SYSTEMS BIOLOGY AND NEUROENGINEERING

Christine P. Hendon, PhD
Assistant Professor
Electrical Engineering
Systems Bio & Neuroengineering

- Development and application of analytical and theoretical techniques to the study of biological systems
- Using engineering techniques to understand, repair, or replicate the properties of neural systems
- Applying systems tools & thinking to biological systems
- Highly interdisciplinary
  - Biology, Chemistry, Neuroscience, BME, CS, ME, MBBI
- Key EE areas
  - Biological-artificial systems interfaces
  - NeuroRobotics
  - Neuromorphic systems
  - Synthetic Biology
Systems Biology and Neuroengineering Centers at Columbia University

- The Center for Neural Engineering and Computation
- The Center for Computational Biology and Bioinformatics
- The Center for the Multiscale Analysis of Genomic and Cellular Networks
- Institute for Data Science and Engineering
- Optical Techniques for Actuation, Sensing and Imaging of Biological Systems

Systems biology and Neuroengineering

- Aurel Lazar - computing with neural circuits
- Dimitris Anastassiou - Computational biology and genomic
- Predrag Jelenkovic - Mathematical models of biological systems
- Nima Mesgarani - Reverse-engineering the auditory system
- Christine Hendon - Optical imaging and cardiac electrophysiology
- Ken Sheperd - Bioelectronics and neural interfaces
- Paul Sajda - Neural engineering, neuro-computation
- Qi Wang - Neural coding, brain machine interfaces

Systems Biology and Neuroengineering Course Flow
### Fall 2015 courses

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<th>Professor</th>
<th>Course</th>
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<tr>
<td>ECBM E4060 (Prof. Anastassiou)</td>
<td>Genomic Information Science and Technology</td>
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<tr>
<td>BMEB W4020 (Prof. Lazar)</td>
<td>Computational Neuroscience: Circuits in the Brain</td>
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<td>BMEE E4030 (Prof. Wang)</td>
<td>Neural Control Engineering</td>
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<td>ECBM E4090 (Prof. Mesgarani)</td>
<td>Brain Computer Interfaces Lab</td>
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**Electives, Other departments:** Computational Genomics, Biological Networks, Biomedical Engineering
BMEB W4020 Computational Neuroscience: Circuits in the Brain

Prof. Aurel Lazar

- **The Biophysics of Computation**

- **Encoding with Neural Circuits**
  - Stimulus Representation with Time Encoding Machines, Geometry of Time Encoding, Encoding with Neural Circuits with Feedback, Spatio-Temporal Receptive Fields, Population Audio and Video Time Encoding Machines.

- **Functional Identification of Neural Circuits**

- **Projects in Matlab or Python**
Hands on experience with neural signal recording and analysis

- Gaining experience with electroencephalography (EEG)

- Exploring the applications in scientific, engineering and medical fields
ECBM E4060 Introduction to Genomic Information Science and Technology

Prof. Dimitris Anastassiou

- Introduction to the information system paradigm of molecular biology.
- Representation, organization, structure, function and manipulation of the biomolecular sequences of nucleic acids and proteins.
- The role of enzymes and gene regulatory elements in natural biological functions as well as in biotechnology and genetic engineering.
BMEE E4030 Neural Control Engineering

Prof. Qi Wang

- Basic cell biophysics, models of neurons, ion channels, spike generation
- Large-scale electrophysiological recording methods, sensorimotor integration and optimal state estimation, operant conditioning of neural activity
- Nonlinear modeling of neural systems, sensory systems
- Neural encoding model
- Neuronal response to electrical micro-stimulation, DBS for Parkinson's disease treatment, motor neural prostheses, and sensory neural prostheses.
Getting involved in research

- Many opportunities to work on neuro/bio related research projects: experimental, medical, computational or theoretical projects.
- Open Labs 2-4PM
- Contact the faculty directly: http://www.ee.columbia.edu/systems-biology-and-neuroengineering
- Up to 6 points of research count towards MS degree (e.g., ELEN E4998, ELEN E6001, ELEN E6002)