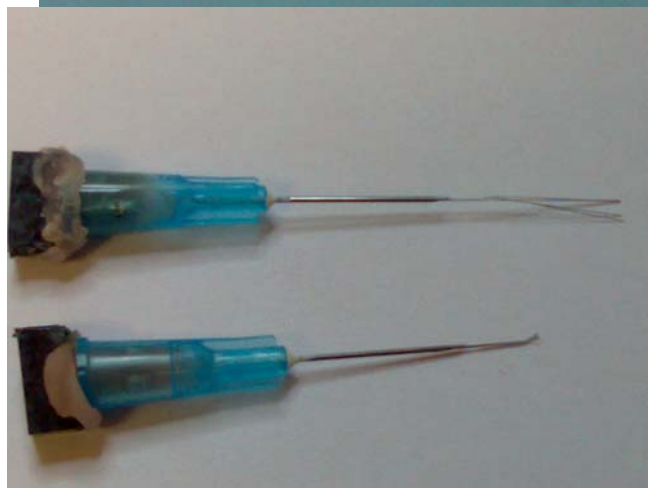




Cranial Window Prototype

- Attached to the skull of the rat
- Incorporates
  - Microdialysis
  - Multi-depth microwire electrode array
  - Cannula for photo-thrombosis fiber optic
- Made using 3D printer
  - Dimension Elite

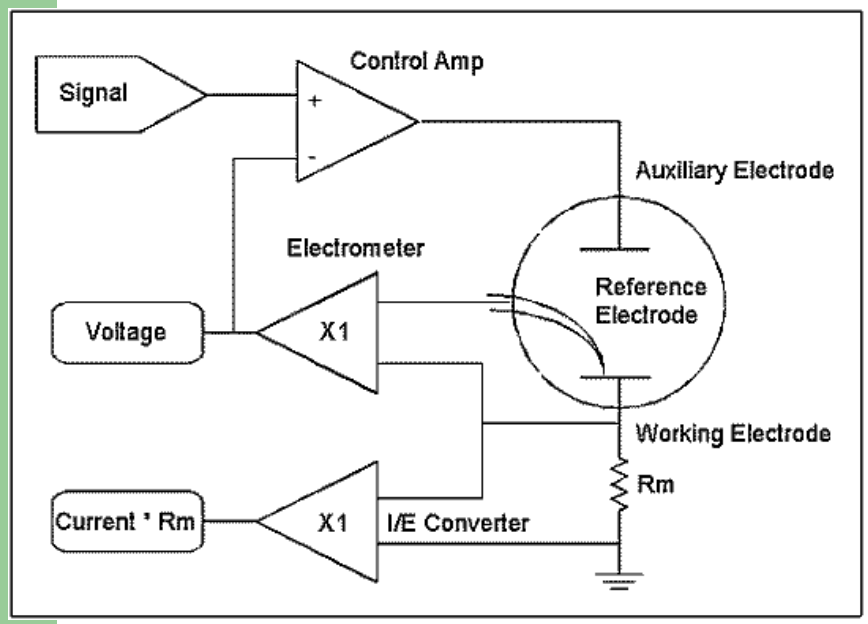
Electrochemical Impedance Spectroscopy

- Electrochemical impedance spectroscopy (EIS)
  - powerful technique for the characterization of electrochemical systems
    - Applications in the field of materials characterization
    - Tool for investigation of mechanisms involving passivity and localized corrosion studies
    - Evaluating properties of surface modified and coated materials
- Like Resistance, Impedance is a measure of the ability of a circuit to resist the flow of electrical current

Ohms Law: $V = IZ$ where V is Voltage, I is Current, and Z is Impedance

http://www.metrohm.com.sg/other-products/eco-pgstat302.jpg

How EIS Works



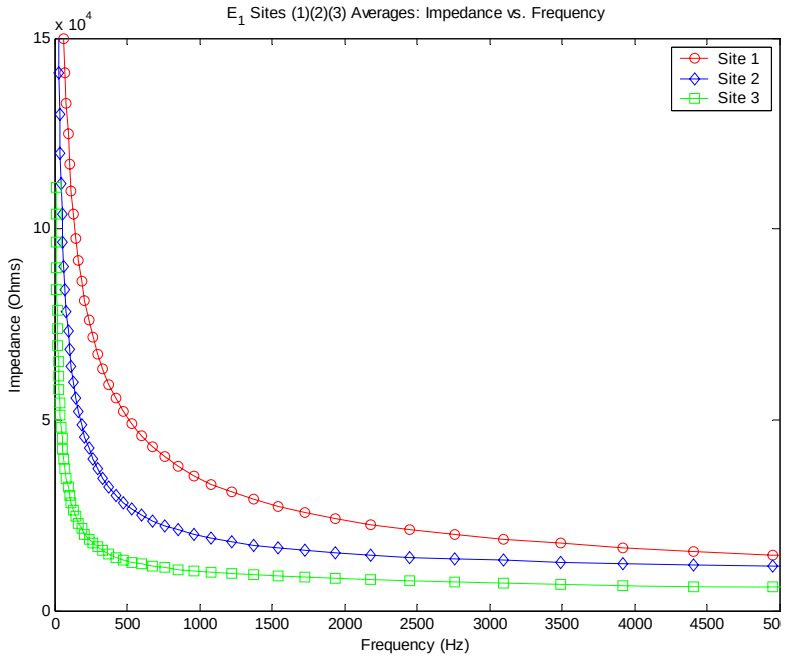
- Potentiostat or Galvanostat
- Potentiostat: Sets up a voltage between working and reference electrode, measures current in the cell
- Galvanostat: Sets up a current between the two electrodes, measures potential of the cell
- Impedance is then calculated Z = V/I

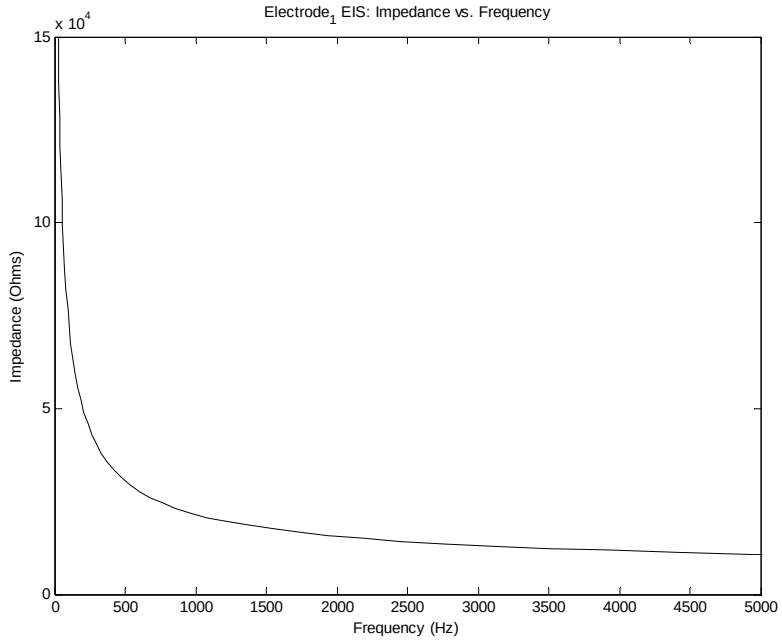
http://www.gamry.com/App_Notes/EIS_Of_Coatings/EIS_Of_Coatings.htm

Electrochemical Cell

- 3 electrodes in electrolyte liquid
- Working Electrode
  - Electrode under study
  - Point at which the voltage is controlled and current is measured, or visa versa.
- Reference Electrode
  - Constant electrochemical potential when no current flows through it
  - Used in measuring working electrode potential
  - Typically Ag/AgCl or Saturated Calomel Electrode (SCE)
- Counter (Auxiliary) Electrode
  - Conductor that completes the electrical circuit of the cell
  - Inert conductor like platinum or graphite
- Electrodes emmersed in electrolyte solution
  - PBS – Phosphate Buffer Saline

EIS Data for First Electrodes

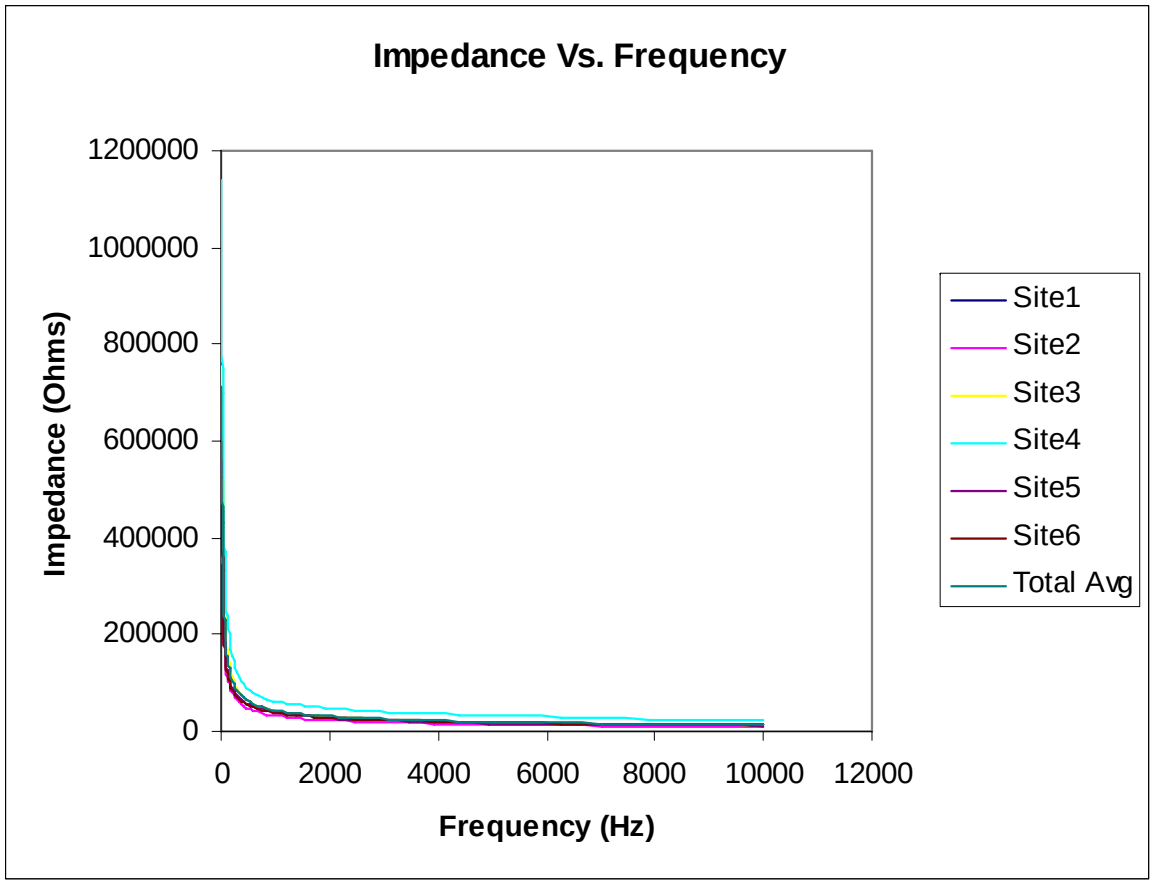




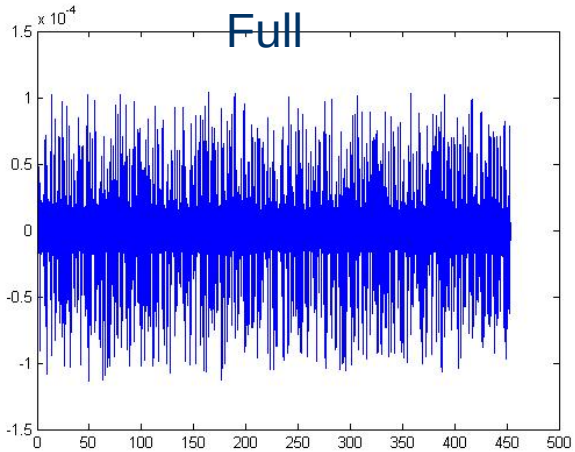
Recording electrodes: Low impedance necessary

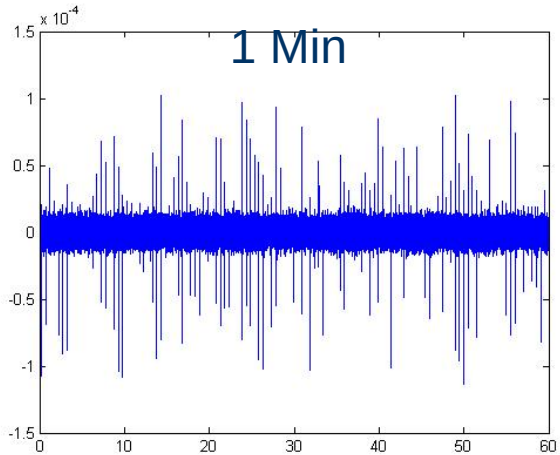
Stimulating electrodes: High impedance is preferred

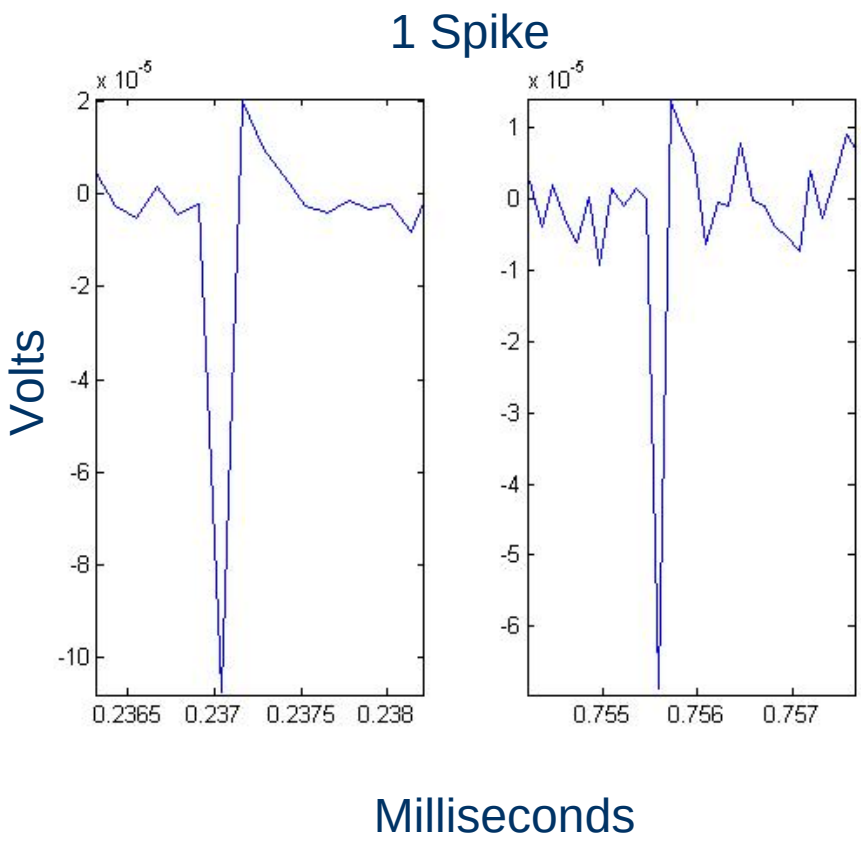
EIS Data for Redesigned Electrode



TDT Data from Electrode Array







Conclusion

- Purpose of study is to better understand the complex spatiotemporal events that occur during a stroke and during the recovery process
- Sensor will give us a tool to quantitatively look at what happens to neural tissue
- Allow for more affective treatment of stroke in the future
  - Aide in rehabilitation
  - Prevention of the devastating damage during stroke

Acknowledgements

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