Los Alamos NATIONAL LABORATORY

Postdoctoral Research Associate
Theoretical Biology and Biophysics
Los Alamos National Laboratory
PO Box 1663, MS K710

Los Alamos, NM 87545
Email: gullah@lanl.gov
Phone: (814) 321-7120

Prof. David Sheinberg
Chair, Faculty Search Committee
Department of Neuroscience
Brown University
Providence, RI 02912

April 22, 2012

Dear Prof. Sheinberg,

I am writing to apply for the assistant professor position in computational neuroscience, advertised in Science Magazine. I believe that my extensive research experience in using emerging computational techniques in neuroscience at various scales of complexity makes me a strong candidate for this position.

My central motivation is to understand the role of channel proteins, ion concentrations, and other intra- and intercellular signaling pathways in pathological conditions such as epilepsy, Alzheimer's disease, and cerebral hypoxia. I work to address questions like the following: What are the molecular bases of calcium signaling modulation leading to Alzheimer's? What causes the failure of glia network to efficiently buffer potassium and other waste from the extracellular space and how it affects neuronal behavior? Why vasculature fails to keep up with the oxygen demand of neuronal networks? What is the role of these failures in seizures and spreading depression? What are the electrochemical energy requirements of the brain at the cellular level? What is the relation between energy deprivation and brain disorders? Answering these and other relevant questions will enhance our understanding of neuropathology and help us develop better therapies. My long-term goal is to employ modern engineering tools used for controlling robots, to develop rigorous control algorithms for biomedical applications, particularly neural prostheses. Although my primary objective is to understand neurological diseases, the theoretical tools that I develop, have broad relevance to cell physiology.

I have made significant progress along these lines. During my PhD at Ohio University, I studied the spatiotemporal patterning of calcium ions – the main mechanism through which calcium encodes information and performs numerous cellular functions. I modeled calcium signals from single channel events to globally orchestrated calcium waves in several cell lines including neurons, glia, and cardiac muscles. At the Pennsylvania State University, I was involved in several projects devoted to modeling neuronal networks, understanding epilepsy, and controlling epileptic seizures. I employed model-based approach used by control engineers for tracking and predicting the trajectory of various objects, to accurately estimate the full dynamics of brain circuits from a single measured variable and put forward an efficient strategy for neuronal control. The model-based framework offers a paradigm shifting improvement in our ability to develop noninvasive early detection methods for neurologic disorders. At Los Alamos National Laboratory, I developed a novel data-driven approach to model channel proteins. While the aim was to examine ion channels, the method has many potential applications in biology, for example, enzymes, ligand-binding proteins, population processes, and mean-field modeling. This work also led to a simple theory for aggregating Markov chain models that are widely used in biology and engineering.

In addition to a rare research background, I have a significant experience of teaching various graduate and undergraduate courses and providing mentorship regarding computational neuroscience, biophysics, and neural engineering-related careers. I have taught classes ranging from introductory biophysics to advanced courses in statistical methods, signal processing, and neural engineering. I have extensively guided students in their projects at Penn State and Ohio University. Teaching and working in interdisciplinary environment helped me to learn engaging a diverse group of students in the class and designing courses with special attention to the needs of individual students from various disciplines.

Being a member of the labs with excellent external funding records and active involvement in writing proposals have taught me how to compile a successful grant application. I have recently submitted a proposal to NIH on using model-based control engineering approach to estimate the experimentally inaccessible neuronal variables. Score from the initial review is encouraging and I hope to adequately address reviewers' concerns. My second proposal on investigating the calcium bases of Alzheimer's disease is under review.

I am confident that my inclusion would strengthen the computational neuroscience program at Brown Institute for Brain Sciences. Furthermore, my unique research skills would help students to target many problems at the intersection of electrical and chemical signaling, particularly in brain and cardiovascular system.

I am excited about this position and hope to speak with you soon. If there is any question, please do not hesitate to contact me. Thank you for your time and consideration of my application.

Sincerely,

Ghanim Ullah, PhD

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P O BOX 1663, MS K710
Theoretical Biology and Biophysics
Los Alamos National Laboratory
Los Alamos NM 87545
Phone: (814) 321-7120
E-mail: gullah@lanl.gov

Education

Ph.D. Computational Biophysics/Neuroscience: Department of Physics and Astronomy, Quantitative Biology Institute, Ohio University, 2006.
Thesis title: Computational modeling of calcium signaling from the nanoscale to multicellular systems, http://www.ohiolink.edu/etd/view.cgi?ohiou1160584521.

M.Sc. Physics: University of Peshawar, Pakistan, 2000.

B.Sc. Physics and Mathematics: University of Peshawar, Pakistan, 1998.

Research Experience

Los Alamos National Laboratory, July 2010 - present.
Advisor: Prof. John E Pearson
○ Investigating calcium signaling impairment leading to Alzheimer's disease.
○ Developing statistical methods for processing and analyzing noisy spatiotemporal imaging and patch-clamp data from single and multiple ion channels.
○ Developed (1) A data-driven approach to model the dynamics of single biomolecules.
(2) Theoretical tools for ion channel kinetics.
(3) A simple theory for Markov chain models simplification.

The Pennsylvania State University, Sep 2006 – June 2010.
Advisor: Prof. Steven J Schiff
○ Modeled neuronal systems from single cell to network and system scale.
○ Developed computational models for understanding the dynamics of epilepsy.
○ Used engineering control theory to track and control neuronal dynamics.
○ Investigated the role of glia and ion concentration dynamics in epileptic seizures, memory, and other brain functions.

Ohio University, 2001-2006.
Advisor: Prof. Peter Jung
○ Developed models for the gating of calcium ion channels.
○ Modeled the statistics of elementary calcium release events in various cells.
○ Modeled calcium signaling during sexual fertilization.
○ Investigated intercellular calcium waves in astrocytes.

Publications

1. **Ullah G**, Mak DOD, and Pearson JE, A data-driven model of a modal gated ion channel: the inositol 1,4,5-trisphosphate receptor in insect Sf9 cell, in review, Journal of General Physiology.
2. Ullah A, **Ullah G**, Jung P, and Machaca K, Enhanced inositol 1,4,5-trisphosphate receptors clustering during oocytes maturation and its role in calcium signaling differentiation, in review, Cell Calcium.
3. Vais H, Foskett KJ, **Ullah G**, Pearson JE, and Mak DOD, Permeant calcium ion feedback regulation of single inositol 1,4,5-trisphosphate receptor channel gating, in review, Journal of General Physiology.

4. **Ullah G**, Bruno W, and Pearson JE, Simplification of reversible Markov chains by removal of states with low equilibrium occupancy, in review, Physical Biology.
5. **Ullah G**, Parker I, Mak DOD, and Pearson JE, Multi-scale data-driven modeling and observation of calcium puffs, accepted for publication, Cell Calcium.
6. Ahmad F, **Ullah G**, and Kim SH, A neighborhood method for statistical analysis of fMRI data, Open Journal of Biophysics, 2(1) (2012) 15.
7. **Ullah G** and Schiff SJ, Assimilating seizure dynamics, PLoS Computational Biology, 6 (2010) e1000776.
8. **Ullah G** and Schiff SJ, Models of epilepsy, Scholarpedia, 4(7) (2009) 1409.
9. Sawaminathan D, **Ullah G**, and Jung P, A simple sequential-binding model for calcium puffs, Chaos, 19 (2009) 037109.
10. **Ullah G** and Schiff SJ, Tracking and control of neuronal Hodgkin-Huxley dynamics, Physical Review E, 79 (2009) 040901.
11. **Ullah G**, Cressman JR, Barreto E, and Schiff SJ, The influence of sodium and potassium dynamics on excitability, seizures, and the stability of persistent states: II. Network and glial dynamics, Journal of Computational Neuroscience, 26 (2009) 171.
12. Cressman JR, **Ullah G**, Ziburkus J, Barreto E, and Schiff SJ, The influence of sodium and potassium dynamics on excitability, seizures, and the stability of persistent states: I. Single neuron dynamics, Journal of Computational Neuroscience, 26 (2009) 159.
13. **Ullah G**, Jung P, and Machaca K, Modeling calcium signaling differentiation during oocyte maturation, Cell Calcium, 42 (2007) 556.
14. **Ullah G** and Peter Jung, Modeling the statistics of elementary calcium release events Biophysical Journal, 90 (2006) 3485.
15. **Ullah G**, Jung P, and Cornell-Bell AH, Anti-phase calcium oscillations in astrocytes via inositol 1,4,5-trisphosphate regeneration, Cell Calcium, 39 (2006) 197.
16. Jung P, Neiman AB, Afghan MKN, Nadkarni S, **Ullah G**, Thermal activation by power-limited colored noise, New Journal of Physics, 7 (2005) 17.

Manuscripts in Preparation

1. **Ullah G**, Parker I, Mak DOD, and Pearson JE, Modeling the buffer modulation of intracellular calcium patterns.
2. **Ullah G**, Cressman JR, Barreto E, and Schiff SJ, Modeling the cellular interaction during seizures.
3. **Ullah G** and Schiff SJ, Neuronal microenvironment differentially affects action potential propagation along dendritic tree.

Peer Reviewed Conference Proceedings

1. Wei Y, **Ullah G**, Parekh R, Ziburkus J, and Schiff SJ, Kalman filter tracking of intracellular neuronal voltage and current, 50th IEEE Conference on Decision and Control and European Control Conference, (2011) 12-15.
2. **Ullah G** and Schiff SJ, Tracking neuronal dynamics during seizures, Computational Neuroscience Meeting, in BMC Neuroscience, 11 (s1) (2010) O9.
3. **Ullah G** and Schiff SJ, Assimilating and controlling seizure dynamics, American Epilepsy Society Meeting, in Epilepsia, 50 (s11) (2009) 395.

4. **Ullah G**, Cressman JR, and Schiff SJ, Modeling the cellular interaction mechanism responsible for seizures, American Epilepsy Society Meeting, in Epilepsia, 49 (s7) (2008) 355.

5. **Ullah G**, Cressman JR, and Schiff SJ, Modeling the interplay between interneuron and pyramidal cell during seizures, Computational Neuroscience Meeting, in BMC Neuroscience, 9 (2008) P145.

6. Cressman JR, **Ullah G**, Ziburkus J, Barreto E, and Schiff SJ, Ion concentration dynamics: mechanisms for bursting and seizing, Computational Neuroscience Meeting, in BMC Neuroscience 9 (2008), O9.

7. **Ullah G**, Cressman JR, Barreto E, and Schiff SJ, The role of glia in seizures, Computational Neuroscience Meeting, in BMC Neuroscience, 8 (2007) P28.

8. Cressman JR, **Ullah G**, Ziburkus J, Barreto E, and Schiff SJ, Slow potassium dynamics and seizure evolution, Computational Neuroscience Meeting, in BMC Neuroscience, 8 (2007) P80.

Distinction and Awards

First position in M.Sc. from the Department of Physics, University of Peshawar, Pakistan.
Won Oriental Physics Award (awarded to top Physics students in Pakistan), 2000.
Recipient of University gold medal from University of Peshawar, Pakistan, 2000.

Technical Skills

Languages: Fortran77/90, C++, Matlab, Mathematica, Maple, parallel programming on MPI architectures, experienced in Linux, OSX, and Windows environments.
Software: XPPAUT, NEURON, PPLANE, Gnuplot, Xmgr, Xfig, Xmgrace, Plot, and Latex.

Academic Positions

Research Associate, Theoretical Biology and Biophysics, Los Alamos National Laboratory, Jul 2010 – present.

Research Associate, Center for Neural Engineering, Department of Engineering Science and Mechanics, The Pennsylvania State University, 2006 – 2010.
- Taught advanced neural control engineering course.
- Organized and run journal clubs in cellular neuroscience, dynamical systems, and computational neuroscience for postdoctoral scholars, graduate, and undergraduate students.

Teaching/Research Assistant, Department of Physics & Astronomy, Ohio University, 2001- 2006.
- Taught laboratory Physics 250, 200, and 100 series for Physical Sciences majors.
- Graded Physics 250 and 100 series courses for Biophysics majors.
- Conducted help sessions for undergraduate students in Biophysics.
- Compiled and incorporated homework problems into computerized system for Physics courses.

Lecturer, Department of Physics, University of Peshawar, Pakistan, Feb 2001 – Jun 2001.
- Taught statistical mechanics and general Physics courses to the undergraduate students.

Lecturer, Warsak Model College, Peshawar, Pakistan, Aug 2000 – Feb 2001.
- Taught calculus based Physics courses to the undergraduate students.

Teaching Interests

- Graduate and undergraduate level courses on
  - Modeling, analyzing, tracking, and controlling neuronal systems.
  - Statistical and numerical methods in biology.
  - Computational neural engineering.

Other Activities

Reviewer: Cell Calcium, Physical Biology, Nanoscale Research Letters, Journal of Cell Biology, International Journal of Neuroscience, Journal of Neural Engineering, Concepts in Magnetic Resonance, and Epilepsy Research.

Judge at the Ohio State Science Fair, Ohio State University, 2004.

Organizer of Science Society, University of Peshawar, Pakistan, 1998 - 2000.

Invited Talks

Modeling calcium signaling from single channel release events to intercellular waves.
Florida Atlantic University, March 2010.

Tracking and controlling neuronal dynamics during seizures
Ball State University, April 2009.

Calcium signaling differentiation in the maturing xenopus oocytes: A modeling approach.
Joint SIAM-SMB conference on the Life Sciences, Raleigh, July 2006.

Computational modeling of calcium signaling from the nanoscale to multicellular systems.
George Mason University, May 2006.

Anti-phase calcium oscillations in astrocytes via inositol 1,4,5-trisphosphate regeneration.
Applied and Computational Mathematics Department, Ohio University, November 2005.

References

John E Pearson
Theoretical Biology and Biophysics
Los Alamos National Laboratory
Los Alamos, NM 87545
Email: johnepearson@gmail.com
Phone: (505) 667-7585

Steven J Schiff
Center for Neuronal Engineering,
Departments of Engineering Science and Mechanics,
Physics, and Neurosurgery
The Pennsylvania State University
University Park, PA 16802
Email: sjs49@engr.psu.edu
Phone: (814) 863-4210

Peter Jung
Department of Physics and Astronomy,
Quantitative Biology Institute
Ohio University
Athens, OH 45701
Email: jung@phy.ohiou.edu
Phone: (740) 593-1720

Ghanim Ullah – Research Statement

My area of interest is computational neuroscience, specifically understanding the role of channel proteins, ion concentrations, and other intra- and intercellular signaling pathways in disorders such as epilepsy, Alzheimer's, and cerebral hypoxia. My long-term goal is to develop rigorous control algorithms for biomedical applications, particularly neural prostheses.

Past and Present Research

Ca^{2+} is a highly specific universal second messenger that encodes information through it's spatiotemporal patterning. As a graduate student, I investigated Ca^{2+} signaling at several scales. I developed a model that explained all observations about micrometer-sized Ca^{2+} release events caused by single and clusters of Ca^{2+} channels (Ullah and Jung, 2006; Swaminathan et al., 2009). At the cellular level, the model explained the molecular bases of observed Ca^{2+} signaling differentiation during oocytes maturation - a prerequisite for fertilization. I predicted the rearrangement and enhanced sensitivity of Ca^{2+} channels to be the primary reason for the elevated Ca^{2+} concentration in eggs (Ullah et al., 2007). Recent observations confirmed these predictions. As glial cells affect many aspects of brain function (Fields 2004), I expanded the model to intercellular Ca^{2+} waves in astrocytes (subtype of glia) in the hippocampus of epileptic rats. Based on this work, I proposed a testable mechanism for the spontaneous Ca^{2+} oscillations in astrocytes network - a feature of epileptic brain (Ullah et al., 2006). This behavior was recently implicated in Alzheimer's disease (Riera et al., 2011).

The study of astrocytes then sparked my curiosity about the relationship between ion concentrations and brain states. To answer these questions, I began a postdoctoral position in Steven Schiff's lab at Penn State University. In the Schiff lab, I showed that impaired neuronal microenvironment such as the K^+ clearance ability of glia and blood vessels causes neuronal networks to transition from physiological to pathological states like seizures and spreading depression (Ullah et al., 2009; Ullah and Schiff, 2009a; Cressman et al., 2009). This work revealed that the dynamics of seizures is more complex than just a nonlinear interaction between specific excitatory and inhibitory neuronal subtypes. Variety of metabolic processes governs the excitability of both cell types. However, existing techniques can measure only a small fraction of the variables and parameters of neurons. To overcome this problem, *I incorporated biophysical models into a model-based predictor-controller framework from modern control theory and estimated the full dynamics of brain circuits from a single measured variable* (Ullah and Schiff, 2009b & 2010, Wei et al., 2011). I also showed that model-based framework significantly reduces the energy requirement for seizures control as compared to other methods and proposed an improved strategy for dynamic conductance clamping (Ullah and Schiff, 2009b). We are working to implement this strategy in the experimental setup.

As I have a long-standing interest in channel proteins, I obtained a postdoctoral position doing channel modeling at Los Alamos National Laboratory. I developed a novel data-driven approach to model ion channels (Ullah et al., 2011). *This method can be easily applied to other biological systems such as enzymes, population process, and mean-field modeling. This work also led to a simple theory for aggregating Markov chain models that are widely used in biology and engineering.* Currently, I am developing statistical methods for processing and analyzing noisy spatiotemporal imaging and patch-clamp data from single and multiple ion channels.

Future Research Plans

Three example projects that illustrate my short-term research directions are:

1. Calcium and Alzheimer's disease: Ca^{2+} signaling has been implicated in a number of disorders such as epilepsy and Alzheimer's disease (AD) (Bezprozvanny, 2009). AD is a fatal neurodegenerative disease that leads to cognitive, memory, and behavioral impairments followed by progressive cell death (Hardy 2006). AD is the sixth-leading cause of death in the US and cannot be prevented, cured, or

slowed. The lack of understanding of the disease pathogenesis hinders the efforts to develop efficient therapies for AD. Recent evidence suggests the remodeling of neuronal Ca^{2+} signaling in AD. The Ca^{2+} hypothesis of AD, which is based on the remodeled Ca^{2+} homeostasis, accounts for early memory loss and subsequent cell death. *Understanding the Ca^{2+} bases of AD is of crucial importance as it presents certain Ca^{2+} pathways as the potential therapeutic targets.* Although an area of active biomedical research in leading laboratories throughout the world, efforts in the mathematical modeling of Ca^{2+} signaling in AD are nonexistent. Development of biologically accurate and comprehensive theoretical models is of a paramount importance for further progress in this area. I have spent significant time to model Ca^{2+} signaling pathways at all scales (Ullah and Jung 2006, Ullah et al., 2006, Ullah et al., 2011a, Ullah et al., 2011b). *I will build on this work to understand the mechanism of Ca^{2+} signaling modulation in AD and propose therapeutic targets.*

In a complementary vein of research, I would like to determine the role of Ca^{2+} signaling in other neuronal disorders such as epilepsy, Parkinson's, and Huntington's disease.

2. Metabolic process and epileptic seizures: Theoretical neuroscientists often assume constant ion concentrations while modeling various behaviors. The validity of this assumption in the mammalian brain, particularly in states involving high frequency neuronal activity such as seizures and gamma rhythms, is subject to debate. The excitability of neuronal networks depends on a variety of metabolic processes such as K^+ concentration gradients and local O_2 availability. Indeed, it is becoming apparent that electricity is not enough to describe a wide variety of neuronal phenomena. For example, several seizure prediction algorithms, based only on EEG signals, have achieved reasonable accuracy when applied to static time-series. However, many techniques are hindered by high false positive rates, which render them unsuitable for clinical use. As one cannot see much of an anticipatory signature in EEG dynamics prior to seizures, the same can be said of a variety of oscillatory transient phenomena in the nervous system ranging from up states, spinal cord burst firing, and cortical oscillatory waves. *My hypothesis is that there are aspects of the neuronal dynamics that are not captured in current models. I propose to develop next generation biophysical models that will account for the metabolic variables, such as K^+, Na^+, Cl^-, Ca^{2+} and O_2 concentrations, glucose supply, and pH levels along with the electrical part. An essential component of these models will be the glial network and vasculature surrounding the neurons. These models will not only enable us to study the role of neuronal microenvironment in epileptic seizures but will also provide an opportunity to know (1) the electro-chemical energy (ECE) requirements of the brain in various states, (2) the transition from physiological to pathological states due to the lack of ECE, (3) how the ECE is redistributed in therapies involving the application of electric fields to the brain such as deep brain stimulation, and (4) the possible side-effects of such redistribution. These models will also set the foundation for the mathematical description of cerebral hypoxia and hypoxia-induced seizures.*

A related problem is to compute the O_2 (or ATP) consumption of synapses and explore the role of O_2 deprivation in the inhibition failure during spontaneous seizures.

3. Tracking inaccessible neuronal variables using model-based approach: Existing techniques can measure only few of the metabolic variables described above and other neuronal dimensions. However, recent advances in nonlinear control theory offer a paradigm shifting improvement in our ability to observe, predict, and control spatiotemporal biological systems. I will continue to use cutting edge state reconstruction techniques for estimating the experimentally inaccessible neuronal variables. Model-based control frameworks such as Ensemble Kalman filter (EKF) are going through their initial stages. *From my preliminary work, I learnt that EKF often lose track of the system when applied to networks of more than few neurons. This happens due to two reasons. First, the framework itself is not suitable for the nonlinearities of the order of neuronal dynamics. The second issue is the inadequacy of neuronal models. I will utilize the variety of schemes suggested by the meteorological community to solve some of the stability problems. The next generation biophysical models described above will address the issue of model*

inadequacy. Furthermore, I will mostly adhere to the data-driven approach for modeling neuronal systems so that the models are as close to nature as possible. Model-based tracking and model development will feedback to each other. Improved models will be implemented in model-based framework to estimate the experimentally inaccessible variables of neuronal networks. The estimated variables and parameters will be used to further improve the models. *The final outcome of this exercise will be rigorous real time control algorithms for disorders such as seizures and Parkinson's disease.*

Summary

I plan to utilize my theoretical background with the broad aim of understanding the role of ion channels, ion concentrations, and neuronal microenvironment in brain states. Although my primary motivation is to understand neurological disorders, the tools that I develop, have broad biomedical applications. I have a successful history of bringing new theoretical techniques to biology, and as the problems that can be attacked are often limited by the techniques at our disposal, I hope to make use of new methods throughout my career to answer questions that have yet to be asked.

References

Bezprozvanny I. Trends Mol. Med. 15:80 (2009).
Fields D. Scientific American, p55 April (2004).
Hardy J. Neuron 52: 3 (2006).
Cressman JR, Ullah G, Ziburkus J, Barreto E, and Schiff SJ. J. Comp. Neurosci. 26:159 (2009).
Riera J, et al. Biohphys. J. 101:554 (2011).
Sawaminathan D, Ullah G, and Jung P. Chaos 19:037109 (2009).
Ullah G, Cressman JR, Barreto E, and Schiff SJ. J. Comp. Neurosci. 26:171 (2009).
Ullah G, Jung P, and Machaca K. Cell Calcium 42:556 (2007).
Ullah G and Jung P. Biophy. J. 90: 3485 (2006).
Ullah G, Jung P, and Cornell-Bell AH. Cell Calcium 39:197 (2006) .
Ullah G, Parker I, Mak DOD, and Pearson JE. Cell Calcium, in press (2011a).
Ullah G, Mak DOD, and Pearson JE. J. Gen. Physiol. in review (2011b).
Ullah G and Schiff SJ. PLoS Comp. Biol. 6:e1000776 (2010).
Ullah G and Schiff SJ. Scholarpedia, 4(7):1409 (2009a).
Ullah G and Schiff SJ. Phys. Rev. E. 79: 040901 (2009b).

Wei Y, Ullah G , Parekh R, Ziburkus J, and Schiff SJ. IEEE Decision and Control, in press (2011).

Ghanim Ullah – Teaching Statement

Theoretical techniques are becoming significant in driving and explaining experiments in biology. Familiarity with these tools has become more and more important to biologists. My aim would be to bring engineers and biologists closer by teaching courses at the intersection of both disciplines. As an instructor, I would emphasize:

1. Empirical approach: We find out truths about nature by doing experiments. I would get across not only facts about science, but how they were obtained. If scientific facts are framed by how they were discovered, they become more memorable. Furthermore, scientific facts are only as good as the experiments. But experiments may have flaws, or alternate interpretations. Therefore, it's important to have multiple methods of verification.

2. Quantitative approach: Many biology students have weak quantitative skills, and many engineers are turned off from biology by a perceived lack of quantitative foundations. I would strive to engage both groups of students by emphasizing the utility of a quantitative approach to the study of living organisms. I would try to breakdown the seemingly insurmountable mathematical and computational problems into smaller fragments and talk students through them. Approaching biology in this way will appeal to engineers, who will see commonalities between the functions of organisms and fundamental engineering concepts.

3. Knowing the facts: In order to reason about biological problems, it's important to have a solid grasp of the underlying facts. By relating biological details to real-life problems, both the concepts and the problem-solving skills stick much better. For non-majors, it helps to relate the problem at hand to the area of their comfort.

4. A core skill set: Students are preparing for professional careers. Employers look for specific technical skills. Skills learnt in class must make their way onto resumes. To make this happen, I would try to identify a set of skills that equates to a working knowledge of the course material.

Prior teaching experience: After my M.Sc. degree, I taught statistical and algebra based physics courses to undergraduates for a year. As a PhD student, I served as a teaching assistant for biophysics courses. I conducted tutorial sessions, taught laboratory courses, designed computer-based assignments, graded assignments, and helped students on an individual basis. At Penn State, I worked as an instructor for a course on advanced neural engineering, covering special topics such as models of neuronal networks, Kalman filters, seizure detection and control, and biological signal analysis. I led journal club discussions on computational neuroscience, dynamical systems, and cellular neuroscience. I gave informal lectures at the Center for Neural Engineering on statistical methods, simulations in biology, models of epilepsy and normal brain function among other topics.

Teaching interests: I would like to teach courses on modeling, analyzing, tracking, and controlling neuronal systems. My classes would consist of lectures, assignments, and discussions of current literature. I would also like to include some of the following elements: ungraded surprise quizzes that alert students to problem areas and prepare them for future exams; brief student presentations, to improve communication skills; a stupid question time, for doubts that students would otherwise hesitate to bring up; and real world assignments, in which students acquire and analyze their own data. The following are sample course outlines:

1. Mathematical modeling in neuroscience: Modeling intra- and intercellular signaling, stochastic and deterministic approaches, Markov chain models for ion channels, proteins, reactions, and macromolecules, data-driven modeling, model simplification, state-space models, discrete processes, lumped and distributed parameter systems, phase plane analysis, bifurcation theory, equilibria, stability, excitable systems, and oscillations.

2. Statistical and numerical methods in biology: Statistical analysis of biophysical data, spectral estimation, linear filters, point processes, forecasting, nonlinear methods, programing languages, use of utility scripts such as mathematica, matlab, xppaut, neuron, and pplane.

3. Computational neural engineering: Biophysics of neurons, mean field and biophysical models, brain signals and rhythms, data assimilation, control engineering techniques for parameter estimation, brain state detection and discrimination, control strategies for neuronal systems, hypothesis testing and power analysis.

I will tailor these courses to suit the needs of students with different backgrounds, at the basic and advanced level, and to complement other courses in the curriculum. Special topics of interest to students or based on ongoing research will be included as appropriate.