Cooperative Microsystems

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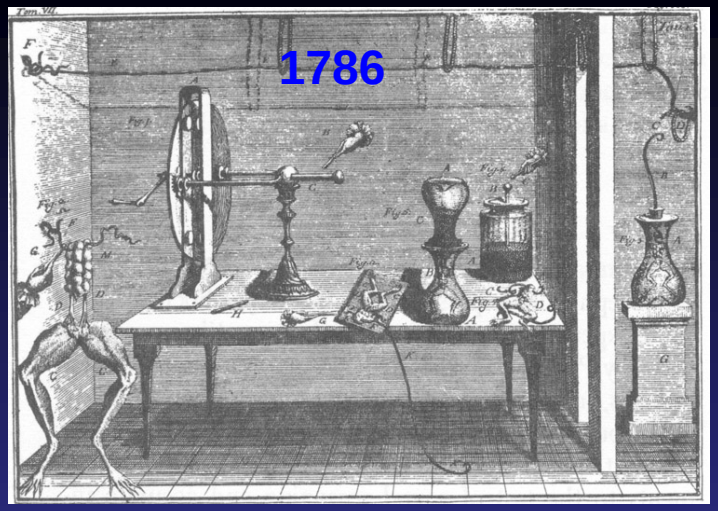
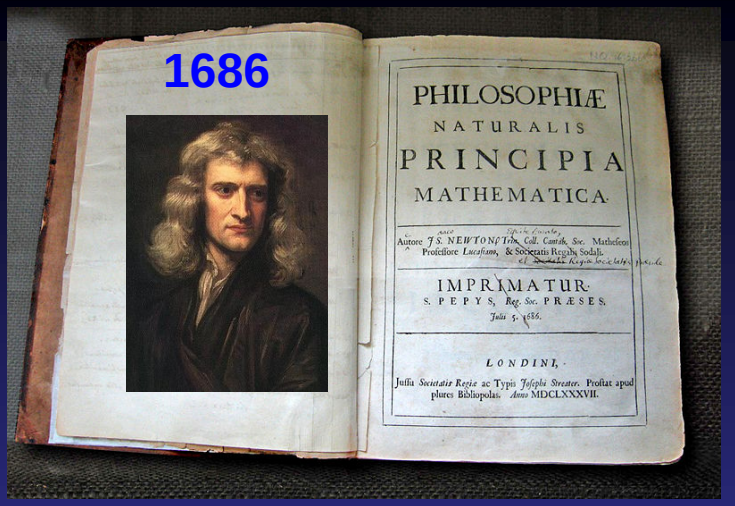
Cooperative Microsystems and Neural Interfaces





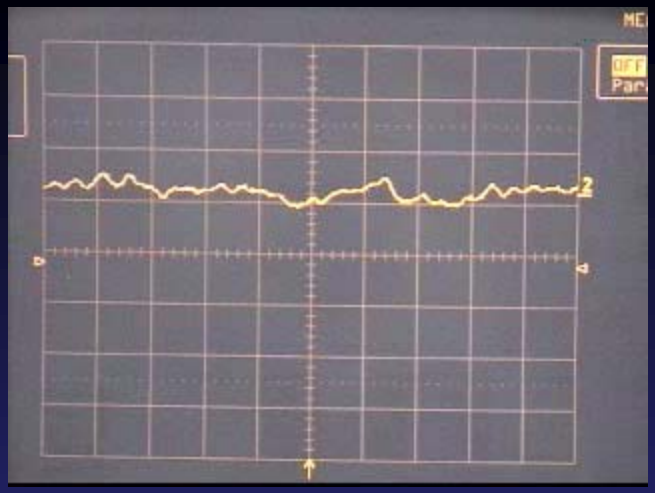
Joseph J. Pancrazio, PhD
Program Director
March 4, 2009

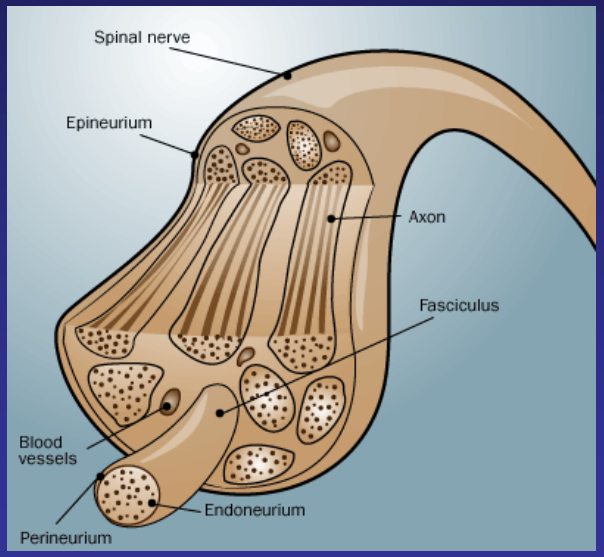
Google “Neural Prosthesis Program”

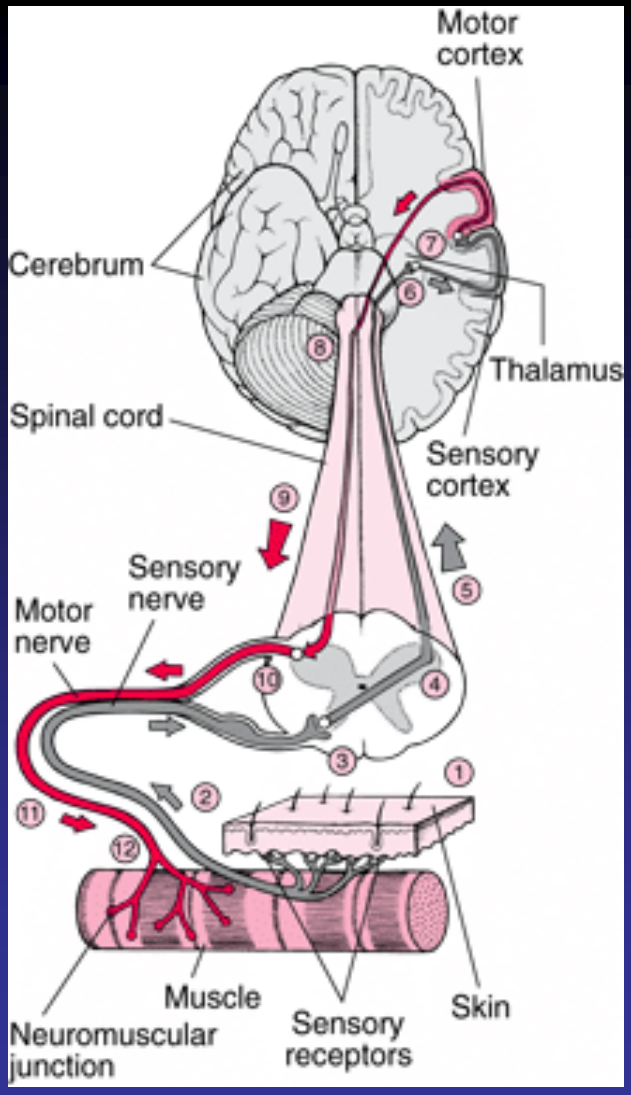
Outline

- Signaling in the Nervous System
  - Signal sources of cortex and peripheral nerve
- Clinically Useful Neural Interfaces
- Cortical Recording Arrays
- Peripheral Nerve Interfaces
- Challenges and Opportunities for Microsystems in New Neural Interfaces

Signaling in the Nervous System



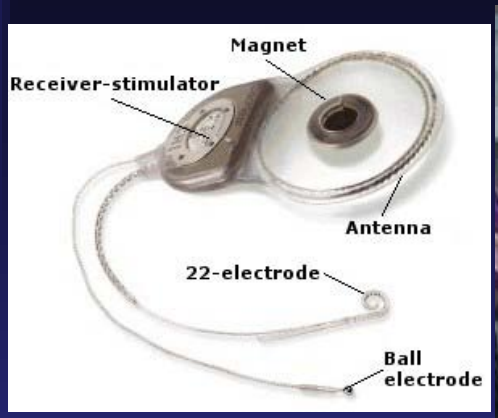




Control signal sources at the level of motor cortex and peripheral nerve

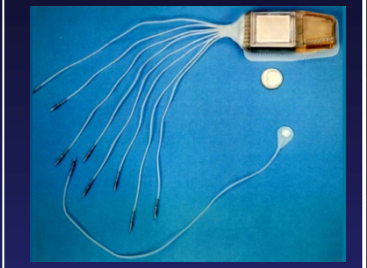
Clinically-Relevant Neural Interfaces

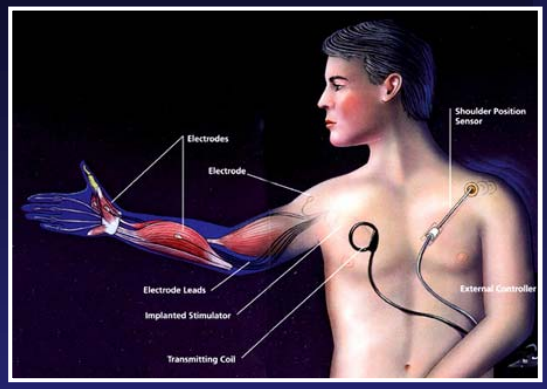
Neural interfaces have already provided substantial benefits to individuals.



Cochlear Ltd. Nucleus® 24 cochlear implant system

Cochlear Prosthesis bypasses damaged hair cells in the auditory system by direct electrical stimulation of the auditory nerve. 60,000 world-wide



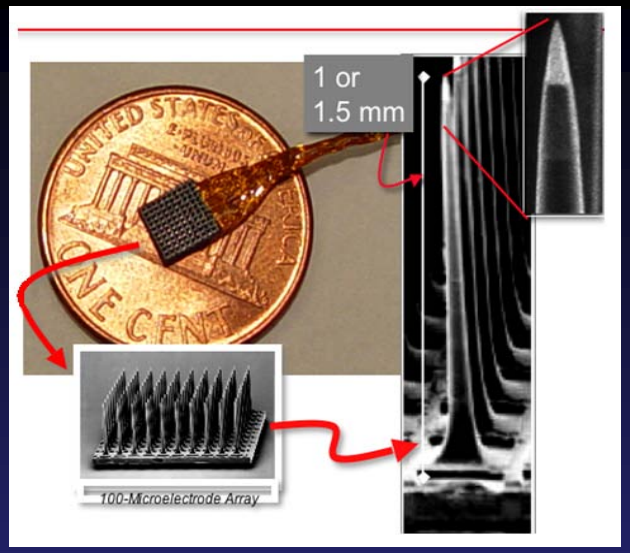


Case Western Reserve University, Cleveland, OH

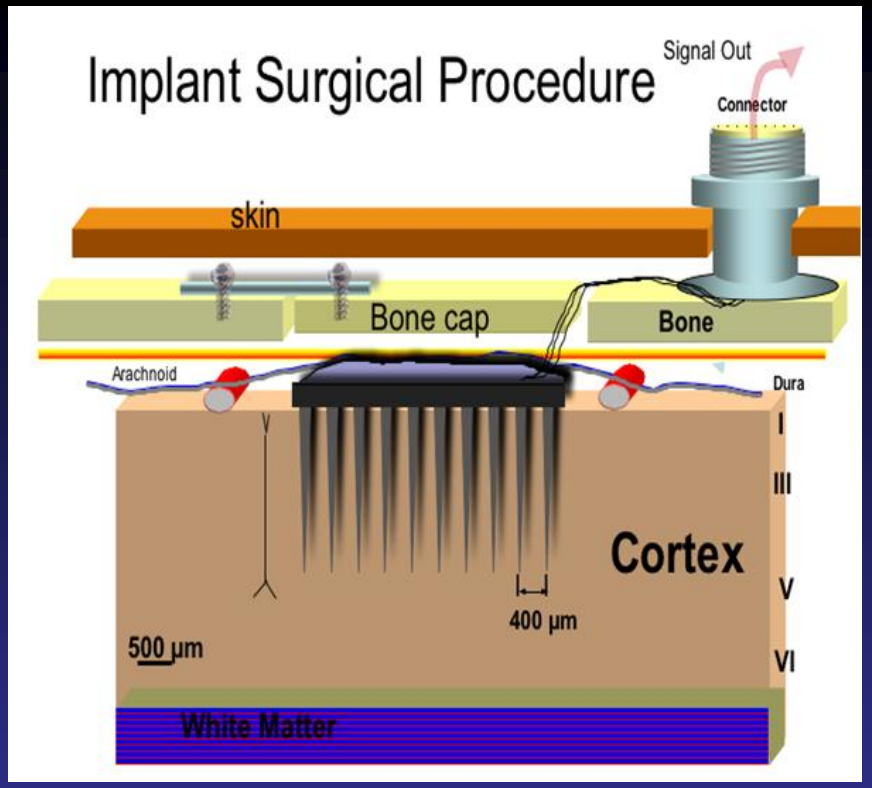
Functional Electrical Stimulation has been used to restore motor function in paralyzed individuals. e.g., Upper- and lower-extremity, bladder.

- Neural Interfaces for restoring neurological function via electrical stimulation
- Cortical recording arrays and the peripheral nerve interfaces?

Cortical Recording Arrays



Design inspired by biology?



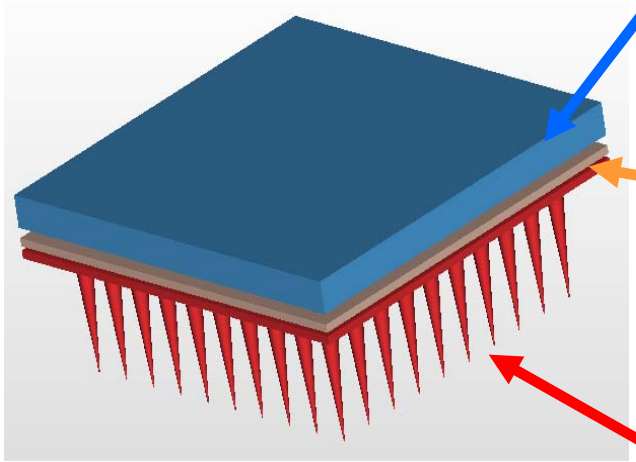
Critical Issue – tethering forces

- Pedestal connector, wireless system
- Cable flexibility and scalability

Cortical Array Microsystems

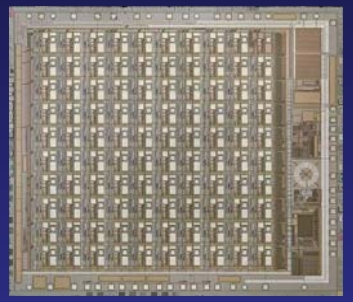
F. Solzbacher, University of Utah – K. Shenoy, Stanford

Performance Specifications
100 recording sites, integrated spike detection, 6 months capability

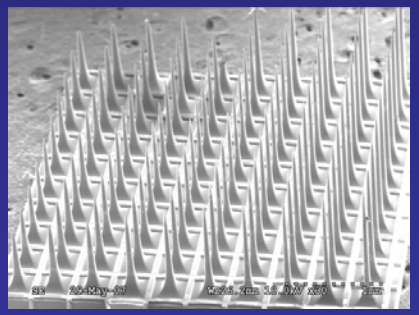


Thin film fabricated gold-on-polyimide coil for wireless power/data transfer

Integrated amplifiers, signal processing & RF telemetry electronics VLSI ASIC



Microelectrode array

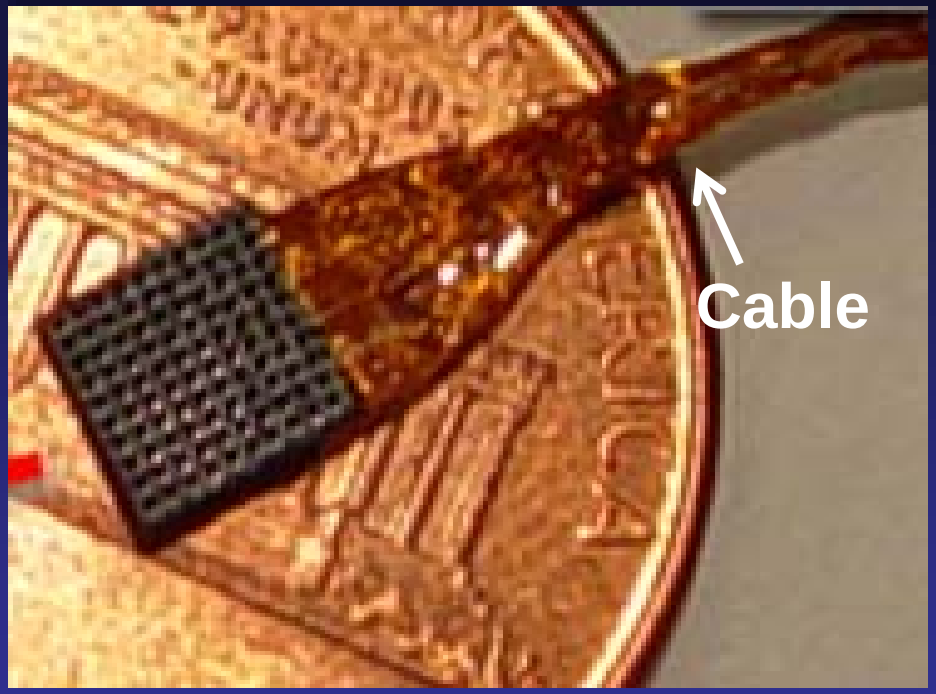


- Demonstrated wireless operation of implanted chip in non-human primates.
- Research platform for freely behaving non-human primates; pre-clinical technology

Cortical Array Microsystems

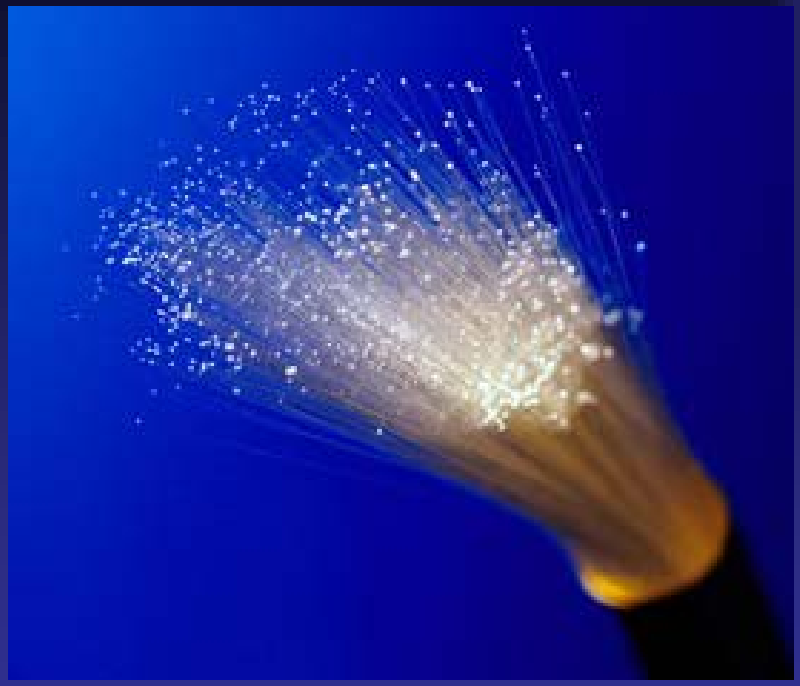
Critical issue:

Cable flexibility & scalability – limit to how many leads you can pack.



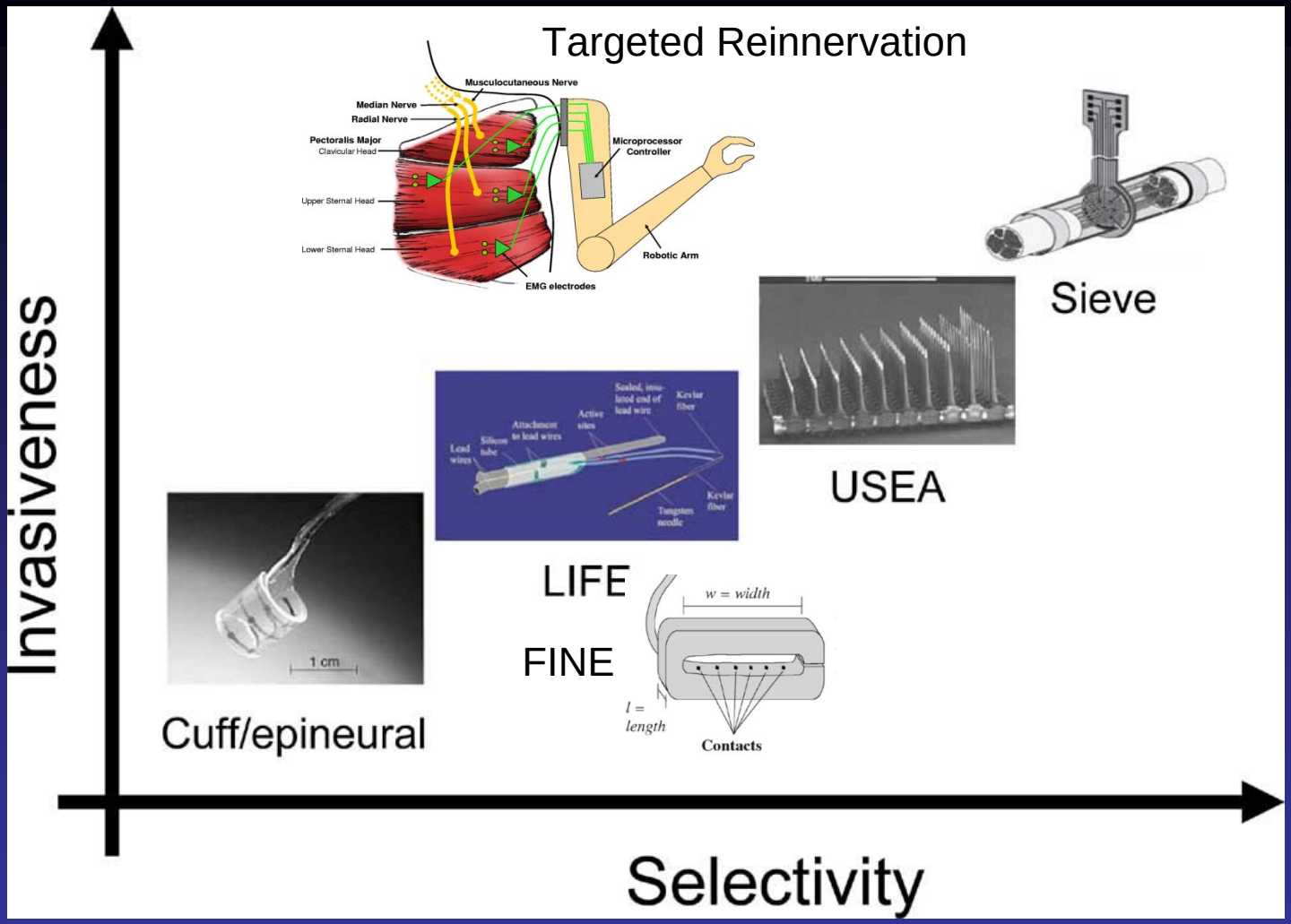
Possible Approach:

Collapse cable into a single biocompatible optical fiber.



Challenge: develop and demonstrate low power multi-channel data acquisition chip to multiplex data onto one optical fiber

Peripheral Nerve Interfaces



Adapted from IEEE Trans Neural Syst Rehab Engin 16: 453-472 (2008)

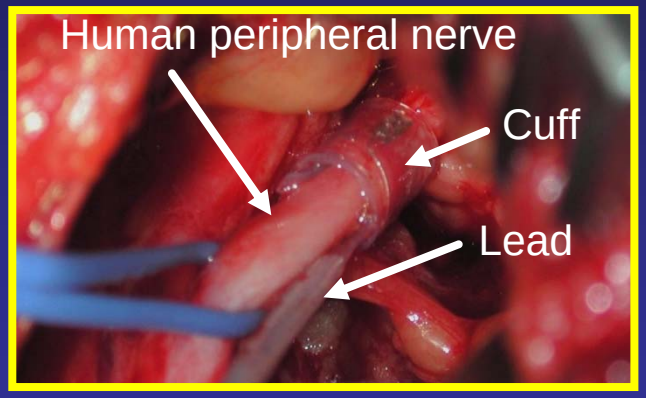
Peripheral Nerve Microsystems

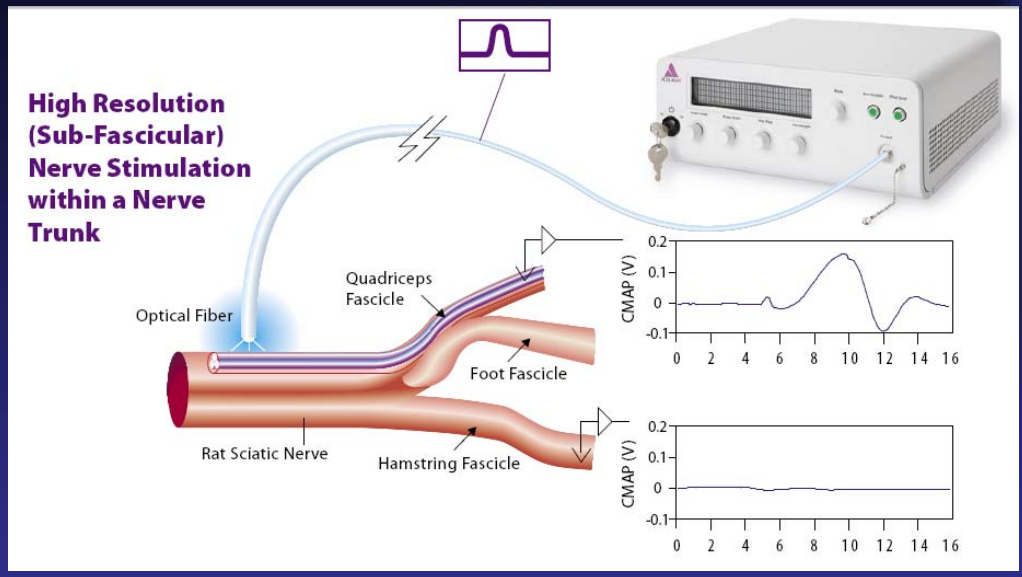
Critical issue:

Lack of spatial selectivity with electrical stimulation of cuff electrodes

Possible Approach:

Optically-based stimulation – use spatial selectivity of light





Infrared pulses, λ=4 μm, <1J/cm^2

From *Optics Lett.* 30: 504-506 (2005) – Vanderbilt & Aculight

Challenge: implement flexible cuff electrodes that incorporate multiple light sources

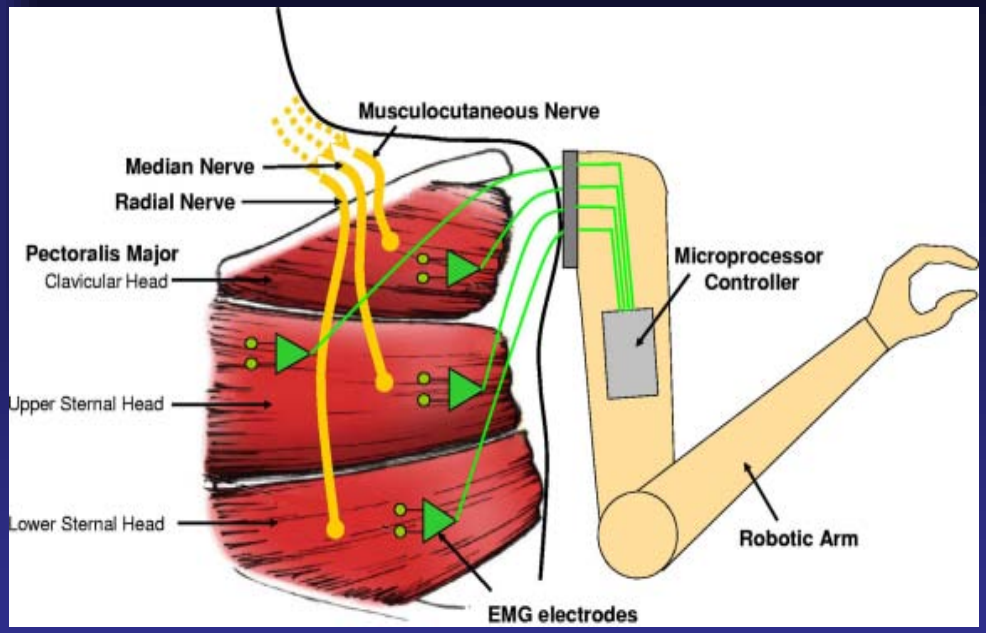
Peripheral Nerve Microsystems

Critical issue:

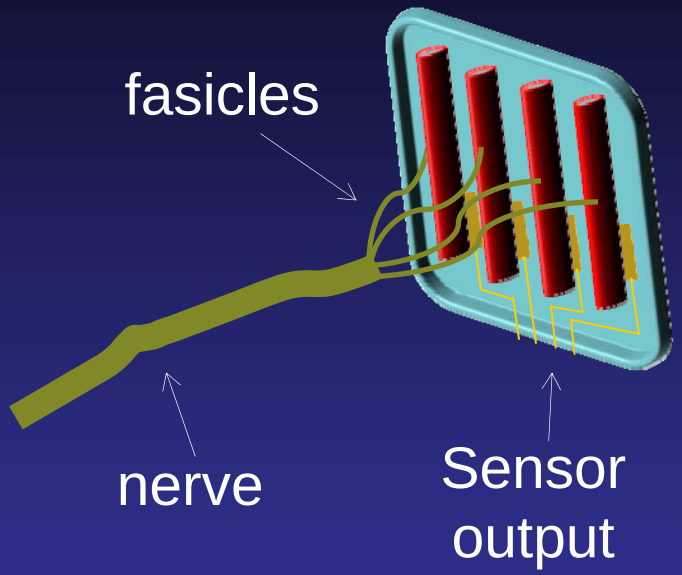
Selectivity of targeted reinnervation limited to donor muscle constraints

Possible Approach:

Microscale reinnervation; device integrated muscle fibers



From *J Neurophysiol* .98:2974-2982 (2007)



Challenge: develop microelectrode/microactuator integrated 3D structures that maintain myofiber integrity and nerve viability

Summary

- Neural Interfaces - applications
- Opportunities and challenges for integrating microsystems in neural interfaces:
  - Optical technologies
  - Microscale targeted reinnervation
- Emergence of computational neuroscience systems biology – eventually will result in predictive models of biological that facilitate the design of interactive microsystems.

Thank you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