Term Project List (as of 11/23/04, revisions likely)

Each student must work with 1 or 2 other people (*i.e.*, in groups of 2 or 3) on a project for the term. Students will present their final project in a poster session on Wednesday, March 9th, 2004. Each student must attend the poster session and write up a 1-2 page evaluation of another poster that they enjoyed. Evaluations should be emailed to me by Wednesday, March 16th. Note that most projects can easily be modified to fit the background of all students, regardless of whether they are from NUIN, BME, ME, Applied Math, or any other department.

<u>Project 1:</u>
Relationship between granule cell and Purkinje cell firing in the cerebellum
I will give you 18 paired recordings from the granule cell and Purkinje cell layer. Your job is to ensure that the spikes are sorted accurately (this is a non-trivial problem) and then to analyze the relationship between activity in the two cell types. What types of correlations exist, do the correlations change over time, and if so, how do they change ? This project may be a good introduction to spike sorting and nonstationary data analysis.

<u>Project 2:</u>
The relative roles of feedforward and feedback in Central Pattern Generation
Art Kuo (U. of Michigan) has suggested that central pattern generators might be interpreted as a "filters for processing sensory information rather than as generators of commands." The oscillator acts as an internal model of limb motion that predicts the state of the limb, and then generates a sensory error signal that is fed back to entrain the neural oscillator. Start with Kuo's paper "The relative roles of feedforward and feedback in the control of rhythmic movements" (Motor Control, 2002, 6:129-145), and implement his model (or one similar to it) in Matlab. Next, implement the model in hardware.

<u>Project 3:</u>
Origins of spasticity in Spinal Cord Injury
In spinal cord injury (SCI), reflex and CPG circuits operate in the relative absence of descending commands. In addition, most SCI individuals suffer from clonus (rhythmic spasticity about one or more joints). Starting with the Simulink models of Hidler and Rymer (1999, 2001), analyze the relative roles of the stretch reflex and CPGs in the generation of clonus.

<u>Project 4:</u>
Analysis of the air flow generated by rat whisker movements
I will give you the approximate 3-d shape of a rat's head and whiskers, and data that characterize the mechanical properties of the whiskers. Construct models of the fluid flow that would be generated by movements of the whiskers to quantify how air might

circulate around and into the nose/snout of the animal. How might these patterns of air flow aid in the olfactory capacities of the animal?

Project 5:

Analysis of the fluid flow around an array of whiskers underwater

Evidence suggests that seals can use their whiskers to track hydrodynamic trails for up to 2 minutes after a fish has swum by. I will give you the approximate 3-d shape of a rat's head and whiskers, and data that characterize the mechanical properties of the whiskers. Read the literature to determine whether and how the whiskers of seals, sea lions, and walruses might differ from those of rats, and change the 3-d model accordingly. Construct models of the fluid flow that would occur around the whiskers. How might these patterns of water flow aid in the wake-tracking capacities of the animal?

Project 6:

Spatiotemporal patterns of 3-d whisker contact with objects

I will give you the approximate 3-d shape of a rat's head and whiskers, and data that characterize the mechanical properties of the whiskers. Make some assumptions about curvature changes (or lack thereof) during movement to predict the pattern of activity across the receptor sheet as the rat explores different objects? What would be the effects of cutting all the whiskers to the same length? How does the geometry of the sensor array aid sensory acquisition?

Project 7:

Instantiating "neurons" in electronic circuits

Build integrate-and-fire neurons using Schmitt triggers. How does their behavior change when you couple them together? Can you use the output of these electronic "neurons" to drive a pendulum? What happens if you couple sensory feedback from the pendulum back to the neurons? How does the mass of the pendulum affect the system? This project requires some background in EE/mechatronics and an ability to construct small electronic circuits.

Project 8:

Construct a McKibben muscle and examine the difficulties in controlling it.

McKibben muscles are (in principle) easy and cheap to build, but notoriously difficult to control. I will give you the instructions (i.e., a cook-book-type recipe) for how to build a McKibben muscle. Your first job will be to determine whether the instructions work. Next, use the muscle to control something (for example, a catapult). Analyze why such a muscle is difficult to control, and determine methods (both mechanical and algorithmic) that may aid in control. A background in ME/mechatronics will be helpful.

<u>Project 9:</u>

Neural processing channels?

Examine when it might be important for an animal to extract the envelope of a signal. Can the envelope of a broadband signal be reconstructed by summating the signals from several narrowband channels? If so, would such an "envelope" ever be useful to an animal, or should the nervous systems of animals just rectify and low pass filter? This project requires a background in signal processing.

<u>Project 10:</u>

Propose a project

I am very open to suggestions about possible projects. Projects should include both a neurobiological and an engineering/modeling component. Projects that involve detailed models of single neurons are likely to be more appropriate for Dr. Bill Kath's course on Computational Neuroscience.