DO YOU WANT TO DO RESEARCH?

A PRACTICAL GUIDE FOR THE STUDENT

Biology Department, Gettysburg College.

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Students' independent research can be one of the most gratifying parts of a Biology major education; it can also be the worst if not done correctly. To succeed, a student must plan carefully and work diligently. The rewards will be worth the effort. Motivated students may get involved with a professor's research early in their academic career and are encouraged to look over faculty bios and contact professors about opportunities for research. Research can be done informally (not for academic credit), or for credit. There are a variety of ways to get credit – you should discuss the options with your advisor or with your research supervisor. Many students complete a one, or multi-, semester independent research project to fulfill the "capstone" requirement for the BIO major, usually during their junior or senior year. Such independent research capstones can be satisfied by an on-campus research experience (Bio460) or an approved off-campus research opportunity (Bio461). Note that there are other ways to fulfill the capstone requirement of the Biology major such as by taking a designated capstone course, rather than completing an independent research project. ***This document is intended to guide students through the process of completing a BIO 460 or BIO 461 experience***.

RESEARCH ON CAMPUS: BIOLOGY 460 - HOW DO I DO IT?

1. The first and most important step is to **choose your research area and your research project advisor**. Every Biology 460 project is guided by a faculty member. *You must choose your faculty research project advisor as early as possible in the semester preceding that of the project.* The types of projects that each faculty member could oversee and a brief list of Bio460 projects that faculty have recently directed can be found at the end of this document. From your examination of this list and from other sources of information about each faculty member's interests (courses, readings, or from talking with other students and faculty), approach one or more of the faculty in the department and discuss the possibilities. **Don't be shy: we expect you to come and talk to us!**

Once you have scouted the territory, make your decision. Directly ask the faculty member if he or she will serve as your research project advisor. While all faculty members can accept 460 students, there are limits to the number of students that each faculty member can advise. If you start your search late, it is possible that the project advisor with whom you want to work will have a full load and cannot accept you. The faculty member may suggest that you do the project in another semester or work with another advisor. *Don't take a refusal personally!*

2. Once you and your faculty project advisor have agreed to work together and have decided on an area of research, it is your responsibility to **learn about this area and to work on formulating a precise research project**. Your research project advisor may make suggestions about reading material, library resources, and possible experiments. You should dive into the material immediately and regularly consult with your research project advisor.

Students considering a particularly ambitious project that cannot reasonably be completed in a single semester should consider enrolling in Individualized Study - Tutorial (Biology 453) in the semester preceding the 460 research project or consider enrolling in Individualized Study – Research (Biology 463) in the semester following the 460 semester. Biology 453 and 463 are graded S/U and **do not count** toward the major requirements.

Many students considering ambitious projects also work on it over the summer prior to the year in which they'll formally complete their BIO 460.

3. Once you and your research project advisor have clearly identified a research project, **you should begin work on a prospectus**. The prospectus is a formal, typewritten document (double-spaced) which must contain the following:

Title page: A brief and informative project title, along with your name and that of the faculty research sponsor.

Introduction: A description of the main ideas behind your project. It should lay the groundwork for the reviewer and must include a short literature review, a summary of any preliminary research you may have already completed on the topic. Definitions of special terms unfamiliar to biologists outside of the proposed research discipline should be incorporated into the text.

Hypothesis *or* **Objectives**: A clear statement of the hypothesis you will test, questions to be addressed, *or* a statement of the objectives of the study. This should be based on the material presented in the introduction.

Research Design: Descriptions of how you will test your hypothesis, address your questions, and/or meet your objectives. The research design includes your laboratory and/or field procedures, the methods you will use to analyze your data (including statistical methods), and a time-line showing when you expect to finish each part of your project. In consultation with your faculty research sponsor, you must list the costs of any special supplies and equipment necessary for the project. *The student researcher and/or project advisor must also apply for Senior Project funding from the Provost Office*.

References: A list of the references you cited in the Introduction and Research Design sections. At least five references relevant to your topic must be cited. Use the CSE author-year format.

Your prospectus will be read and must be approved by two faculty readers (your research project advisor plus another faculty member). In consultation with your project research advisor, you should ask another Biology faculty to be your "second reader" (under special circumstances, your second reader may be a faculty member from another department); this faculty member will typically have expertise that enables them to judge and assist with certain aspects of your proposed project. Your two readers (project research advisor and the second reader) will study your prospectus and may make some useful suggestions and offer important ideas.

You, your project research advisor, and your second reader must meet to discuss and approve your complete prospectus by Friday of the 12th week of the semester (2nd week of November or April) preceding the semester in which you plan to do your project. For summer / fall projects, this would be the Spring semester. Approval of the prospectus may be conditional if the prospectus is incomplete or if the project is judged to be either too ambitious or too simple. After the necessary revisions, you will meet again to finalize approval of your

prospectus. The approved final prospectus must be submitted to the department by the end of 13th week of the semester**.** The form used by the Registrar for BIO 460 registration will be signed by the department chair ***only if the prospectus has been unconditionally approved by your two initial readers.***

Students planning to do research involving any vertebrate animals must complete and submit, in coordination with your faculty supervisor, an "Institutional Animal Care and Use Committee" (IACUC) official protocol proposal, which details the proper care, experimental use and eventual disposition of their animal subjects. This form must be co-authored with your supervisor, and approved and signed by the department chair before submission to IACUC. IACUC's approval should be obtained by the end of the semester BEFORE research is to begin and it is a requirement for registration into Bio 460. Students must secure IACUC's approval of the experimental protocol BEFORE any research with vertebrate animals can begin.

Later in the process, there will also be a "third" reader which will be assigned to your research project by the Biology Department; this person typically has expertise very different from the focus of your project, and will help judge whether your final project paper is understandable by a broader audience.

4. **The actual implementation of the project will be governed by a contractual agreement with your project research advisor**. The formality of this contract is up to your project advisor. *It is always the responsibility of the student to meet with the project advisor on a regular basis and to conduct the project at a pace that will lead to completion by the end of the semester. As a rule, students have discovered that the time demands of a 460 project commonly exceed those of a regular course.* As such, you are strongly advised to commence the project at the earliest time possible after the approval of your prospectus and to plan a detailed work schedule!

5. **You will be assigned research space** in the department to do your work. You might be given a key to this area for which you must sign a receipt. If you fail to return the key to the Biology Administrative Assistant (Amanda Whitcomb), facilities will charge you $55. *It is your responsibility to safeguard this key and to keep your work area clean, orderly and secure at all times!* In addition, you must complete the mandatory laboratory safety training provided by Gettysburg College at the beginning of every semester.

6. During the last week of the semester, **you will give a brief (10-15 minutes) oral presentation to the department**. The precise date and location of the Bio460 Symposium will be announced late in each semester. Your project advisor will help you in preparing your presentation. You must **submit a Microsoft word file document with the final abstract of your project** results to the Biology Administrative Assistant one week before the symposium. This abstract will be printed in a program booklet that will be distributed at the symposium and a compilation of all student abstracts will be made available to interested persons.

7. **The second and third readers (in addition to your project research advisor) will both read your final research paper.** You must submit a complete draft to your project research advisor and both readers by no later than 10 days before the last day of classes. The readers will make comments about the paper for you and for your project advisor, suggesting appropriate revisions as necessary. The final version of your research paper must be submitted by no later than the Wednesday of finals week.

This report must follow the standard format of a scientific paper in your field or the guidelines in Victoria McMillan's book, *Writing Papers in the Biological Sciences*.

8. **You will be graded A-F by your project research advisor**. Your final grade will be determined by your effort and execution, your final paper, and your symposium presentation. Although both readers will discuss with your project advisor a grade for your final paper and a grade for your symposium presentation, it is the responsibility of your project research advisor to determine and assign the final grade. Your project advisor will also evaluate the difficulty of the project you attempted, the quality of the data you obtained (independent of the quality of your data reporting), and your effort throughout the project. It is possible for a project with little useful or conclusive data to receive a good grade; it is also possible for a project with good data to receive a poor grade.

CAN I DO RESEARCH OFF CAMPUS?

Some students choose to do a research project off-campus. Most commonly, this is done if a student is enrolled for a semester at an approved off-campus program, such as the Duke University Marine Laboratory semester, the School for Field Studies, or the Semester-at-Sea program, or does summer research at a laboratory other than at Gettysburg College.

1. If a student performs off-campus research that is not formally credited as a research course, he or she may nonetheless receive Biology 461 credit. After the work is completed and the student has returned to Gettysburg College, he or she must secure a project research advisor from the department. (It is preferable, but not always possible, that this be done before leaving campus.) The research project advisor is normally that faculty member whose own specialty is nearest to that of the project. The student enrolls in Biology 461 with this faculty member as the instructor. Unlike Biology 460, Biology 461 is graded S/U. During the semester, the project advisor will work with the student in analyzing the data and writing the research paper. It is preferable (but not always possible) that students planning an off-campus project write a prospectus for approval before commencing the work.

2. If a student enrolls in an off-campus individualized research course and successfully transfers the credit to Gettysburg College, he or she may petition the Biology Department to accept this course in lieu of Biology 460. This petition must be a formal, written request. The department may grant approval *only if the student convincingly demonstrates that the course was sufficiently similar to a Biology 460 experience at Gettysburg College*. To prepare for the symposium oral presentation (see below), the student is strongly advised to seek guidance from a member of the Biology faculty.

In either case, a written scientific research paper (to be read by a Biology research project advisor) and an oral presentation during the Bio460 symposium is required at the end of the first semester that the student returns to campus.

Some examples of recent projects done off-campus:

Zoe Yeoh (with Patricia Springer, University of California, Riverside, Center for Plant and Cell Biology, and Jennifer Powell). (2017) "LOF1 and interacting transcriptional factors in plant organ boundary development."

Katherine Kraft (with the Prostate Oncology Translational Research Team, Janssen Pharmaceutical Company, and Jennifer Powell). (2017) "Gene expression signatures during the development of drug resistance in castration resistant prostate cancer patients."

Brielle Barnard (with David Sweatt, primary investigator, University of Alabama, Dept. of Neurobiology, and Matt Kittelberger). (2014). "The effect of transcription factor 4 on cerebellar nodal signaling, a developmental pathway involved in left-right determination"

CAN I DO A 460 PROJECT IN ANOTHER DEPARTMENT?

Several faculty members at Gettysburg College, in science departments other than Biology, can advise Bio460 projects. There are two ways for a student to do this and obtain Biology 460 credit.

1. A student may enroll in Biology 460 with a Biology faculty member as their formal project research advisor. The actual work, however, may be supervised by the faculty member in the other department, *e.g.,* Environmental Studies.

2. A student may enroll in a 460 course (or its equivalent) in another department under the exclusive direction of a faculty member in that department. In this case, as with a student who completes a course at another institution, the student may petition the department to accept this course in lieu of Biology 460. This petition must be a formal, written request. The department may grant approval *only if the student convincingly demonstrates that the course in the other department is sufficiently similar to a Biology 460 experience.*

In either of these cases, the oral presentation and the submission and approval of the final research paper to the Biology department is required at the end of the semester in which credit is given.

CAN I DO A SECOND 460 PROJECT?

Any student may choose to perform a second Individualized Research project. Since only one such project may count toward the Biology major, students should enroll in Biology 463 (graded S/U). In effect, a student chooses this project as an elective outside of the major. The second Individualized Study project may be an extension of the first under the direction of the same faculty member or it may involve a completely different topic under the direction of a different faculty member. In either case, the students are not obligated (but are highly encouraged) to present their work at the Bio 460 symposium at the end of the semester.

HOW ARE BIO 460 PROJECTS GRADED?

The faculty project research advisor, in consultation with the two faculty readers, determines and records the grade that a student receives for his or her 460 project. To assist the faculty member in this task and to make research students better aware of their responsibilities, a set of grading guidelines has been agreed to by the faculty of the Biology Department.

Grades for the BIO 460 project will be based on three criteria:

1. **Effort and execution, 40%**. In the short period of time that a 460 project lasts, a great deal of work must be accomplished. It is therefore essential that a student start early, work hard, and make frequent progress reports to the faculty project research advisor. The final grade, therefore, is based, in part, on the level of effort and on the degree of responsibility shown by the student. Since it is not uncommon for a project to generate only a small amount of good data in so short a time period, this category will reward the student who failed to complete the project as planned, but who worked hard, long, and creatively in the attempt.

2. **The final paper, 40%.** No research project is complete until it is "written up." The writing of a formal research paper is, therefore, a very important part of the final grade. The final paper will be judged on its formal style, on the completeness of the reporting of the relevant background literature, on the quality and clarity of the data reported, and on the completeness and aptness of the discussion of that data**. The faculty project research advisor will consider the input of both faculty readers in determining the grade**.

3. **The symposium presentation, 20%.** Scientists must frequently stand before their peers to present and defend their work. The presentation of research to the faculty and students of the Biology Department is an honor and a final opportunity to share an important accomplishment. This grade will be based on the preparation for and organization of the presentation, on the quality of the presentation itself, including its clarity and coherence, and on the quality of responses made to questions asked by the audience. **The faculty project research advisor will consider the input of both faculty readers in determining the grade**.

Faculty Research Interests

Michael Caldwell: I study the ways in which animals use vibrations traveling through surfaces, such as the ground or plant stems, to assess their world. Although we know far less about how animals use vibrations, as opposed to other sensory modalities like vision or hearing, we do know that vibrational information is important in the communication, foraging, and risk assessment behavior of hundreds of thousands of species.
Methods in my lab include the recording and playback of vibrational and sound signals produced by animals, video analysis of behavioral responses to these signals, and the measurement of vibrations as they propagate through body tissues and the environment.
I do not require any previous experience of students wishing to conduct 460 projects in my lab, but do expect a willingness to learn new techniques, including software tools, and a careful attention to detail. While most of my work focuses on vibrational communication in treefrogs, I would be excited to see student projects with a broader range of organisms in my lab.

Véronique Delesalle: Prerequisite: a semester doing a complete phage genome annotation in my lab.

Have you ever wondered about the factors that allow a pathogen to jump from one host to another? What makes a pathogen capable of invading lots of hosts or just a few hosts? These are ecological and evolutionary questions and my lab is answering these questions, using bacteriophages, viruses that "eat" bacteria, as the model pathogen. In particular, we want to understand:

- what factors determine a phage's host range (their ability to infect a few versus many bacterial strains, to be specialists versus generalists);
- how phages evolve as they exchange genetic material with other phages and as they encounter different bacterial strains to infect;
- the relative importance of mutation versus recombination (horizontal gene transfer) in the process of adaptation in phages; and
- the spatial and temporal scales at which these interactions take place (*e.g.*, how does the diversity of phages and hosts change along these two dimensions). We are working with three

different bacteriophage systems:

1) the phages of *Bacillus subtilis.* This soil bacterium is one of the best-studied bacterial species and working with this species comes with all the benefits associated with model organisms. We are describing the diversity of phages that can lyse this bacterium, exploring the genetic factors that determine the host range of our phages and conducting experimental evolution studies.
2) **the phages of *Micromonospora*.** Like *Bacillus* this is a spore-forming bacteria found in soil communities that exhibits non–clonal population structure with high levels of genetic diversity. In addition, *Micromonospora* form symbiotic relationships with legumes in root nodules. We are describing the effects of phages on this relationship.

3) the phages of plant pathogens. In collaboration with Dr. Koskella (UC Berkeley), we are looking at the genome changes of phages as they evolve or coevolve with their hosts.

Natalie Tanke (2017). "Assessing bacteriophage community diversity along an elevational gradient in Death Valley National Park."

Albert Vill (2016) "Comparative genomic analyses of a novel cluster of phages that differentially lyse strains of *Bacillus subtilis."*

Brianne Tomko (2016). "Characterization of three new SPP1-like *Bacillus* bacteriophages and isolation of host range mutants."

Katherine Boas (2016). "Genotypic and phenotypic variation in space and time of naturally occurring *Bacillus* bacteriophage communities."

Recent publications with student co-authors*:

Delesalle, VA, NT Tanke*, AC Vill*, and GP Krukonis. 2016. Testing hypotheses for the presence of tRNA genes in mycobacteriophage genomes. Bacteriophage, 6:3, e1219441.

Kay Etheridge: Students working with me should be prepared to study some aspect of endocrinology or metabolism and should expect to spend at least two semesters on the project. I have worked extensively with thyroid hormone in reptiles and mammals, but also have supervised projects on subjects such as cortisol levels and stress in dogs. Students wishing to work with me should take Bio 340 Comparative Animal Physiology or an equivalent physiology course first. I also help supervise students working away from campus on physiological, biomedical or other projects.

Katherine Pavlos (2017). Efficacy of pressure wraps in stress management in noise- phobic domestic dogs.

John Vitarello (2013) Diagnosis of peripheral artery disease using the ankle-brachial index

Kelly McConville (2009). Salivary cortisol levels in dogs: The effect of shelter conditions

Ashton M. Trawinski (2009). Behavior and cortisol levels: Predicting behavioral problems in dogs housed in animal shelters

Peter Fong: My students and I study effects of pollutants on the behavior and physiology of aquatic animals. We work on emerging contaminants such as human pharmaceuticals released from wastewater treatment plants and engineered nanoparticles. Our recent work has focused on the effects of antidepressants on model aquatic organisms like snails, clams, and the tadpole larvae of frogs. I supervise enthusiastic students interested in aquatic animals, chemicals, and the environment.

Taylor Bury (2015), "The effect of antidepressants on righting behavior in marine and freshwater snails: Do laboratory results agree with field results?"

Christina Jasion (2013), "Antidepressants boost locomotion in marine and freshwater snails: A prelude to foot detachment from the substrate"

Caitlin Hoy (2011), "Antidepressants (venlafaxine and citalopram) cause foot detachment in freshwater snails at environmentally relevant concentrations"

Recent publications with student co-authors*:

Fong PP, *Bury TB, *Donovan EE, *Lambert OJ, *Palmucci JR, *Adamczak SK. 2017. Exposure to SSRI-type antidepressants increases righting time in the marine snail *Ilyanassa obsoleta*. *Environmental Science and Pollution Research,* 24(1): 725-731.

Fong PP, Thompson LB, Carfagno GLF, *Sitton AJ. 2016. Long-term exposure to gold nanoparticles accelerates larval metamorphosis without affecting mass in wood frogs (*Lithobates sylvaticus*) at environmentally relevant concentrations. *Environmental Toxicology and Chemistry* 35(9): 2304-2310.

Fong PP, *Bury TB, *Dworkin-Brodsky A, *Jasion C, and *Kell R. 2015. The antidepressants venlafaxine ("Effexor") and fluoxetine ("Prozac") produce different effects on locomotion in two species of marine snail, the oyster drill (*Urosalpinx cinerea*) and the starsnail (*Lithopoma americanum*). *Marine Environmental Research* 103: 89-94.

Kazuo Hiraizumi: My research interest is in the role of genetic variation in adaptive evolutionary changes, population and quantitative genetics of gene regulation, the biochemical characterization of proteinases and peptidases, and neurochemistry and the genetics of mammalian play behavior. Projects involve a number of different techniques and approaches in molecular and cell biology, genetics, biostatistics, and/or neurophysiology.

Connor McLaughlin (2017). "Genetic variation for Dip-B gene expression in *Drosophila melanogaster*.

Chelsea Loughner (2015). "Analysis of Dip-B mRNA isoforms in *Drosophila melanogaster*."

Kelly Burke (2008). "Genetic analysis of late life phenotypes associated with genes on mouse chromosome 1 of a UM-HET3 sibling population."

Matthew Wendler (2006). "Identification of gene that codes for sulochrin oxidase in *Penicillium frequentans*." (Koren Deckman, co-sponsor)

Steven James:
Research approaches**:** molecular genetics, genetics, protein biochemistry, bioinformatics, fluorescence microscopy

Research focus: mRNA export from the nucleus to the cytoplasm: DNA damage responses and cell cycle control mediated by mechanisms governing the maturation and export of messenger RNA.

Research description: The James laboratory uses the fungal model system *Aspergillus nidulans* to investigate nucleocytoplasmic transport of messenger RNA (mRNA) governed by the 8- subunit THO/TREX complex, and assisted by the *snxA* shuttling mRNA-binding protein. These proteins guide messenger RNAs (mRNAs) out of the nucleus where they are transcribed, and into the cytoplasm where the mRNAs are translated into proteins. In addition to impairing the movement of mRNAs out of the nucleus, defects in these 9 proteins hamper DNA repair, and thus lead to increased mutation and in mammals, elevated cancer incidence; several mutations disrupt cell cycle control at the transition from G2 to M phase; and one subunit, *thoc6*, causes intellectual disability in humans. *Aspergillus* is an especially relevant model system for studying THO/TREX and *snxA*. For example, *thoc6* studies are very limited and descriptive, largely because this protein is absent from other widely used model systems such as the budding and fission yeasts. As a result, *Aspergillus* provides the simplest model system amenable to mechanistic studies of *thoc6* function and its impact on *snxA*.
Dr. James works with students interested in applying molecular, biochemical, and cellular approaches to unravel the interplay of THO/TREX genes and *snxA* to control mRNA transport, DNA damage responses, and the cell cycle.

Sarah Francisco (2017). "The *set2* histone H3K36 methyltransferase suppresses transcriptional defects of *snxA* mutants in *Aspergillus nidulans"*

Matthew Dunworth (2016). "A Functional Analysis of the 5' Regulatory Region of the *Aspergillus nidulans snxA*$^{\text{Hrb1}}$ Inhibitor of Cell Division

Dina Mohamed-Aly (2015). "Investigating epigenetic mechanisms of transcriptional repression in *Aspergillus nidulans snxA*^{Hrb1} mutants by removal of histone deacetylases"

Lorela Ciraku (2014). "Epigenetic down-regulation of *snxA*Hrb1 rescues G2-M cell cycle defects"

Emily Kohlbrenner (2013). "Generation of new snxA^{Hrbl} alleles by a non- complementation assay"

Amanda Orzechowski (2013). "Control of DNA damage signaling by SSPP/SSPT motifs in *Aspergillus nidulans snoA*^{Rif1}"

Cam Nguyen (2013). "An Anti-checkpoint Role for *Aspergillus nidulans snoA*^{Rif1}" Recent

publications with student co-authors*:

James SW, Banta T, Barra J*, Ciraku L*, Coile C, Cuda Z, Day R, Dixit C, Eastlack S, Giang A, Goode J, Guice A, Huff Y, Humbert S, Kelliher C*, Kobie J*, Kohlbrenner E*, Mwambutsa F, Orzechowski A*, Shingler K*, Spell C, Anglin SL (2014). Restraint of the G2/M transition by the SR/RRM family mRNA shuttling binding protein SNXA^{HRB1} in Aspergillus nidulans. *Genetics* 198(2): 617-633.

Ryan Kerney: I am an organismal biologist specializing on the ecology, evolution, and development of amphibians. Current projects include research on the diversity of skeletal development, the formation of "vestigial" structures, symbioses between salamander embryos and green algae, limb development, lung development, and descriptive morphology. While this work is focused on a specific taxonomic group, it touches on many fields within biology.

Check out our lab site for more information: https://sites.google.com/site/kerneylabgc/

Jasper Leavitt (2015). "Examining the initiation of algal cell entry into an embryonic salamander host."

Kenneth Anderson (2014). "Abundance and establishment of symbiotic bacteria in *Plethodon cinereus*."

Matthew Spano (2014). "Bone development in metamorphosing *Xenopus tropicalis*."

Recent publications with student co-authors*:

Burns J, Zhang H*, Hill E*, Kim E, Kerney R (2017). Endosymbiont fermentation and host modulation of immunity and nutrient sensing in a vertebrate-alga endosymbiosis revealed by de novo dual-RNA seq. *eLife.* 2017;6:e22054.

Kerney R, Whatley Z, Rivera S*, Hewitt D. (2017) The prospects of artificial endosymbioses. *American Scientist*. 105: 36–46.

J. Matthew Kittelberger: As a neurobiologist, I am interested in how the anatomy and physiology of nerve cells and circuits of interconnected nerve cells shape the myriad fascinating behaviors and perceptual abilities of animals and humans. Specifically, my own research focuses on the brain circuits involved in vocal communication behaviors in fish and birds (mainly the former). Students interested in working in my lab could be involved in a variety of projects using different techniques to study the anatomy, the neurochemistry, and/or the electrophysiology of these circuits in the context of how fish produce their courtship and territorial songs. Students should expect to spend at least 2 semesters on their project (with one of these ideally occurring over the summer), and should therefore begin planning for this project no later than spring semester of their junior year.

Elizabeth Heisler (2012). "The effects of dopamine antagonists on dopamine- induced inhibition of vocal output of a toadfish, *Poricthys notatus*."

Amanda Miller (2012). "Localization of dopamine receptor distribution in plainfin midshipman fish using fluorescent dopamine ligands."

Alex Allen (2010). "Dopaminergic modulation in midbrain vocal structures of midshipman fish: implications for shaping social behavior."

Geraldine Katherine Hickey (2010). "Differential catecholamine expression in the vocal circuits of male and female midshipman fish: Evidence for a role in context- dependent vocal production?"

Recent publications with student co-authors*:

Goebrecht, GKE*, Kowtoniuk, RA*, Kelly, BG*, & JM Kittelberger. (2014) Sexually- dimorphic expression of tyrosine hydroxylase immunoreactivity in the brain of a vocal teleost fish (*Porichthys notatus*). *Journal of Chemical Neuroanatomy*. 56: 13-34.

Jennifer Powell: Bacteria are everywhere! The animal innate immune system is charged with the critical task of recognizing and responding to these bacteria so they do not cause potentially fatal infections in the host animal. Recognition of potentially pathogenic bacteria and other microorganisms by the immune system is relatively straightforward in sterile body tissues. Professional immune cells typically express receptors that bind conserved microbial components such as fragments of cell wall, flagella, etc. This method of identifying invading microbes works well as long as no microbes are permitted in that space.

But what about tissues such as the intestine? The animal gut is full of bacteria and so the cells lining the intestine are continuously exposed to myriad species of microorganisms. Because it depends on many of these microbes for health, an animal cannot simply wipe them out using its immune system. However, many gut microbes have the potential to be pathogenic, so the animal immune system cannot ignore them either.

The tiny nematode *C. elegans* is an outstanding model system to answer these fundamental biological questions. One exciting hypothesis is that epithelial cells such as those lining the intestine use a different method of detecting infection. Rather than scanning for bacteria and other microbes, these cells monitor signs of cellular stress that may accompany the early stages of infection. This indirect detection method allows the immune system to discriminate among benign or helpful microbes and harmful pathogens. To test this hypothesis, our lab uses molecular genetic analysis to explore the connections between the innate immune response and the response to other types of cellular stress.

Joe Robinson (2015). Long-term recovery from acute cold shock in *C. elegans*

Jimmy Nguyen (2015). Searching for the role of adenylyl cyclase in the *Caenorhabditis elegans* innate immune response.

Elizabeth Miller (2013). The dual role of FSHR-1 in oxidative stress and innate immunity in *C. elegans*

Olivia Ruth (2013). A role for adenylyl cyclase in innate immune signaling Jon Hibshman

(2012). *P. aeruginosa* infection induces *clec-67* in *C. elegans* Hannah Anthony (2012). Pathogen

response genes mediate *C. elegans* innate immunity

Recent publications with student co-authors*:

Robinson JD*, Powell JR (2016). Long-term recovery from acute cold shock in *Caenorhabditis elegans*. BMC Cell Biology. 17(1):2.

Miller EV*, Grandi LN*, Giannini JA*, Robinson JD*, Powell JR (2015). The conserved G-protein coupled receptor FSHR-1 regulates protective host responses to infection and oxidative stress. PLOS ONE. 10(9):e0137403.

Nikki Shariat: As a microbiologist, I am interested in how the pathogenic bacteria, *Salmonella,* is transmitted through the food chain, how it colonizes different niches, and how different *Salmonella* can have quite distinct modes of pathogenesis. We apply molecular techniques that exploit the sequences of CRISPR elements to precisely track *Salmonella* both as individual strains that have infected humans and also on a population scale in different environments where *Salmonella* is found using next-generation sequence profiling and metagenomics. We are also working to decipher the function of CRISPR-Cas in *Salmonella*, which has been shown to act as an adaptive immune system against phage in other bacterial species.

Alex Trillo: I use a combination of methods and variety of organisms to answer questions related to Ecology, Behavior and Evolution. Some of the current projects in the lab are:

1. The influence of eavesdropping bats on mating signal divergence and novel call emergence: We are interested in how eavesdropping predatory bats, such as the frog-eating bat *Trachops cirrhosus,* respond to sounds produced by their prey, and in how selection imposed by these predators interacts with female call preferences to affect the evolution and maintenance of mating calls. It is well known that the evolution of male mating calls is guided by the sexual preferences of females. But just as females more strongly prefer some call types to others, eavesdropping bats are also more strongly attracted to certain calls. This trade-off, between attractiveness to mates on one hand, and attractiveness to predators on the other, has the potential to shape mating call evolution. We are particularly interested in how this can drive the divergence of mating calls across populations and influence emergence of novel call types within a population. Student researchers conduct playback experiments, presenting a variety of acoustic stimuli to bats in flight chambers and in the field. These studies are carried on at the Smithsonian Tropical Research Institute in Panama during the summer.

2. Predator and parasite risk transfer in mixed species frog aggregations: We are interested in how mortality risk due to eavesdropping predators, such as the bat *Trachops cirrhosus,* and parasites, such as the midge *Corethrella spp.* gets transferred from one prey frog species to another in mixed species aggregations. We investigate whether calling near males of another species makes signalers more or less vulnerable to 'eavesdroppers'. We are particularly interested in how these prey species interactions drive calling site choice and calling behavior in mixed choruses of tropical frogs. Student researchers that work in this project conduct playback experiments, presenting a variety of acoustic stimuli to bats in flight chambers and in the field. These studies are carried on at the Smithsonian Tropical Research Institute in Panama during the summer.

3. Pre and post-copulatory sexual selection in insects: Sexually selected traits are often studied one at a time, in isolation from one another, and as if they were the product of a single selective force. In nature, however, multiple sexual traits can interact to affect individual fitness, and multiple selective forces can interact to shape the evolution of a single sexual trait. With these ideas in mind, I simultaneously examine variation in traits used during pre-copulatory processes, such as weapons, and traits used during post-copulatory processes, such as genitalia and testes in insects, such as the tortoise beetle *Acromis sparsa*, to determine how these primary and secondary sexual traits interact to affect male reproductive success.

I am also willing to supervise motivated students interested on conducting research on behavioral ecology and conservation. Students interested in doing research with me should count on spending more than one semester developing and working on their project.

Samantha Siomko (2017). "Odd one out: Is differential predator attention directed toward rare calls in frog mating mixed-choruses?"

Natalie Pitman (2017). “Assessment of the impact of copper (II) chloride on the multimodal predatory response in zebrafish (*Danio rerio*).”

István Urcuyo: My research interests are primarily in the field of Marine Biology and Ecology. Although my current research focuses on the biodiversity of tropical marine invertebrates in Central America, I am also willing to supervise motivated students interested on conducting research on marine environmental problems, marine resources or working away from campus on a marine-related topic. I also have a longstanding interest in cave biology and invertebrate fossils. Students interested in doing research and field work with me should start planning their projects early during their junior year and count on spending two semesters working on their project.

Emily Jankowski (2016). “Effects of thermal stress on nerite grazing activity.”

Jeffrey Romano (2016). “Analyzing the biodiversity of macro invertebrates and abiotic factors in the local p-caves of Franklin County, PA.”

Maria Wanner (2015). “Evaluating the phototaxis of subterranean and surface amphipods.”

Sean Pearson (2014). “Calibration of modern coral climate signals to ensure accuracy of Medieval climate reconstruction in the northeast Caribbean.”

Margaret Buell (2009). "Cytotoxicity of Nicaraguan Opisthobranch species against NIH3T3 mouse fibroblast cells."