Neurosurgical-Bioengineering Development Initiative

A Call for Applications

Paired Translational Research Proposals

Department of Neurological Surgery and McCormick School of Engineering

Northwestern University

Background and Rationale

Northwestern's Department of Neurological Surgery has an excellent reputation in the application of novel neurosurgical procedures, with nationally recognized programs and clinical leadership in each of the subspecialties of brain and spine surgery. The Department's faculty recognize the incredible opportunities to expand these capabilities through the application of new and cutting-edge technologies (e.g., photonics, nanotechnology, computer and materials science, robotics, molecular imaging etc.). These could enhance existing procedures, provide novel solutions to clinical problems or serve as platforms for novel therapeutic interventions.

Yet many of the most promising technologies are new, and unfamiliar to those outside the physical and engineering sciences, and partly because most neurosurgeons have not been exposed to emerging technologies, especially ones whose usefulness hasn't yet been shown. At the same time, bioengineers have had limited exposure to clinical problems that need to be surmounted by novel technology, and typically have had no training or experience within the neurosurgical environment where these technologies need to be applied. Familiarity with disease or surgical questions and problems, and access to the surgical environment and human tissue, can promote translational research initiatives and facilitate solutions and applications through emerging technologies.

This is ironic since many technologies that might benefit neurosurgery are unusually well represented in Northwestern's McCormick School of Engineering and Applied Science. These departments also have significant numbers of faculty and students who understand these technologies and are looking for novel ways of implementing them. A mechanism to facilitate translational program development among bioengineers and neurosurgeons is recognized as expressly beneficial to both groups. Such programs could build new bridges for technology development and application, and create a new collaborative environment for the training of a future generation of neurosurgeons and bioengineers who are more facile and skilled at collaborative research integrating both environments.

The Departments of Neurological Surgery and the McCormick School of Engineering at Northwestern University have explored a number of potential mechanisms to enhance collaboration between their faculty and trainees. They have recognized that faculty in both departments are currently working on technology and applications that are imminently braced for translation and collaborative application. They have also recognized that current funding mechanisms require demonstration of preliminary work that has already bridged the two environments and has demonstrated a working collaboration. Toward this end, we hereby announce a novel initiative aimed at pilot funding of joint projects, pairing faculty from Neurological Surgery and McCormick.

This new initiative will provide full time funding of salary and benefits for a postdoctoral fellow (1.0 FTE at current NU rates, commensurate with experience) and modest research expenses ($ 7,500 per year), working under the joint mentorship of a paired neurosurgery and bioengineering faculty for one to two years, focusing on a specifically articulated research project. The project may involve novel applications to solve specific neurosurgical problems through new technologies, or address basic questions in neuroscience. The use of expertise and resources of the University is strongly encouraged. The project should articulate a hypothesis, specific aims, and methods with the goal of generating preliminary data in support of applications for extramural funding.

Research Opportunities in Neurological Surgery at Feinberg School of Medicine

Neurological surgeons deal with some of the most catastrophic and disabling conditions facing human beings. These conditions range in scope from head and spinal injury, to stroke (hemorrhagic and ischemic), to neoplasms of the nervous systems and its supporting structures, and to degenerative conditions of the brain, spinal cord, and the spinal column. This broad spectrum of illness levies an enormous impact on society with lost years of productivity and family life, and on our economy due to these losses and the costs of catastrophic care and chronic maintenance for survivors. Fundamental to the mission of the Department of Neurological Surgery is that it is our responsibility to ensure that future generations of physicians will have better weaponry with which to attack these diseases. Research opportunities and resources are committed in the following areas:

1. **Diseases of the spine**
   Degenerative, traumatic, and neoplastic diseases of the spine including their impact on neurologic function, posture, and quality of life. Strategies for prevention of and recovery from paralysis and pain due to spinal injury and disease.
2. **Neurovascular biology, stroke and brain injury**
   Vascular diseases causing hemorrhagic and ischemic stoke. Brain tolerance to injury and mechanisms of brain protection from trauma, stroke, systemic and neurologic illness. Optimizing outcome from stroke and traumatic brain injury.
3. **Brain tumors and neurosurgical oncology**
   Benign and malignant tumors arising from or spreading to the brain and spine, and optimal strategies for their diagnosis and treatment.
4. **Functional and restorative neurosurgery, epilepsy, movement disorders and pain**
   Diseases affecting abnormal movement, neurologic function and pain, and optimal strategies for their management. Modulation through targeted stimulation, lesioning or therapeutic delivery to enhance function, inhibit pain or seizures, or enhance recovery from neurologic injury.
5. **Developmental neurobiology and pediatric neurosurgery**
   Diseases affecting the developing nervous system. Unique strategies for the diagnosis and treatment of infants and children with congenital or acquired neurologic diseases and injury, and their impact on future development and quality of life.
6. **Image Guidance and Neuronavigation**
   Neurosurgeons often use a surgical microscope during the conduct of microsurgical procedures on the brain and spinal cord. Contemporary technology in neuronavigation is

relatively crude (stealth). A great opportunity for collaboration concerns better ways of navigating intraoperatively as well as better ways of displaying navigational data to the surgeon through his or her eyepieces. It is very counterproductive to have to turn completely around away from the patient to look at a flat screen. Three-dimensional imaging would be spectacular and could be displayed to the surgeon much as a fighter pilot sees data in his goggles.

Research Opportunities in Bioengineering at Northwestern University

Biomedical research at Northwestern University is well represented in the McCormick School of Engineering. The Biomedical Engineering Department has the broadest range of expertise and interest, but other McCormick Departments, including Chemical and Biological Engineering, Mechanical Engineering, Electrical Engineering and Computer Science, and Materials Science, have significant and expressed interests in collaborations with practicing physicians and surgeons. The primary research pursued by faculty and students in our program falls into a number of overlapping areas:

1. **MR Imaging and Biophotonics**
   Modalities for imaging structure and function in brain, including anatomical MR imaging, and diffusion tensor imaging, functional MR imaging (fMRI) using the BOLD (blood oxygen level dependent) effect. fMRI can be used to map changes in brain hemodynamics that correspond human brain function.

   Optical methods for imaging and sensing. Technologies include Light Scattering Spectroscopy for non-contact detection of carcinogenesis, polarization spectroscopy and visualization of structures in turbid media, Raman and fluorescence spectroscopy for quantitative *in vivo* and *in vitro* measurement of analytes, and optical coherence tomography.

2. **Computational and Experimental Biomechanics**
   Modeling the biomechanics of the spine, limbs, joints and other hard-tissues. Soft tissue biomechanics and fluid mechnics. Solid-fluid interactions and biotransport. Cell and tissue response to physical stimuli. Tissue morphogenesis.

3. **Biomaterials and Biotechnology**
   Bioinspired synthesis of materials, self-assembly, and polymeric biomaterials. Targeted delivery of therapeutics, design of *in vitro* cell and tissue culture systems, engineered tissue constructs, molecular engineering. Biofilms.

4. **Biointerfaces and Nano/Micro Fabrication**
   Surface design, modification and characterization. Interactions of cells and tissues with surfaces. Soft lithography and micropatterning, microfabricated sensors and actuators, nanostructured systems for biosensors, cellular and ECM mechanics.

5. **Neural Engineering**
   Systems neuroscience, electrophysiology, sensory motor performance and rehabilitation. Learning and plasticity. Model systems for cognitive, motor and sensory processing, brain-machine interfaces, neuroprosthetics. Computational neuroscience.

6. **Robotics**
   Bioinspired robotics, haptic interfaces, visualization and image registration systems. Robot assisted surgery, virtual environments.

Call for Applications

Paired faculty from the Departments of Neurological Surgery and McCormick School of Engineering holding the ranks of Assistant, Associate or Full Professors are invited to apply. Engineering faculty must be tenured or tenure track, or hold a position otherwise considered "permanent". The application, not to exceed **5 pages excluding CV's**, should address a 1-2 year research plan, and be organized as follows:

1. Project title, anticipated start date and requested duration of support (1 or 2 years), and the signature signifying endorsement by a McCormick Department Chair.
2. Names of neurosurgeon and engineering faculty co-principal investigators, their academic ranks and year of appointment to the faculty at Northwestern. Names and titles of other key co-investigators (an NIH-style biosketch, including other support, submitted as an appendix is preferred).
3. Statement of hypothesis and specific aims.
4. Background and significance of the research to both disciplines, and the co-PI's backgrounds and experience relevant to the project. Include preliminary data, if available here.
5. Research methods, should summarize techniques to be used, specific data to be collected and methods of analysis and interpretation. If human subjects or tissue are to be used, include methods of recruitment or procurement and a brief justification of patient or sample numbers needed. Include a statement that the IRB has approved these procedures, or a statement that such approval is pending. If animals will be used, provide an estimate of the numbers of animals used with and a brief justification. Include a statement that IACUC has approved these procedures or that such approval is pending. Specific roles of the fellow (justifying full time involvement) and each mentor should be clearly stated in relation to the research methods.
6. Future directions should present anticipated findings, potential problems and alternative techniques. A clear plan should indicate how this research will be used to justify a more comprehensive research project including extramural funding to be sought.

Timeline and Mechanism of Review and Funding

Applications should be submitted in pdf format by email to Cynthia Jardiolin CJardiolin@nmff.org on or before January 23, 2006. Applications shall be reviewed by the Selection Committee which will consist of four members appointed by the Biomedical Engineering and Neurosurgery Department Chairs, and may be referred to ad-hoc reviewers for specific questions on technique or merit upon request by any member of the Selection Committee. Ad hoc reviewers will advise the referring members of the Selection Committee regarding specific questions, but will not have an additional vote on the ranking of the application. Ad-hoc reviewers shall all be at the rank of Professor of Neurosurgery or Engineering. Each of the four members of the Selection Committee shall grade the applications as 1-5 (1 strongly favor; 2 favor; 3 acceptable; 4 needs improvement; 5 reject) based on

responsiveness to the aims of the proposal, scientific merit and feasibility, and shall provide a brief summary statement and critique. Final decision regarding funding, revision, or rejection will be made by the Selection Committee. Reviewer critiques (but not grades) shall also be provided to the co-applicants. Special consideration will be given to projects where one or both co-applicants are junior faculty.

The postdoctoral fellow shall be appointed in the Neurological Surgery Department and the McCormick School, with salary support from the Department of Neurological Surgery. Research expenses shall be provided through a special account in the McCormick School of Engineering.

Funded projects will be required to submit a progress report one year after the project start date. For two-year projects, funding in year 2 will be contingent on satisfactory progress in year 1.