Undergraduate Research Award Application
2009- 2010
Please use word processor or type.

Note: To view previous proposals and obtain helpful advice, go to www.umbc.edu/undergrad_ed/ura

Name: Geoffrey Clapp

Title: ______ **Ms.** ___X___ **Mr.** **Major:** Mathematics, Computer Science

Title of Proposal: Modeling Sensory Input to the Lamprey Spinal Cord

Local/Current address for notification of proposal acceptance:

UMBC e-mail: clappge1@umbc.edu
Current telephone number for communications about this proposal:
Permanent telephone number for contact over the summer:

Permanent address for payment of stipend in June:
How did you learn of this opportunity/decide to apply? My advisor/mentor suggested it.

Expected semester and year of graduation: Spring 2011 *(Note: Students must be conducting research and be in undergraduate status for at least one semester beyond spring 2009 to be eligible for consideration*

UMBC Faculty Mentor:
Name: Dr. Kathleen Hoffman **E-mail:** khoffman@math.umbc.edu

Department: Mathematics and Statistics

________________________________ ________________________________
Student Signature **Date**

Note: Complete the attached *Narrative* as pages two and three of this proposal.
As page 4 of 4, please attach your current unofficial UMBC transcript.

Submit this application with a current unofficial transcript to the Office of Undergraduate Education (OUE), Administration, Room 913 by 5:00 p.m. March 4, 2009.

IMPORTANT: All applications ***must*** be logged in by a member of the OUE Staff.

Office Use Only:
Date Received: _____________ **Receiving Staff Member:** ________**Entered in Log?:** ______
Transcript Included? (Required): ______ **Graduation Date Summer 2009 or Later?** ______
Faculty Recommendation Subsequently Received?____________________ **(Date)** _______

Undergraduate Research Award Narrative

I. Statement of Specific Aim(s), Purpose, or Goals(s)

The research project aims to understand how lampreys swim. Swimming motion is modulated by input to the spinal cord of the lamprey from sensory organs, called edge cells [5]. We would like to develop a model for the lamprey spinal cord and edge cells in order to better understand the role of sensory input in vertebrate swimming. Ultimately, with a stronger understanding of how lampreys swim, we become a step closer to understanding vertebrate locomotion as a whole.

The proposed project would be a continuation of my work with Dr. Hoffman started last semester on the lamprey's spinal cord. The focus of last semester was the relationship between connection strength between oscillators and entrainment ranges for all-to-all connections between oscillators. In theory, for sufficiently high connection strengths, the entrainment ranges should be independent of small changes in magnitude. For smaller connection strengths, the entrainment ranges should depend linearly on connection strength, approaching no entrainment as the strengths go to zero. Results from this project demonstrated the correct behavior for large connection strengths, but there were some interesting discrepancies for the smaller connection strengths. The proposed work for this URA is two-fold. First, we would like to explore the discrepancies in the small connection strength limit. Second, we would like to explore the same entrainment ranges, but for nearest neighbor connections. We would then like to compare the results to a simpler model of coupled oscillators, called a phase model, in which analytic results of entrainment ranges are known. [1,3]

II. Motivation

My interest in studying the lamprey research stems from a math-biology first year seminar with Dr. Hoffman. The course exposed me to biology applications that were never considered in my standard math and computer science courses. Besides that course, my academic background is primarily in mathematics and computer science. My specific knowledge of the lamprey spinal cord has been enhanced by reading the publications of Dr. Hoffman and her colleagues at College Park. These sources include:

(1) Koppel, N., Ermentrout, G.B. Williams, T., On chains of oscillators forced at one end, SIAM J. Appl Math 51(5):1397-1417

(2) P. Varkonyi, P. Holmes, T. Keimel, K. Hoffman and A.H. Cohen (2008) J. Comp. Neurosci. 25

(3) J. Previte, N.Shiels, K. Hoffman, T. Kiemel, E.Tytell, Entrainment ranges in coupled phase oscillators, in preparation.

(4) TL Williams ,Phase coupling by synaptic spread in chains of coupled neuronal oscillators, Science 23 October 1992: Vol. 258. no. 5082, pp. 662 - 665

(5) E. D. Tytell and A. H. Cohen Rostral Versus Caudal Differences in Mechanical Entrainment of the Lamprey Central Pattern Generator for Locomotion. (2008) J Neurophysiol 99, 2408-2419

I have attended meetings and presentations led by Dr. Hoffman and jointly presented a poster with her at the Society for Neuroscience Annual Meeting. My understanding of the overall study of the lamprey spinal cord has greatly evolved over last semester and the current semester.

III. Methods

The electrical activity of the lamprey's spinal cord is modeled as a chain of coupled oscillators. Each oscillator is modeled as a neural model of 3 different types of neuron [4](in comparison to the simpler phase model referenced earlier in the proposal). Sensory organs, called edge cells, are modeled as forcing along the chain. To simulate the input from edge cells, a sensory organ in the lamprey, the chain of oscillators is forced at various positions along the spinal cord. The simulations using Matlab are performed to determine the range of forcing frequencies for which the electrical activity along the spinal cord oscillates with the same uniform and constant frequency as the forcer. These ranges of forcing frequencies, called entrainment ranges, depend on various parameters and conditions. Our research will explore the effects of the type of coupling and connection strength on small chains of oscillators. Specifically, we will compare all-to-all and nearest-neighbor coupling. It is currently known that the lamprey spinal cord consists of primarily shorter connections but that longer connections do exist [2]. Therefore, the actual type of coupling in lampreys lies between all-to-all and nearest-neighbor coupling.

Although I am already familiar with the code used to simulate the entrainment ranges, we anticipate that there are some obstacles to overcome. To further investigate the discrepancies in the small strength limit of the all-to-all connections, a more detailed study of the criterion for entrainment in necessary. Some time-series graphs of the phase indicate sufficiently complex behavior that our current method for determining entrainment is not sufficient to deal with this more complicated behavior. Also, preliminary computations involving nearest-neighbor coupling reveal that the oscillators are not entrained at any forcing frequency other than the baseline frequency of the chain.

IV. Evaluation and Dissemination (How do you plan to evaluate your work at the end?)

Dissemination of the results will be two-fold. Along with other work by Dr. Hoffman, this project would be part of a journal publication submitted to a peer-reviewed journal. The peer-review will serve as the evaluation of the research. In addition, we will be presenting the results at group meetings consisting of scientists from College Park, UMBC and Princeton at their yearly group meeting. We anticipate that the meeting will take place in May 2009 and 2010. I also have submitted an abstract to URCAD for this year's meeting and I plan to submit another abstract for next year. If additional funds can be found, it may be possible to present results at the SIAM Annual Meeting, July 2010.

V. Budget

Total funding requested: **$**<u>1500</u>
Will funding from other sources also be needed to complete this project? <u>Not at this time</u>
Has this additional funding already been secured? <u>No</u>
Itemized budget:

Item	**Cost**
Student salary	**$1500/year**

VI. Role of Faculty Mentor/Advisor

I will meet with Dr. Hoffman weekly to review my progress. In addition, I will continue to accompany her to research meetings with her collaborators at College Park, as my schedule permits.

VII. Additional Information

Although my research is part of my mentor's established project, I have my own distinct piece of the project. There will be various opportunities to achieve a leadership role in determining the next step and resolving problems as they occur.