

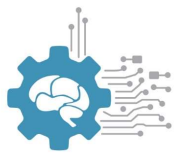
## Neural Engineering for Secondary Science Classrooms (Resource Exchange)

### Ms. Kristen Clapper Bergsman, University of Washington

Kristen Clapper Bergsman is the Engineering Education Research Manager at the Center for Sensorimotor Neural Engineering at the University of Washington, where she is also a doctoral student and graduate research assistant in Learning Sciences and Human Development. Previously, Kristen worked as an educational consultant offering support in curriculum design and publication. She received her M.Ed. in Curriculum and Instruction (Science Education) from the University of Washington.

### Dr. Eric H. Chudler, University of Washington

Eric H. Chudler is a research neuroscientist interested in the neuroactive properties of medicinal plants and herbs and how the brain processes information about pain and nociception. He received his Ph.D. from the Department of Psychology at the University of Washington in Seattle in 1985. He has worked at the National Institutes of Health in Bethesda, Md. (1986-1989) and in the Department of Neurosurgery at Massachusetts General Hospital in Boston, Mass. (1989-1991). Chudler is currently a research associate professor in the Department of Bioengineering and the executive director of the Center for Sensorimotor Neural Engineering. He is also a faculty member in the Department of Anesthesiology & Pain Medicine and the Graduate Program in Neuroscience at the University of Washington. In addition to performing basic neuroscience research, he works with other neuroscientists and classroom teachers to develop educational materials to help K-12 students learn about the brain.



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Visit <http://www.csne-erc.org> for free curriculum resources!

### Neural Engineering is a Contemporary, High Interest Topic

Media reports of cutting-edge technologies, such as brain-computer interfaces, deep brain



stimulation, retinal implants, and smart prosthetic limbs, make sensorimotor neural engineering a high-interest topic for the science classroom. The field brings together experts from across disciplines to develop innovative solutions to restore or enhance sensorimotor functions in the human nervous system, including neurological disorders such as stroke, Parkinson's disease, and spinal cord injuries.

*“Overall, the idea of neural engineering is super interesting. How you can mix neuroscience and engineering in one and how you can help people.” (Science student)*

### Free Curriculum Units for Secondary Teachers

For the past six years, the Center for Sensorimotor Neural Engineering at the University of Washington has hosted a Research Experience for Teachers (RET) program that engages secondary science teachers in a seven-week research experience paired with curriculum design. A growing library of RET curriculum units is available for free to secondary STEM teachers, with additional units coming soon. The 7 units are teacher-authored, classroom-tested, and designed for the Next Generation Science Standards (NGSS). They provide suggestions on integrating neuroscience and neuroethics content with engineering design. Many of the units engage students in using technologies—such as EMG-controlled robotic gripper hands, circuit boards, SnapCircuits, Arduino Uno rigs, and SpikerBoxes—that illustrate basic concepts of the sensorimotor feedback loop. However, several of the units only feature low-cost, readily available materials to be implemented in schools with limited resources.

*“This set of lessons was more hands-on, tactile learning than any other lesson set I have learned from this academic year.” (Science student)*

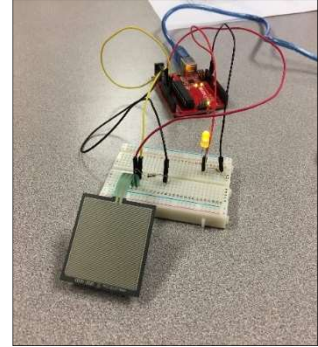
Program evaluation results indicate that 100% of RET teachers who authored and enacted units (N = 12) agreed or strongly agreed on a 5-point Likert scale that the units were: effectively presented through engaging, real life contexts; presented at an appropriate age level; included adequate resources to support student learning; and well aligned to the NGSS. Also, 100% of the teachers felt that their students were very interested in the activities and that the unit increased their students' awareness of neural engineering. Results from surveys of students in 2017 (N = 212) indicate that they self-reported on a 5-point Likert scale statistically significant ( $p < .001$ ) differences before and after enactment of the units in their knowledge of concepts in neural engineering, engineering, neuroscience, and neuroethics, as well as careers in neural engineering.



### **Featured Unit: Modeling & Designing a Sensory Substitution Device**

**Time:** 4-5 weeks    **Lessons:** 10    **Grades:** 6-8    **Focus:** STEAM/Engineering

In this unit, students will learn about the basic structure and function of the nervous system, explore the relationship between electrical circuits and the nervous system, and then construct a simple, sensory substitution device with Arduino Uno microprocessors and breadboards, used in aiding individuals with a missing or impaired sense. Students will test and present a work-in-progress prototype to peers, and then modify the design based on the test results and peer feedback. Finally, students will explore other perspectives, including the needs of end-users, budget, type of materials, ease of use, maintenance, and accessibility. In this unit, students experience the iterative stages of the full engineering design process, including using an engineering design notebook.



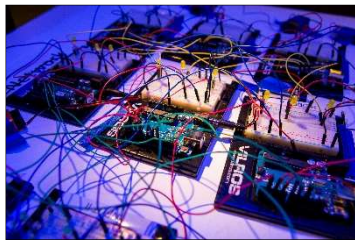
This curriculum was designed by Phelana Pang of Seattle Girls School and has been pilot-tested with her students over two years. Lessons include:

- Introduction to Neuroscience
- Robot Gripper Hand
- Prosthetic Fingers
- Neural Engineering and Sensory Substitution
- End-Users and Ethics
- Circuits
- Breadboards
- Introduction to Arduinos
- Designing a Sensory Substitution Device
- Presenting and Evaluating the Design

### **Featured Unit: Building Artificial Neural Networks with Arduinos**

**Time:** 6 50-min periods    **Lessons:** 4    **Grades:** 9-12    **Focus:** Biology/AP Biology

In this unit, biology students will explore the applications of artificial neural networks, especially in the field of artificial intelligence. Students will learn about the history of artificial intelligence, explore the concept of neural networks through activities and computer simulations, and then construct a simple, three-level artificial neural network using nine Arduinos to simulate neurons. After building the network, they will be challenged to discover how altering the connections or programming of the “neurons” alters the behavior of the network. Finally, students will explore the ethical implications of building artificially intelligent machines.



This curriculum was co-designed by Benjamin Hart of Redmond High School and Larry Bencivengo of Mercer Island High School and has been pilot-tested with their students over three years. Lessons include:

- Introduction to Artificial Intelligence
- Introducing Artificial Neural Networks
- Introducing Arduinos
- Building Neural Networks with Arduino