Research Opportunities on the Edgewood Campus

Updated 8/27/16

Below is a list of research opportunities on the Edgewood campus for the next several semesters. Space in research courses is limited and requires an application that must be approved by the research mentor AND the undergraduate research coordinator before registration. Students who are interested in pursuing research off-campus must also have an Edgewood faculty research mentor. Please contact Dr. Kime to discuss your plans and begin the application process.

Bio 251 is a prerequisite for all research courses. **Bio 252** is the course that we recommend for most students; it is an organized course intended for students who are beginning research. The **Ebben Fund** is a paid research internship for students interested in working on intensive summer research with a faculty mentor; it requires a separate application to the College for funding. **Bio 479** and **Bio 489** are more advanced independent study courses; we only recommend these courses to advanced students who are prepared to purse independent research on a particular topic or who are continuing research projects from previous semesters.

Descriptions of research from faculty mentors and potential Bio 251 research proposal questions are included below the table.

Mentor	Fall 2016 *(Bio 251 required)*	Spring 2017	Summer 2017	Fall 2017	Spring 2018
Brenda del Moral	**Bio 252** Behavioral Neuroscience or Molecular Neuroscience	**Bio 489** Neuroscience *independent research*		**Bio 252** Behavioral Neuroscience or Molecular Neuroscience	**Bio 489** Neuroscience *independent research*
Jake Griffin	**Bio 489** Ecosystem Ecology (Impacts of EAB Invasion) Urban Plant Ecology (Southwest Bike Path) Landscape Ecology (pollinator diversity)	**Bio 252** Ecosystem Ecology (Impacts of EAB Invasion) Urban Plant Ecology (Southwest Bike Path) Landscape Ecology (pollinator diversity)	**Ebben Fund** Ecosystem Ecology (Impacts of EAB Invasion) Urban Plant Ecology (Southwest Bike Path) Landscape Ecology (pollinator diversity)	**Bio 489** Ecosystem Ecology (Impacts of EAB Invasion) Urban Plant Ecology (Southwest Bike Path) Landscape Ecology (pollinator diversity)	**Bio 252** Ecosystem Ecology (Impacts of EAB Invasion) Urban Plant Ecology (Southwest Bike Path) Landscape Ecology (pollinator diversity)
Jessica Heckman	**Bio 252** Cancer Biology	**Bio 489** Cancer Biology			**Bio 252** Cancer Biology

Mentor	Fall 2016 *(Bio 251 required)*	Spring 2017	Summer 2017	Fall 2017	Spring 2018
Nicole Kime	**Bio 489** Behavior and Physiology of Frogs, Lizards, etc. *independent research*	**Bio 430 + Bio 252** Animal Behavior	**Ebben Fund** Behavior and Physiology of Frogs and Lizards *independent research*	**Bio 489** Behavior and Physiology of Frogs, Lizards, etc. *independent research*	**Bio 425 + Bio 252** Animal Physiology
Tim Kuhman	**Bio 489** **Ecology 450 + Bio 252** Invasive Plants (purple loosestrife) Land-use History in WI Oak Savanna History Glenway Woods research *independent research*	**On Sabbatical** **Spring 2017** *research opportunities for selected students*		**Bio 489** **Ecology 450 + Bio 252** Invasive Plants (purple loosestrife) Land-use History in WI Oak Savanna History Glenway Woods research *independent research*	**Bio 252** Invasive Plants Land-use History in WI Oak Savanna History Glenway Woods research
Pete Kuhn	**Bio 252** Cell Growth Regulation	**Bio 489** Cell Growth Regulation *independent research*		**Bio 252** Cell Growth Regulation	**Bio 489** Cell Growth Regulation *independent research*
Zachary Pratt	**xxx**			**BIO 252** Bacteriophages of Lake Wingra	**BIO 489** Bacteriophages of Lake Wingra Stress response of *E. coli* mediated by OmpX *Independent research*
Debbie Sharp	**xxx**				

Mentor	Fall 2016 *(Bio 251 required)*	Spring 2017	Summer 2017	Fall 2017	Spring 2018
Rachael Lancor	**Bio 489** Teaching Science *independent research*	**Bio 489** Teaching Science *independent research*		**Bio 489** Teaching Science *independent research*	**Bio 489** Teaching Science *independent research*
Francie Rowe	**Bio 352 + 489** Developmental Biology *independent research*	**Bio 489** Developmental Biology *independent research*		**Bio 352 + 489** Developmental Biology *independent research*	**Bio 489** Developmental Biology *independent research*

Faculty Research Descriptions / Bio 251 Research Proposal Questions

Brenda del Moral (Neuroscience):

I carry out research in 2 areas of neuroscience. The first project is in the area of behavioral neuroscience, and includes the use of a water-filled plus maze to measure the ability of a zebrafish to learn an associative learning task. Specifically, zebrafish are trained to associate the sight of other zebrafish (a reinforcer for the zebrafish) with a red card. After training is complete, the zebrafish will be tested to see if they successfully spend more time in the area of the maze with the red cue card where the other zebrafish used to be than in the other areas of the maze. This demonstrates associative (Pavlovian) learning. I am interested in piloting a different learning technique called conditioned place preference, which measures the rewarding properties of a drug. The conditioned place preference technique would need to be developed by a motivated student, and would allow to test a different aspect of the drugs and toxins included below in the question to determine if there are any rewarding properties to the drugs currently being tested. There is a possibility of testing other drugs or toxins, provided they can be reasonably obtained, if a motivated student makes a case for testing a different drug using the either associative learning task or conditioned place preference.

The second type of research I carry out focuses on the neurodegeneration caused by a toxin that depletes dopamine in the midbrain, which is used as an animal model of Parkinson's disease. The first step in this research will focus on identifying dopamine-containing neurons in the ventral diencelphalon of the midbrain with a dopamine-specific promoter that expresses Green Fluorescent Protein (GFP) using rtPCR. This will involve exposing zebrafish embryos to a neurodegenerative toxin MPTP and then trouble-shooting the rtPCR technique under my guidance. The second step is to use this PCR method to measure dopamine loss as a result of trichloroethylene (TCE) and perchloroethylene (PERC) solvent exposure and see if it mimics the dopamine loss induced by MPTP, which is an animal model for Parkinson's disease. These solvents are used by mechanics, dry cleaners, and in other industrial settings.

Questions:

- Do the solvents trichloroethylene (TCE) or perchloroethylene (PERC) alter the expression of tyrosine hydroxylase, the rate-limiting enzyme that produces the neurotransmitter dopamine, in the brains of exposed zebrafish as measured by qPCR?

- How do the effects of MPTP compare to the effects of chlorinated solvents on associative learning (or conditioned place preference) in zebrafish?
- How does the toxin bisphenol A (BPA), a chemical found in plastics, influence associative learning (or conditioned place preference) in zebrafish?
- If my laboratory is able to use conditioned place preference to demonstrate alcohol's rewarding properties, can drugs with antidepressant and anxiolytic properties such as inhibiting tropomyosin receptor kinase B (TrkB) reduce alcohol preference in zebrafish?

Jake Griffin (Ecosystem and Plant Ecology):

The composition of plant communities can play a key role in the cycling of energy and elemental nutrients within ecosystems, and can influence the delivery of ecosystem services to human society. I study the role that disturbances of all kinds (fire, harvest, insect outbreak) play in shaping plant communities, and in turn how changes in vegetation influence the flow of energy and nutrients through an ecosystem. In one project, we investigate how the emerald ash borer (EAB) may impact carbon and nitrogen cycling in forested ecosystems. In another project we examine some of the urban plant communities surrounding our Edgewood campus, and study how human activity within these areas shapes the relationship between plant communities and the ecosystem services we derive from them.

Questions:

- How might extensive tree mortality caused by the emerald ash borer (EAB) change carbon and nitrogen cycling in leaf litter and soils?
- How might extensive tree mortality caused by the EAB change the ability of forested ecosystems to retain nitrogen, and impact nutrient delivery to Lake Wingra?
- What plant communities are present in our urban forests and transportation corridors? How are plant communities influenced by human activity in these areas? How does plant species composition in urban forests influence the delivery of ecosystem services? What are best management practices for maintaining native plant communities in urban forests? What has been the effectiveness of community action to restore native plant diversity?

(Landscape Ecology):

From the air, the Madison/Dane Co. landscape looks like a patchwork quilt of different kinds of ecosystems—forests, farm fields, residential areas, urban areas, lakes, and prairies to name a few. The type, size, shape, and arrangement of these patches can have big consequences for the organisms and ecosystem processes within them, and for the benefits, or ecosystem services, that we humans derive from them. In this project students and I investigate how different landscapes impact the biodiversity of pollinating insects, and in turn the benefits we derive from their activity.

Questions:

- What kinds of pollinators are found in different types of ecosystems around campus and around Madison?
- How do different combinations of ecosystems affect biodiversity at the landscape scale?
- How big is a pollinator's world? How far away is too far away to matter for a pollinator?
- Can urban environments be as biodiverse as other environments?

Jessica Heckman (Cancer Biology):

Breast cancer is the most common cancer diagnosed in women in the US and the vast majority of cases require hormones found naturally in our bodies to fuel its growth; estrogen, progesterone and testosterone. I study the proteins inside our cells that respond to these hormones, the transcription factors estrogen receptor, progesterone receptor and androgen receptor. I am interested in which genes they turn on or off inside the cell and what other proteins in the cell they interact with. My research program incorporates both "wet lab" experiments using cancer cell models that we can grow in the laboratory and computer-based approaches to analyze datasets that have been generated from experiments that either look for cancer causing mutations in patients (DNA-sequencing) or that discover new protein-protein interactions in cancer (mass spectrometry). Finally, a number of products on the market claim to naturally boost hormone activity inside the body and therefore may contribute to the growth and development of breast cancers. I am interested in studying the effects of these products on breast cancer cell growth and ability to metastasize.

Current projects that are available for students to engage in are: 1) determining the cell cycle genes switched on by hormones in breast cancer which fuel the tumor's growth, 2) determination of which proteins interact with the hormone receptor in cancer and whether these proteins are frequently mutated in cancer and 3) investigation of the effect of compounds that claim to increase testosterone or estrogen levels on cancer cell growth.

Questions:

- Which of the cell cycle family of proteins (the Cyclins, e.g. Cyclin A, Cyclin E, Cyclin D) are switched on in breast cancer cells after treatment with testosterone or progesterone? (laboratory based)
- By analyzing mass spectrometry data, can we determine which proteins commonly interact with androgen receptor in prostate or breast cancer? (computer based)
- What effect do compounds that claim to "naturally boost hormone production" have on breast or prostate cancer cell growth? (laboratory based)

Nicole Kime (Animal Behavior and Physiology):

In most species, males compete with each other for access to females. In this competition, they must both convince females to mate with them and deter rival males. Male frogs make distinctive calls to attract female to for mating. Male *Anolis* lizards use their dewlaps to keep rival males out of their territories. I study the ways in which male lizards and frogs use visual and acoustic communication to attract females and mediate male-male aggression. I am interested in how these communication signals are produced (physiology & endocrinology), how they travel through the environment (environmental bioacoustics), how they affect the behavior of other individuals (sexual selection), and their evolutionary history (phylogenetics).

Students are currently working with me on four research projects, the first two of which I will focus on in the next year: 1) we are using computer models to understand the biomechanics and evolution of the frog vocal system, 2) we are doing field and laboratory experiments that explore the role of the hormone arginine vasotocin on aggressive behavior, 3) we are doing field studies that investigate the transmission of frog calls through native and non-native environments in Wisconsin, and 4) we are investigating behavioral thermoregulation in laboratory lizards. Students are also invited to use my Bio 425: Comparative Animal Physiology and Bio 430: Animal Behavior courses as a springboard for writing comprehensive review papers in these areas.

Questions:

- How does the presence of a "fibrous mass" in the túngara frog's larynx allow it to produce its unusually complex advertisement call? (modeling)
- How does the vocal sac of different frogs influence the movement of air through their larynx when making sounds? (modeling or review paper)
- How does the vertebrate hormone arginine vasotocin influence male-male territorial aggression in green anole lizards? (laboratory experiment)
- How does the vertebrate hormone arginine vasotocin influence mating calls in male frogs? (field experiment)
- In which types of wetland environments do frog calls transmit most effectively? (summer field research)
- How does social status influence behavioral thermoregulation in laboratory green anole lizards? (laboratory experiment)

Tim Kuhman (Invasive Species, Plant Ecology):

I am broadly interested in forest ecology, particularly the role of human land use (both contemporary land use patterns and land-use history) and invasive species in changing forest ecosystems. My research in recent years has focused on the non-native invasive plant, Oriental bittersweet, with the goal of determining the efficacy of using prescribed burning as a control method. I have recently begun work with a student on the invasive shrub, common buckthorn, and am eager to address questions related to the rapidly growing population of non-native purple loosestrife along the boardwalk in the Edgewood wetlands. I am also interested in the effects of land-use legacies (e.g., in previously cultivated areas that have reverted to forest) in shaping the species composition of forests, particularly with respect to their susceptibility to invasive plants. There are some great opportunities for students interested in land-use history to utilize aerial photographs and maps of Wisconsin from the 1930s in conjunction with computer mapping software to address a variety of ecological questions. This sort of study would likely entail a combination of computer-based and field-based approaches.

Recently I have also become interested in using the information contained in tree rings to address various questions about the conditions under which trees germinate and grow. One project that is underway aims to determine the climate conditions under which oak savannas, once the dominant community type in southern Wisconsin and now nearly absent from the landscape, were maintained through recruitment of new oak trees during pre-European-settlement times.

Finally, there is an opportunity to work closely with a local neighborhood association along Madison's southwest bike path to conduct various vegetation surveys, set up monitoring plots for invasive plants species, and address a number of interesting ecological questions in the Glenway Woods. This forested natural area has not yet been studied extensively and information from student research projects would be used by the neighborhood association to guide their land management decisions.

Questions:

- Can fire be used as a method to control the invasive plant Oriental bittersweet in the UW Arboretum? What are the effects of fire on seed germination? What are the effects of fire on established plants? Does burning stimulate resprouting of damaged vines?
- How has land cover changed in southern Wisconsin since the 1930s and what are the ecological implications of such changes? (This would, at least in part, be a GIS based project.) Do areas in the Baraboo Hills and/or the Driftless Area of southwestern Wisconsin that were previously in agriculture and are now forest covered tend to have more invasive plants than areas lacking such land-use legacies? If so, how do land-use legacies actually influence plant invasion?

- How do factors such as light conditions, nutrient availability, water availability, and land-use history influence the growth rates of woody invasive plants such as European buckthorn? (Would involve measuring tree rings.)
- Under what climatic conditions and fire regimes did oak savanna tree species (bur oaks, white oaks, and black oaks) recruit new individuals? There is some uncertainty about whether it was during wetter or drier periods that oaks became established, and restoration efforts rely on such information to manage oak savannas in southern Wisconsin.
- Where are invasive plant species most abundant in Glenway Woods and what factors are influencing their distribution? How do native understory plant communities respond to the removal of non-native plants from the understory and/or shrub layer of the forest?

Pete Kuhn (Cell and Molecular Biology):

My research focuses on understanding how cells regulate their growth in response to environmental changes. A conserved pair of molecular chaperones (proteins that help other proteins fold correctly) are necessary for the normal regulation of cell growth in both yeast and human cells. These two proteins, called Zuo1 and Ssz1 in yeast, appear to regulate how quickly cells age. They also affect a cell's ability to survive nutrient deprivation and drug resistance. In human cells, the homologue of Zuo1 appears to affect the growth rate of some types of cancer. In the near future I would like to examine the nature and mechanism by which these cellular functions are affected by Zuo1 and Ssz1. Possible projects include creating yeast strains with mutant versions of Zuo1 and Ssz1 and assessing the effect of these mutations on cellular aging, viability, cell death, and mitosis rates. While some candidate amino acid residues have already been identified, another possible project would be to use bioinformatics (working with a computer instead of an organism) to identify new candidates for future experiments. I am also interested in creating DNA-based sensors that fold to acquire "enzyme" activity when specific DNA sequences are present. I am currently developing a sensor to differentiate between a native (American Bittersweet) and invasive (Oriental Bittersweet) species. This project would also benefit from development of a more standard PCR-based method to differentiate between these species.

Questions:

- What amino acid residues in Zuo1 and Ssz1 are important for drug resistance in yeast?
- What amino acids are important for normal growth arrest in nutrient deprived (starved) yeast cells?
- What are the most conserved amino acids among Zuo1 and Ssz1 orthologues and is there a correlation between those conserved residues and protein function? (Bioinformatics question)
- How can a DNA-sensor be used to differentiate highly similar species?

Zach Pratt (Microbiology):

Prokaryotes control two of the three domains of life, and constitute the most abundant and diverse set of organisms on Earth. In that diversity, microorganisms have developed methods to grow and survive within each of their particular niches. The bacterium, Escherichia coli, is a species of bacterium that include both commensal organisms and pathogenic subspecies. E. coli is a resident of the human gut; it is capable of surviving anaerobic, nutrient-depleted conditions. Additionally, E. coli, like many Gram-negative bacteria, encodes outer membrane proteins that function as pores for solutes, sensors of the environment, or both. Bile salts are steroid-like

molecules that are secreted into the small intestine, and aid in the digestion of fats. They also have antimicrobial properties. OmpX is an outer membrane protein that we have found is required for the growth of E. coli in the presence of bile salts. My lab is elucidating the molecular mechanism by which OmpX protects E. coli from bile salts.

In addition to prokaryotes, I am deeply interested in the study of viruses. Particularly, I have grown fond of bacteriophages, which are viruses that infect bacteria. Bacteriophages are important both medically and ecologically. Medically, bacteriophages were proposed as a treatment for bacterial infections as early as the 1920s; with the increased identify of antibiotic resistant strains of bacteria, "phage therapy" has garnered greater interest. In the course of an infection, bacteriophages could be used to infect a pathogenic bacterium, and to kill the bacterium by bursting the cell. The ability of phages to "burst" their host bacterium contributes to phages ecological role; "bursting" leads to the release of nutrients, which can be used to support growth of other organisms. Despite what we do know about bacteriophages, there is much left unknown. My lab focuses on how environment influences levels of bacteriophages in local waterways, and the role of uncharacterized genes that bacteriophages encode.

Questions:

- How do the levels of bacteriophages in Lake Wingra change throughout the year?
- Are there correlations between levels of bacteriophages in Lake Wingra and environmental or chemical factors?
- How does the outer membrane protein X (OmpX) of *Escherichia coli* allow for *E. coli* to grow in the presence of bile salts?
- What are the functions of numerous hypothetical proteins that are conserved in the bacteriophage family, Myoviridae?

Rachael Lancor (Teaching Science):

Science education research examines how students learn and understand scientific ideas, and also how these ideas are taught and communicated in the classroom. In particular, my research focuses on how energy is conceptualized is various scientific contexts. To study this, we will systematically analyze the discourse used by teachers, students, and/or scientists to communicate these ideas. Research projects could focus on the metaphors and analogies used in verbal or written discourse, how these ideas develop over time, or on the differences between how experts and novices think about energy. We could study one course in particular (e.g. Anatomy and physiology) or look across courses and/or disciplines.

Questions:

- How do students' ideas about energy evolve over the course of a year in the context of ecology/anatomy and physiology/chemistry/physics (choose one)?
- How do experts conceptualize energy? How do they communicate this with their students? How do the students' understanding of energy compare with their professor's?
- How do experts in different disciplines conceptualize energy? What are the similarities and differences between disciplines? (if any)
- What are the differences in the way energy is conceptualized and communicated in the classroom versus in the public sphere (e.g. in the media)?

Francie Rowe (Developmental Biology):

Questions:

- How does early exposure to alcohol affect [some aspect of] eye development in zebrafish (an animal model for studying development)?