

National Science Foundation sponsored
**Summer Research Experience for Undergraduates in
NEUROSCIENCE**

University of Missouri-Columbia

College of Engineering in partnership with
College of Arts & Science, School of Medicine,
and School of Veterinary Medicine

Application Deadline: See website

<https://engineering.missouri.edu/academics/eecs/neuro/neuro-research/neuro-nsf-reu/>
(applications will be evaluated on a rolling basis, so apply early)

Apply on-line via the website – Paper applications will not be accepted

Get Paid, Get Experience, and Have Fun!

- A ten-week research experience (see website for dates)
- A stipend of \$6,000 in addition to travel, tuition, air-conditioned campus dorm housing and full meal plan
- An opportunity to assist graduate students with important research led by leading faculty with a wide range of expertise spanning four different colleges.
- The REU has a strong computational focus, and in some cases research teams will include two undergraduates from different disciplines (e.g., life sciences and engineering).
- 1 hr credit for a course in "Computational Neuroscience" (meets 1 hour a week).
- Opportunity to join approximately 50+ other undergrad research students in a Research Symposium where each student prepares a poster presentation and a one-page abstract for publication in a handbook.
- A full series of evening workshops and brown bag lunches with 50+ other undergraduate researchers will give students information about research, career preparation and options, in addition to scientific ethics. Nationally acclaimed speakers will discuss specialty areas relevant to the summer research program.
- Social activities will be planned with input from participants guiding the agenda.
- Opportunity to enhance resumes and prepare for graduate school.

Application Information: The deadline for applying to the program is provided at the project website. Students must complete the application form on the website above. To do this, be ready with an unofficial transcript; a personal statement including career plans, prior research experience (if any), a statement of research interests; and a resume. You will also need to have a letter of recommendation (two preferred) sent by your referee directly to mizzoureu@gmail.com.

Eligibility: Applicants are expected to have completed at least two years of full-time college enrollment prior to June and be pursuing a major in engineering, biology, biophysics or related fields. Students graduating prior to July are not eligible. Students must be citizens or permanent residents of the U.S. Students must have a minimum GPA of 2.75 (on a 4.00 scale) overall with a minimum 3.00 in science and math courses. An interest in mathematics or statistics is recommended. Students from University of Missouri-Columbia are not eligible.

Faculty Mentors: Can be any 'neuro' faculty at MU, so long as the project has a computational/math/stat component. Use application to state preference of neuroscience level and of mentors.

Sample Projects and Contact information

Students can select any available [neuro mentor](#) from University of Missouri (so long as the project has a computational/math component). MU Interdisciplinary Neuroscience Program - <http://www.neurosci.missouri.edu/>. The neuroscience 'Levels' at MU are:

- Intra-cellular/Cellular Levels
- Behavioral Level
- Systems Level
- Translational/Veterinary Medicine Level
- NeuroInformatics Level
- Cognitive Level

SAMPLE PROJECTS AT THE INTRA-CELLULAR/CELLULAR LEVELS (Contact: David Schulz)

Mechanisms of neuronal homeostasis and compensation

- [Dr. David Schulz](#) ; [Division of Biological Sciences](#) ; schulzd@missouri.edu
- <http://www.biosci.missouri.edu/schulz/>

The Schulz lab focuses on compensatory mechanisms of gene expression at the single cell level that stabilize neuronal output.

Specific undergraduate projects:

- Investigate the functional relationships between pairs of membrane conductances that determine neuronal output, by studying the expression of multiple ion channel genes in single identified neurons in the stomato-gastric ganglion of crabs, and determine how the expression of these genes is correlated or co-regulated; and
- Understand the evolutionary influences on neural network function by detailed measurements of network output from numerous crustacean species (e.g., local crayfish species) and determine how different habitat/species niche has shaped network output.

Call recognition in the katydid genus *Neoconcephalus*

- [Dr. Johannes Schul](#) ; [Division of Biological Sciences](#) ; schulj@missouri.edu
- <http://schulj.biology.missouri.edu/>

Schul's research on acoustic communication in insects stands out in the field as it incorporates evolutionary and neurobiological aspects. He established the katydid genus *Neoconcephalus* as a model system to study the evolution of novel traits.

Specific undergraduate projects:

- Exploring whether call recognition of *N. ensiger* (typically 15 Hz) is based on neuronal resonance and incorporating results into a computational model;
- Flying katydids show evasive responses when stimulated with bat echolocation calls. We will determine whether performance of bat detection is influenced by the behavioral context, i.e., responding to male calls; and
- In katydids, a single neuron segregates bat calls from the auditory scene. The underlying mechanism seems to be adaptation of some but not all parts of the dendrite. We will test this dynamic compartmentalization hypothesis using electrophysiological methods and model this process based on our results and existing neuroanatomical data.

Mechanisms of exocytosis

- [Dr. Kevin Gillis](#) ; [Department of Bioengineering](#) ; GillisK@missouri.edu
- <http://dalton.missouri.edu/investigators/gillisk.php>

The Gillis lab uses optical, electrophysiological, electrochemical and other biophysical techniques to study how neuroendocrine cells secrete transmitters via exocytosis at the cellular and molecular levels.

Specific undergraduate projects: How do second-messenger systems alter patterns of transmitter release by shifting the Ca^{2+} sensitivity of exocytosis?

- Patch-clamp experiments will be conducted with chromaffin cells that secrete catecholamines upon elevation of intracellular $[Ca^{2+}]_i$ to determine how the $[Ca^{2+}]_i$ -exocytosis relationship is changed upon activation of second-messenger cascades; and
- Kinetic models of Ca^{2+} -triggered exocytosis will be developed using the caged Ca^{2+} data and used to predict the rate and amount of catecholamine release that will occur upon elevation of $[Ca^{2+}]_i$ by physiological stimuli such as action potentials or release of Ca^{2+} from internal stores.

Optogenetic interrogation of brain activity for the treatment of neurological disorders

- Dr. Ilker Ozden; Department of Bioengineering; ozdeni@missouri.edu
- <http://bioengineering.missouri.edu/faculty/ozden-i.php>

Ilker Ozden's research focus on optogenetic control of brain activity patterns for the development of therapies for movement disorders, especially for Parkinson's disease. His lab uses optogenetics, multichannel electrophysiology and functional imaging in healthy and Parkinsonian rodents to identify components of abnormal brain activity responsible for motor deficits, and to target these components for therapy.

Specific undergraduate projects

- Use spectral analysis and machine learning algorithms to identify frequency-band specific changes in cortical oscillatory patterns in Parkinsonian brains
- Incorporate a variety of opsin types with existing cortical models to predict opsin-specific effects of optogenetic stimulation on cortical oscillations and activity dynamics.

SAMPLE PROJECTS AT THE BEHAVIORAL LEVELS (Contact: Reginald Cocroft)

Insect behavior and social communication

- [Dr. Reginald Cocroft](#) ; [Division of Biological Sciences](#) ; cocroft@missouri.edu
- <http://www.biosci.missouri.edu/cocroft/homepage.htm>

Research in the Cocroft laboratory focuses on the function and evolution of communication systems. The study organisms are insects that signal using substrate vibration, the most widespread of all mechanical communication channels.

Specific undergraduate projects:

- Aggregations of immature *Umberia* treehoppers attacked by a predator produce cooperative group signals that require the rapid transmission of signaling behavior within aggregations. Dissecting the dynamics of information transmission through an interplay of agent based modeling and behavioral experiments will reveal how adaptive signaling patterns are produced, e.g., patterns that reveal predator location to the defending parent (with one current undergraduate Hispanic female co-mentored by Cocroft and Nair);
- Neurobiological study of the response of the leg vibration receptors to vibrational cues of direction and distance (in collaboration with Dr. Carol Miles of Binghamton University); and
- Statistical modeling of the cues used by insects in behavioral decisions during localization.

SAMPLE PROJECTS AT THE TRANSLATIONAL/VET MED LEVEL (Contact: David Beversdorf)

Autism – Causes, Treatment and Effects of Stress

- [Dr. David Beversdorf; Psychology, Neurology, Radiology; beversdorfd@health.missouri.edu](mailto:beversdorfd@health.missouri.edu)
- <http://radiology.missouri.edu/radWeb/beversdorfLab/Index.html>

The Beversdorf Lab projects involve research into the causes and treatment of autism as well as the effects of stress. This research involves neuropsychopharmacology, fMRI, psychophysical markers, and studies of gene/environment interactions in clinical populations, as well as gene/environment interactions and neuropsychopharmacology in animal models.

Specific undergraduate projects:

- Utilization of optogenetics to examine the regional specificity of the effect of propranolol on problem solving behavior in a rodent model (co-mentored with Dr/ Matthew Will, MU)
- Interaction between maternal diet, prenatal stress, and genetics in the development of autism
- Effects of stress on cognitive performance, fMRI correlates of cognitive performance, and how this relates the immune response associated with stress.
- Effects of propranolol on cognitive performance and fMRI in autism
- Interaction between stress reactivity and gastrointestinal symptomatology in autism

Modeling neuronal mechanisms in control of sleep-wakefulness.

- [Dr. Mahesh M. Thakkar; Department of Neurology, School of Medicine](mailto:thakkarmmm@health.missouri.edu)
- thakkarmmm@health.missouri.edu

The Thakkar Lab is involved in investigating several aspects of the sleep-wake cycles. The projects listed here are collaborations with the Nair Lab on modeling neuronal mechanisms controlling sleep-wake cycle.

Specific undergraduate projects (all collaborations with the Nair Lab):

- Development of computational models to understand the interactions within a population of wake-promoting neurons.
- Development of a computational model to examine the interrelationship between homeostatic and circadian controllers

Biomedical Imaging and Biomedical Informatics

- [Dr. Ye Duan ; Department of Computer Science; duanye@missouri.edu](mailto:duanye@missouri.edu)
- <http://people.cs.missouri.edu/~duanye/>

The Duan Lab conducts research in the area of Computer Graphics and Visualization, Biomedical Imaging and Computer Vision, as well as biomedical informatics.

Specific undergraduate projects:

- Quantitative brain structure analysis for autism using 2D/3D Magnetic Resonance Imaging (MRI) data;
- Quantitative facial pattern analysis for autism using 2D/3D facial imaging data.

Imaging and Analysis of the Brain and Craniofacial Tissues in Neurodevelopment

- [Dr. Kristina Aldridge, Pathology & Anatomical Sciences, aldridgek@missouri.edu](mailto:aldridgek@missouri.edu)
- <http://web.missouri.edu/~aldridgek/>

Research in the Aldridge lab examines growth and development of the brain and its interaction with surrounding craniofacial tissues, with a specific emphasis on neurodevelopmental disorders.

Specific undergraduate projects:

- Quantitative assessment of brain growth in craniosynostosis, a disorder involving dysmorphology of the infant head, using 3D MRI data to better understand the cause and consequences of altered head growth;
- Analyses of mouse models for craniosynostosis syndromes at multiple developmental ages to better understand the development of the brain in these disorders.

Neurodegenerative disorders – Collaborative and translational neuroscience studies

- Dr. Zezong Gu; Pathology and Anatomical Sciences; guze@health.missouri.edu
- <http://pathology-anatomy.missouri.edu/people/gu.html>

Research in the Gu Laboratory focuses on understanding the molecular mechanisms of redox signaling and the impact to neurological diseases using various models representative of ischemic stroke, traumatic brain injury (TBI), Parkinson's and Alzheimer's disease. Multi-disciplinary approaches used in the laboratory include microsurgery, pharmacology, protein biochemistry, molecular and cell biology, confocal/deconvolution microscopy, and quantitative proteomic approaches allowing trainees to conduct translational research and investigate the mechanisms underlying protein aggregation, aberrant proteolysis, and nerve cell death.

Specific undergraduate projects:

- Therapeutic potential of mechanism-based inhibition of matrix metalloproteinases in stroke and TBI;
- Molecular imaging of proteolysis in cells and in animals in vivo;
- 2D DIGE or mass spectrometry (MS)-based analysis of sub-proteome for cysteine thiol posttranslational modifications (PTM) and molecular modeling for PTM-induced conformational changes; and
- Mechanisms of redox modulation of proteins and their down-stream signal transduction pathways that lead to dysfunctional ubiquitination, aggregation of misfolded proteins, aberrant proteolysis and neuronal cell death in neurodegenerative disorders.

The Neuro NSF REU program trainee involving in one of these projects will get additional technical support and collaborate with other lab members. Ultimately, the research may lead to develop a novel strategy for clinical applications of diagnosis and therapy.

SAMPLE PROJECTS AT THE SYSTEMS LEVEL (Contact: Satish Nair)

Reverse Engineering Brain Circuits

- [Dr. Satish S. Nair](#) ; [Department of Electrical Engineering](#) ; nairs@missouri.edu
- <http://engineering.missouri.edu/neuro/>

The Nair lab projects involve reverse engineering the brain circuits in invertebrates and vertebrates, at intracellular, cellular and systems levels, in close association with neuroscientists and biologists.

Specific undergraduate projects:

- Modeling neural dynamics in the cardiac ganglion of crabs and lobsters (co-mentored with D. Schulz);
- Signaling mechanisms between insects and plants (co-mentored with R. Cocroft, MU);
- Modeling fear extinction in the thalamus-amygdala-hippocampus-prefrontal circuits in rats (co-mentored with G. Quirk of Puerto Rico School of Medicine);
- Modeling neuroplasticity in the nucleus accumbens with chronic cocaine (co-mentored with P. Kalivas of Medical University of South Carolina), and
- Cyber- and Cloud-based computing tools to automate programming with NEURON and Python (with P. Calyam, MU)

Acceleration of Computational Neural Network Models and Algorithms

- Dr. Ismail Akturk; Department of Electrical Engineering and Computer Science; akturki@missouri.edu
- <http://faculty.missouri.edu/akturki>

Akturk Lab works on application-specific computer architecture and runtime systems for improving scalability, performance and energy efficiency of compute-intensive workloads.

Specific undergraduate projects:

- Parallelization of computational biology and systems biology workloads on platforms such as GPUs and Intel Xeon Phi.
- Hardware acceleration of neural models and dynamics on FPGAs.

SAMPLE PROJECTS AT THE COGNITIVE AND NEUROINFORMATICS LEVELS (Contact: Nelson Cowan)

Memory and Attention in Human Cognition

- [Dr. Nelson Cowan](#); [Department of Psychological Sciences](#); CowanN@Missouri.edu
- <http://web.missouri.edu/~cowann/research.html>

The Cowan Lab projects involve human behavioral and neuroimaging studies of working memory, the small amount of information that can be held in mind in order to comprehend language and solve problems. The summer work will most likely involve testing children to determine how working memory develops.

Specific undergraduate projects:

- The development of verbal working memory and grouping in childhood: computer-based behavioral research
- The development of visual working memory and attention in childhood: computer-based behavioral research
- Analysis of working memory neuroimaging data: processing of fMRI data (in cooperation with Shawn Christ).

Bioinformatics and Computational Biology

- [Dong Xu](#) ; [Department of Computer Science](#) ; XuDong@missouri.edu
- <http://digbio.missouri.edu/>

The Xu lab conducts research in protein structure prediction and modeling, high-throughput biological data analyses and application of bioinformatics methods to biological systems. This includes the development of effective computational methods for protein structure prediction and modeling, including protein structure comparison, protein secondary structure prediction, protein fold recognition (threading), mini-threading, and structure-based function prediction.

Specific undergraduate projects:

- Investigate the gene circuitry related to cocaine neuroplasticity and dependence using a method based on our recent work of building gene network via various time-course gene expression and proteomic data;
- Protein structure prediction and modeling for autism positional candidate genes using our new tool, MUFOLD.

Deep Learning

- [Jianlin Cheng](#) ; [Department of Computer Science](#) ; chengji@missouri.edu
- <http://people.cs.missouri.edu/~chengji/>

The Cheng Lab projects is involved in developing artificial intelligence methods (deep learning, machine learning, data mining, informatics) to study brain cognition and diseases.

Specific undergraduate projects:

- (i) Developing data mining methods to identify genes related to autism
- (ii) Develop deep learning methods for simulating brain cognition

Joint Bayesian models of brain and behavior

- Ed Merkle; Dept of Psychological Sciences; merkle@missouri.edu
- <http://faculty.missouri.edu/~merkle>

Merkle Lab research involves the development of statistical models that are useful for data collected in

psychology and the cognitive sciences. This includes Bayesian models of cognitive processes underlying both neural and behavioral data.

Specific undergraduate projects:

- Formally investigate ways in which behavioral data (choice, response time) inform the analysis of fMRI data.
- Code joint models of behavioral and neural data using Stan (software for Markov chain Monte Carlo), and use the code to analyze real data.