Faculty Research Interests

Biology, Chemistry, and Physics

DEPARTMENT OF BIOLOGY

Dr. Ben Bahr

Therapeutic Treatments Against the Numerous Diseases that Disrupt Brain Function

The petabyte hard-drive we call our brain (i.e. a million gigabytes, enough to store all 10 billion photos currently on Facebook) is a challenge to study, also making it a challenge to find therapeutic treatments against the numerous diseases that disrupt brain function. In my lab, slices of brain tissue are kept alive to examine neuronal connections responsible for both memory encoding and cellular maintenance pathways, and to study their vulnerability to pathogenesis. While the brain's incredible density of synaptic connections allows for extraordinary memory capacity, the abundant synapses are also vulnerable to pathogenic over-activation. Such excitotoxic brain damage can occur in many disease states including stroke, traumatic injury, and seizure events. We are studying the pharmacological enhancement of endogenous pathways, and we found that positive modulation of internal repair mechanisms protects against the damaging effects of seizures and stroke-type excitotoxic insults. Other efforts are to study age-related neurodegenerative disorders. Every 72 seconds someone in the U.S. develops Alzheimer's disease (AD). Reducing Alzheimer-type protein accumulation is essential for slowing the progression of the disease. Lysosomes and their degradative enzymes (e.g. cathepsins) are known to respond to AD, perhaps in an attempt to offset the abnormal protein accumulations that cause a distinct pathogenic cascade. Recently, we discovered a new class of drugs that act as positive modulators of the lysosomal response, resulting in the up-regulation of cathepsins as well as neuroprotection in cultured brain slices and in mouse models of AD.

Dr. Leon Jernigan

Environmental Biology

Research area involves coastal marshes and freshwater wetlands. Topics of interest are hydrologic alterations, success of restoration/ mitigation projects, ornithology, forest ecology, and environmental monitoring. Much of the expertise obtained by involved students would be in the area of applied ecology. No active research program at this time but will consider mentoring a student-driven project.

Dr. Lisa Kelly

Conservation Biology

I'm a field biologist with research interests in the complementary fields of plant ecology, conservation biology, and plant taxonomy. More specifically, floristics, rare species, and the effects of natural and anthropogenic disturbances on plant diversity, interest me. As the director of the UNCP Herbarium, I have supervised and trained several students in standard herbarium techniques. I look forward to expanding the Herbarium's holdings and assisting students who are interested in the collection and preservation of voucher specimens. I have directed undergraduate research on Chrysoma pauciflosculosa (woody goldenrod), a state endangered species of plant. The work focused on population dispersion in the field and seed germination in the laboratory. I would enjoy assisting students in similar projects as well as in floristic studies in the future.

Dr. Maria Pereira

Molecular Genetics, biotechnology

I have three different projects that students might want to participate. The first deals with biofuels and the production of biodiesel. This project is going to be performed in collaboration with Dr. Siva Mandjiny and Dr. Tom Dooling. Currently, UNCP owns a reactor in which kitchen oil can be converted into biodiesel. We are trying to find ways to use enzymes instead of the standard chemicals to make the reaction more efficient. One of the by-products of the reaction is glycerin. We need to find use for the glycerin. Students will have the opportunity to use their creative thinking, which is usually called "novel" research. The second project involves the growth and expression of eukaryotic cells and is going to be in collaboration with Dr. Jeremy Sellers. Human pancreatic cells (cancerous and control) will be evaluated and maintained alive in a CO2 incubator. We will be exploring different cell lines and looking for the mutations present. Techniques used include PCR, DNA sequencer, bioinformatics and cloning. The third project involves bacterial mutants. I have created E. coli mutants that are ampicillin resistant (no pAMP present). We need to evaluate these mutants and compare and contrast them for the physiological and biological characteristics. We are searching for the mutation present in each one by using the DNA sequencer and we will compare this mutation against all other known mutants by using bioinformatics.

Dr. Robert Poage

Neurobiology, Synaptic Physiology

Synaptic transmission is the basis of all movement, sensation, and stimulation. My research involves ion channel function, primarily voltage-activated calcium channels. I am interested in specialization of neuronal membrane and how certain cellular compartments are capable of extremely rapid interneuronal communication. My primary training is in the use of electrophysiological recording techniques to study basic properties of neuronal communication. I am currently investigating the role of the presynaptic environment on voltage-gated calcium channel function using the frog neuromuscular junction as a model system. We are currently addressing the following hypotheses: 1st, that DAP increases overall acetylcholine release while decreasing the effects of facilitation in LEMS conditions; 2nd, that DAP increases facilitation in LEMS conditions compared to control conditions.

Dr. John Roe

Wildlife Ecology

Research in my lab focuses on wildlife behavior, population biology, and ecology. Students that work with me will log many hours in the field using technologies to monitor populations and examine behavioral responses to environmental challenges such as climate change, habitat modification, roads, and pollution. Technologies that students will have the opportunity to use include radio-telemetry, global positioning systems, environmental data loggers, geographic information systems, automated recording devices, and others. I am particularly interested in reptiles and amphibians in the Lumber River and associated wetlands, the sandhills, and the unique depression wetlands known as Carolina Bays. I conduct basic descriptive research, but I also think it is important to apply research findings to addressing specific wildlife conservation and management issues.

Dr. Maria Santisteban

Yeast Molecular Genetics, Epigenetic regulation of eukaryotic gene expression

In the eukaryotic cell nucleus, DNA is packaged with histones into nucleosomes, the repeating subunits of chromatin. The precise organization of DNA in chromatin has important functional consequences. DNA-template processes such as transcription, replication and chromosome segregation are dependent on the remarkable packaging of the DNA in chromatin. The long-range objective of my research is to understand the molecular mechanisms of chromatin-regulated gene activation.

My research has primarily focused on the role a histone H2A variant, the H2A.Z/F. In the budding yeast Saccharomyces cerevisiae, this variant histone protein is encoded by the HTZ1 gene. We have discovered that Htz1 functions to enable transcription by RNA polII. Specifically, our data indicates that Htz1 possibly plays a role in elongation. I would continue exploring this hypothesis using techniques of molecular genetics that will involve mutational analysis, genetic screens, chromatin imunoprecipitation, microarray analysis, Real-time PCR, etc.

Dr. Jose D'Arruda

Physics and Astronomy (Statistical Mechanics, Quantum Mechanics, and Classical Mechanics

My research is in several areas: Quantum Statistical Mechanic-Solving Schrödinger Equation with various potential energy terms and applying the results to calculating correcting to the Ideal Gas law for high temperatures gases. These corrections lead to terms in the Virial Equation which gives us clues to the forces which exists between atoms and molecules in gases. Applications can be used to understand how stars evolve. Computational Physics-Using computer modeling to demonstrate to students and help them understand physical principles. Developing and deploying interactive models, simulations, and educational tools which improve math and science education through the effective use of modeling and simulation technologies. Robotics-Offering workshops using Lego NXT robotic kits to help teacher excite their students into learning science, math and engineering. Students compete in Robotic Games in the spring on our campus. Astronomy/Astrophysics- As director of the UNCP Space Grant I mentor several students each semester in various undergraduate research project in astronomy. Presently we are using our 16" GPS Meade telescope to measure the light intensity period of several Cepheid Variable stars as a way of determining their distance from the earth and performing spectroscopic measurement of several binary stars. Physics Education-Obtaining grants to offer workshops for teachers which will help them become better teachers of physics, physical science and astronomy. Science Fair- Having created the UNCP Regional Science fair 29 years ago I remain Co-Director with Drs. Ritter and Postek.

Dr. William Brandon

<u>High Precision Faraday Rotation Measurements</u>

Ongoing experiment to measure the Verdet constant of air affords research assistants the opportunity to study magnet-optics, electrical noise, auto-balanced photodetection and phase sensitive detection techniques. The lofty goal of this project is to eventually develop a methodology to measure vacuum birefringence.

<u>Temperature Dependent Behavior of p-n Junction Devices</u>

Various techniques, mainly steady state and low duty cycle current injection methods, are being used to investigate temperature effects on the I-V characteristics of p-n junction devices (e.g. diodes, LEDs, laser diodes).

<u>In-Situ Monitoring of Quantum Dot Synthesis</u>

A plan to use fluorescence spectroscopy to observe the synthesis of CdSe/ZnS quantum dots in real-time is currently underway. This technique would, in principle, provide an efficient way to optimize the temperature and time of the synthesis while providing higher quantum yields. Finally, an apparatus to investigate quantum dot synthesis in the presence of magnetic fields is also being considered.

<u>Low Resonance Frequency Electrical Circuits</u>

In this project extremely low frequency LRC circuits are being studied in hopes of developing a novel method to investigate Schumann resonances of Earth.

Dr. Paul Flowers

Developing New Tools and Techniques for Biomedical Analysis

My research efforts are divided between two projects:

1. development of apparatus and methodology based on simultaneous spectral and electrochemical measurements (aka "spectroelectrochemistry") that are suitable for the microscale analysis of samples of biomedical relevance; and

2. microscopic and electrochemical investigations of iontophoresis, a technique commonly used in neuroscience for the direct delivery of drugs and other compounds to specific regions of the brain (our work aims to develop a calibration scheme suitable for *in-vivo* applications).

(for additional details see http://www2.uncp.edu/home/paul/ *)*

Students engaged in this research will develop their skills in basic lab techniques, literature research, and oral and written communication, in addition to gaining hands-on experience with various modern instruments, including visible and infrared microspectrometers and electrochemical analyzers. I typically work with one to three students during the fall and spring semesters, with summer appointments contingent on the availability of funding support.

Dr. Cornelia Tirla

Synthesis of Organic Molecules with Biological Activity

The objective of this project is to determine the relationship between the structure of small peptides and their ability to affect lysosomal activity. To this end, a close collaboration between organic chemistry and biological science offers great potential for increasing understanding of the role of lysosomes in cellular homeostasis. Researchers and students involved with the proposed project will benefit from work to adopt new scientific knowledge and skills at the interface between organic chemistry and biology as they pursue work in the dynamic field that is lysosomal regulatory properties.

The goals of this project are:

- Synthesize new, non-peptidyl derivatives of diazoketones. Previous studies were able to demonstrate that diazoketones have regulatory properties with respect to lysosomal activity. Because these properties are believed to be a consequence of interactions between the diazo group and the biological tissue, this project will examine the effect of other functional groups alone. Derivatives of Z-Phe-Ala-diazomethylketone (PADK) will be prepared, by replacing the diazo group and leaving the rest of the molecular structure intact.

- Analyze structure of the compounds.

Because of the importance of the structure in determining the biological activity of the organic molecules, the structure of different derivatives will be analyzed using modern spectrometry techniques, such as high field NMR and LC-Mass Spectroscopy.

- Test the new derivatives for lysosomal activity.

Following synthesis, purification and characterization, the new compounds will be tested for metabolic stability *in vitro* including metabolite composition, distribution, deposition, and synaptic integrity.

- Evaluation and dissemination of results.

The results of this research will be disseminated in peer reviewed publications and student research presentations at local and regional meetings.