Information for Potential New Members of the Potter Lab at Georgia Tech

Last update: Saturday, June 28, 2008 by Steve M. Potter

You might be a potential

- Grad (PhD) student (Emory Neuroscience; GaTech/Emory BME; GaTech BioE)
- Postdoc
- Undergrad researcher
- Senior Design student
- Summer intern
- Visiting Scholar
- Volunteer researcher
- Lab technician
- Information manager
- "None of the Above" researcher

Potter Lab Mission

We are an interdisciplinary lab, spanning a range of disciplines such as neurobiology, computer science, robotics, cognitive science, cellular biology, molecular biology, optical imaging, electrophysiology, modeling, chaos and dynamical systems, control theory, information theory, electronics, and biochemistry. I strongly feel that this is the way science is going; in today's world, having a single-topic lab nestled in a narrowly-defined department is no way to make great advances. So what are the great advances that we can make with our multi-disciplinary approach? I see two broad categories of advances, and think they are equally important: Neurobiology and Engineering.

In the **Neurobiology World**, we specialize in the Mechanisms of Learning, Memory, and Information Processing in Living Neural Systems. Advances in this direction are of a basic-science nature, and could have far-reaching benefits to humankind, since we all care about how well we learn, remember, sense, and behave. I expect our research will help not only people in whom these abilities are failing through disease, injury, or old age, but everyone.

In the **Engineering World**, our goal is to take ideas about how living neural systems do the amazing things they do, and apply them to artificial computing systems, or Artificial Intelligence, broadly defined. This may mean that we will try to come up with better algorithms for artificial neural network software, or new ideas for neuromorphic circuits, or perhaps just new approaches to system design inspired by natural systems.

Another goal of ours, which includes both the Neurobiology and Engineering worlds, is to develop and improve tools for us and other researchers to study the collective properties of neural systems. These might include multi-electrode array technology, optical recording technology, or other support technologies, such as long-term neural cell culturing.

A lot of the technology we use to do our basic science research has useful spin-offs. For example, we are building the beginnings of what will someday be commonplace: two-way, closed-loop neural interfaces for stimulation+recording of the nervous system. These can be used to treat a wide variety of neurological disorders and disabilities. Presently, we are focusing on devices for ameliorating epilepsy, or giving sensation (proprioception) to prosthetic limbs.

Potential Types of Projects
(I welcome your input on what you might do; all projects are flexible.)
See our web pages and publications for more details about these...
http://neuro.gatech.edu/

1. Cultured neuronal networks on MEAs
A. Record their spontaneous activity: e.g., “burstology”
B. Stimulate them electrically, and record their responses: input-output mapping.
C. Try to change them with stimulation: plasticity.
D. Have them control simulated animals or robots: embodiment, Embodied Cultured Networks.
E. Have the embodiment’s senses trigger stimulation: closed-loop hybrid systems (hybrots).
    1. MEART2, combining art and science.
    2. Prosthetic arm or leg with proprioception.
    3. Wheeled mobile robots and navigation.
F. Study in-vitro learning with neurally-controlled embodiments.
G. Mine the massive amounts of data we have already collected for interesting new phenomena: data mining, pattern discovery

2. Imaging of cultured networks, two types
<u>A. Imaging Morphology (shape): 2-photon time-lapse microscopy</u>
1. Is action potential plasticity expressed as a visible change in axons? (Following up on 2008 PLOS One paper)
2. Can we see morphological changes coincident with functional changes?
    a. Morphometry using imaging software.
3. Adding to or improving features of the 2-photon microscope
    a. Optics
    b. Electronics
        Photomultiplier detection system
    c. Software
        Controlling the microscope and associated hardware
        Image processing
    d. Mechanical
        Specimen platform
        Ease-of-use
        Laser safety
    e. Environmental: building temperature, gas, and humidity control systems and enclosures.

<u>B. Imaging Activity (function): High-speed videomicroscopy</u>
1. Calcium-sensitive dyes to monitor effects of multi-electrode stimulation.
2. Voltage-sensitive dyes: Network dynamics
    a. How is input processed by the network?
    b. Improvement of imaging, staining, or photodamage.
3. Voltage-sensitive fluorescent proteins (VSFPs)
    a. Development of new VSFP
    b. Building of VSFP screening system
    c. Testing out VSFPs with high-speed imaging of networks’ activity.

3. Epilepsy
A. Developing electronics and software for closed-loop multi-microstimulation in vivo.
B. Testing methods for treating epilepsy using electrical brain stimulation of animal models

4. Optogenetics

A. Developing tools and techniques for stimulating neural tissue optically, after transfecting it with genes for light-sensitive ion channels.

B. Develop optical neural interfaces for deep brain stimulation (DBS).

5. Prosthetics

A. Developing systems to deliver proprioception information from artificial limbs by direct brain stimulation.

B. Test electrical brain stimulation for training and rehabilitation.

6. Modeling--Biologically realistic neural networks

A. Integrate-and-fire networks, plasticity and information processing.

B. Attractor dynamics of neuronal networks.

C. How to make AI less artificial.

7. Drug Abuse: In vitro chemical reward system

A. How does dopamine affect network dynamics and plasticity?

B. Experiments with locally-applied neuromodulators in closed-loop systems.

<u>Courses that are useful for succeeding in the Potter Group at Georgia Tech</u>
This applies mostly to potential grad students. No one is expected to have done all of these! The only absolute requirements for everyone are enthusiasm and fluency with both spoken and written English.

- ✓ Neurobiology, including anatomy, cellular physiology, developmental neuroscience
- ✓ English, scientific writing
- ✓ Cognitive science, physiological psychology
- ✓ Artificial Intelligence
- ✓ Neural modeling, artificial neural nets
- ✓ Electronics (analog and digital)
- ✓ Signal processing
- ✓ Control systems
- ✓ Information theory
- ✓ Computer programming, incl. C++ and low-level programming, hardware interfacing and data acquisition
- ✓ Optical physics and optical engineering
- ✓ Mechanical engineering
- ✓ Robotics
- ✓ Statistics
- ✓ Advanced mathematics (matrices, differential equations, clustering, modeling)
- ✓ General biology
- ✓ General chemistry
- ✓ Biochemistry
- ✓ Molecular biology

HOW TO GET IN THE LAB

1. Do your homework first: Read this document, our web pages and one or more of our papers.

2. Send me an email (steve.potter at bme.gatech.edu) telling me something about yourself and why are are interested in the work we do. What are you most excited about? How did you find out about us?
3. Send me another email, or phone me or drop by, if I don't get back to you. Persistence and taking the initiative pays.
4. If English is not your first language, learn to speak, read and write it well by whatever means available to you.
5. Don't be afraid to give me your credentials (resume, CV, transcripts, papers, or other tangible signs of your accomplishments, enthusiasm, and level of responsibility.)
6. Look for funding or be willing to volunteer. Coming to the lab with your own fellowship or sponsor makes it much easier to get you working here sooner rather than later. In some cases we might cooperate on applying for a grant to help pay for you.

We make every effort to be an "equal-opportunity" lab. We don't discriminate against potential lab workers on the basis of age, race, gender, sexual orientation, religion or belief system, or national origin. Certain disabilities can be accommodated as well.