RESEARCH INTERESTS OF BIOLOGY FACULTY AND THEIR SENIOR PROJECT STUDENTS

Fourteen faculty members in the Biology Department will be advising senior project students during 2015-2016. They are: Drs. Catharina Coenen, Becky Dawson, Christy Donmoyer, Lauren French, Brad Hersh, Anne Jacobs, Ron Mumme, Margaret Nelson, Milt Ostrofsky, Susan Rankin, Matt Venesky, Kristen Webb, Lisa Whitenack, and Scott Wissinger. The research opportunities available in their laboratories, and the types of research activities that their senior project students typically pursue, are described below. (Drs. Lee Coates, Tricia Humphreys, and Ann Kleinschmidt will not be advising senior research students during 2015-2016.)

Catharina Coenen

My research focuses on the roles of the plant hormone auxin in growth and development and in the interaction between plant roots and soil microbes. My students and I have been characterizing the role of auxin in mycorrhiza, an agriculturally and ecologically important symbiotic association between plant roots and fungi. We have also begun to explore auxin as a communication signal between plant-protective bacteria and the roots these bacteria colonize. These projects have implications for organic agriculture, because the fungi and bacteria we study reduce the need for toxic fungicides and fertilizers.

The methods my students use to study auxin responses include genetics, molecular, biochemical and physiological experiments. As long as you enjoy working with plants, fungi, or bacteria, there are lots of different experimental approaches to choose from. Even if you may not be interested in staying in plant research in the long term, you will find valuable techniques and analysis methods to learn here that transfer to other systems.

Becky Dawson

My research draws primarily from epidemiological and biostatistical methods. I am specifically interested in understanding disease risk factors and patterns of disease in human populations. Work in my "lab" is not traditional wet-lab work; instead it involves collecting or using existing data from human participants. Student projects could involve secondary data analyses using data from the World Health Organization, Centers for Disease Control and Prevention, Pennsylvania Department of Health, or Meadville Medical Center. Alternatively, students could work with me to collect primary data from human participants on campus or in the Meadville community.

Christy Donmoyer

My research areas are the fields of vision and metabolism. Located at the back of the eye, the retina is a highly differentiated tissue that consumes glucose exclusively and requires vitamin A for much of its activity and development. Many proteins are needed to transduce a signal from the photoreceptor and to recycle vitamin A in this tissue. Mutations in many of these vitamin A-related proteins result in retinal degeneration and/or impaired visual function. We hypothesize that one of these proteins, interphotoreceptor retinoid-binding protein, also has a developmental role in the retina such that apoptosis occurs in the absence of this protein. My research is focused on understanding the other genes involved in this early retinal degeneration using quantitative RT-PCR to study gene expression in mouse retinal tissue. I am also interested in studying metabolic regulation, especially carbohydrate and a new field of metabolomics.

My projects will typically use vertebrates (mice, amphibians) and may involve *in vivo* experiments, collection of tissues, enzyme assays, and gene expression analyses (RT-PCR).

Lauren French
My research interests fall under the general heading of Cellular and Molecular Neuroscience. I am interested in exploring what makes individual neurons unique from one another, how they "talk" to each other to transmit information in the nervous system, and how drugs and toxins affect their function. The projects in my lab involve both neurophysiology and molecular biology techniques.

Pharmacology is critical to the study of the nervous system; to learn how proteins such as ion channels contribute to normal function, and to discover the mechanism underlying pathological conditions. One project involves a genus of hunting snails whose venom is very complex and potent, acting solely on the prey's nervous system. Many of the snail venom compounds have applications in medicine as well as in basic bench research. My goal is to find pharmacological agents that target some specific calcium and potassium ion channels in order to further understand the role these proteins play in the nervous system.

Another project involves the trafficking of a type of ion channel called the BK channel and its possible role in epilepsy. The activity of this channel has been shown to be upregulated after an animal experiences a seizure. If we want to understand how seizures change neurons, and how this might be prevented, it is necessary to understand the mechanism behind this change in ion channels.

There is also research in my lab involving the neuromuscular system of the crayfish, studying the stretch receptors located in the tail, which are analogous to vertebrate's muscle spindle organs which are responsible for proprioception. I am interested in the pharmacology of this system- how the neurons respond to various compounds (e.g. neurotransmitters, drugs, or toxins).

Brad Hersh
Though virtually all cells in an animal contain the same DNA sequences, different cell types (for example, muscle cells and nerve cells) have distinct physical properties. These differences are achieved during growth and development of the organism by switching on and off specific sets of genes within the common DNA sequence. Research in my lab encompasses two main areas:

1) Identifying and characterizing the DNA sequences that control when, where, and at what level gene expression is switched on and off in the developing animal body. The long term goal of this research is to understand the mechanisms by which Hox proteins, involved in shaping the head-to-tail patterning of all animals, regulate their target genes. We use the fruit fly, *Drosophila melanogaster*, to examine the DNA sequences that respond to the Hox protein Ultrabithorax and either activate or repress gene expression in the fly hindwing. We are also interested in identifying the genes, possibly targets of Hox proteins, that are important for differences between insect species to understand how evolutionary changes occur in the developmental processes that produce animal shape.

2) Characterizing the role of gap junction proteins in the immune response of the fly to various pathogens. The long-term goal of this research is to understand how cell-cell communication influences the innate immune response. The fly has genes for eight gap junction subunits, and we use molecular techniques to increase or decrease their activity and determine the effect on survival of flies exposed to bacterial pathogens or parasitoid wasps.

Anne Jacobs
My research interests focus broadly on behavioral ecology, particularly mating behavior in animals and the ways that parasites can affect host behavior. I'm particularly interested in exploring the interplay between sexually transmitted infections (STIs) and host mating behaviors. From a host perspective, it is beneficial to select healthy mates. However, STIs are in direct conflict with their hosts over this strategy, as such diseases only spread when the host successfully mates. Furthermore, increased mating success

may also increase the risk of infection. This may create a paradoxical situation where the most "fit" individuals (i.e. the ones mating the most) may also be the most likely to carry disease. To test such ideas, I focus on a cricket system in which males can be infected with a sexually transmitted nematode.

Ron Mumme

My primary research interests are animal behavior, behavioral ecology, and evolutionary biology. Although most of my own research involves field work with birds, my senior project students have pursued laboratory and field projects on a wide variety of organisms, including insects, fish, amphibians, reptiles, birds, and mammals. For examples of senior projects conducted by my students, see https://sites.google.com/a/allegheny.edu/ron-mumme/student-research.

Margaret Nelson

I am interested in the way in which signal transduction pathways allow cells to interpret and respond to external cues during development. My research is currently focused on the role that two proteins, FbxA and FbiA, play in the development of *Dictyostelium discoideum*. FbxA is a member of an evolutionarily conserved protein family that regulates cell behavior by targeting specific components of signal transduction pathways for degradation. Malfunctions in this degradation system have been implicated as a potential causative agent in several human diseases, including Alzheimer's disease, Parkinson's disease, and cancer. Data from former comp projects suggest that FbiA may be a target of FbxA-mediated degradation. Proteins homologous to FbiA are found in a wide array of eukaryotes, including fungi, plants, *C. elegans*, *Drosophila*, mice, and humans. The function of these FbiA homologues is, however, unknown. Hence, further characterization of FbiA's role in *Dictyostelium* development may shed light on the function of this conserved protein family.

Work in the near future will address questions such as: (i) when and where the FbiA protein is expressed, (ii) what signaling pathway(s) are responsible for the complex, developmentally regulated pattern of *fbiA* RNA expression, (iii) why the absence of FbiA disrupts pattern formation, (iv) what effect over-expression of FbiA has on development, and (v) whether FbxA & FbiA interact in a biologically relevant fashion. We have also begun characterization of the *Dictyostelium* FbiB protein, a structural homologue of FbiA and have isolated a homologue of FbiA from the yeast *Saccharomyces cerevisae*, in hopes of assessing to what extent structural homology correlates with functional homology. Depending upon the project you choose, you might employ any of the following techniques: restriction digests, agarose gel electrophoresis, plasmid & genomic DNA preps, PCR, introduction of recombinant DNA molecules into cells (bacteria, *Dictyostelium*), cell propagation & sterile technique (bacteria, *Dictyostelium*), protein purification, protein gels, Western blots, histochemical staining, phase contrast microscopy, immunofluorescent microscopy, bright-field microscopy (stereozoom scope), and digital photography.

Recent comp projects include:

- "*Dictyostelium fbiA* mRNA expression analysis via *in situ* hybridization"
- "Characterizing the relationship between the proteins FbxA and FbiA in *Dictyostelium discoideum*"
- "Regulation of FbiA protein levels via ubiquitination-mediated proteolysis in *Dictyostelium discoideum*"
- "Characterization of *Dictyostelium discoideum* mutants overexpressing FbiA"
- "Creating and Characterizing the *fbiA*$^-$ mutant in *Dictyostelium discoideum*"

Milt Ostrofsky
My research focuses on the question "To what extent do limitations of nutrients and/or energy determine the quantitative and qualitative characteristics of biological communities in aquatic habitats?"

In most aquatic communities, the demand for phosphorus exceeds the supply, making phosphorus the limiting element in the classical sense. Part of reason for the shortage of phosphorus is that it is not recycled very efficiently within communities. The phosphorus cycle is intimately tied to the biogeochemical cycles of both iron and sulfur, and changes in the solubility of iron (regulated by redox changes) and changes in the availability of sulfur (derived from acid precipitation) have significant effects on the phosphorus cycle. Most recently we have been attempting to develop a model to predict phosphorus recycling efficiency, and the rates of phosphorus flux across the sediment/lake water interface. Related to nutrient limitation in lakes we have been doing a bit of "forensic limnology" by using biological and chemical cues in the sedimentary stratigraphic record of lakes to reconstruct historical trophic status and the effects of various land use changes (settlement, agriculture, mining, deforestation) on the ontogeny of lake ecosystems.

A second area of interest is the effects of invasive species on the structure of aquatic communities. Two invasives in particular (Eurasian water milfoil, and the zebra mussel) are gaining ground in northwest Pennsylvania lakes, and the consequences of their range expansions are not clear. Both are strong competitors, and have been shown to completely displace some native species, altering community structure and function. What might the long-term effects of these invaders have on local aquatic communities?

Susan Rankin
My overall objective is to explore the hormonal regulation of egg development and the behaviors that accompany reproduction. I've used a number of crustacean and insect systems to look at these biological phenomena. In fact, insects have been widely used as model systems to study basic mechanisms of hormone action and the physiological bases of specific behaviors. Moreover, identification of neuropeptides that regulate hormone production (such as the recently described allatostatins) are essential to the development of biorational pesticides. (In fact, some of my work has been integrated into currently marketed pesticides).

Students in my laboratory typically utilize behavioral observations, coupled with manipulations of hormone levels, microsurgery, tissue culture, and radiochemical or immunological identification and quantification of various hormones.

Recent comps performed in my lab include the following:
- "Detection of pheromones in the ringlegged earwig, *Euborellia annulipes*"
- "Female choice and nuptial feeding in the cricket, *Oeocanthus nigricornis*"
- "Male reproductive tract myogenic activity and the effects of selected neuropeptides in earwigs"
- "Effects of adipokinetic hormone on fat body size and on the expression of maternal care in the earwig, *Euborellia annulipes*"
- "Effects of diet reproduction, juvenile hormone production, and salivary gland sizes in an earwig"
- "Effects of juvenile hormone III on mating and maternal behaviors in an earwig"
- "Nest and clutch recognition in a species of earwig"
- "Esterase activity and the effects of manipulated levels of juvenile hormone on embryogenesis"

Matthew Venesky
The emergence of infectious diseases is one of the largest threats to human and wildlife health. The overall aim of my research is to better understand the consequences of parasite infection on wildlife and the cascading effects that parasites have on species interactions. I take a multidisciplinary approach to studying host-parasite interactions and I integrate molecular, physiological, and ecological approaches in my research. Currently, most of the research in my lab falls under three general themes within disease ecology: (1) understanding the relationship between host physiology and disease risk, (2) identifying host traits that reduce, or amplify, pathogen transmission, and (3) surveying natural populations of aquatic vertebrates for parasites. My laboratory is equipped to study various aquatic pathogens; however, most of my students work with amphibians and the fungal pathogen *Batrachochytrium dendrobatidis* ("*Bd*"). *Bd* is one of the deadliest organisms on the planet and it is linked to amphibian declines and extinctions on every continent except Antarctica.

In addition to studying wildlife diseases, I have expertise in ecology and herpetology (the study of amphibians and reptiles) and I can oversee comp projects that fall under numerous categories in these fields.

Please visit my website for more info about past and current research projects as well as my own research interests: https://sites.google.com/site/veneskylab/

Kristen Webb
My research is in the fields of Molecular Evolution and Bioinformatics. I use DNA sequences of genes, non-coding regions, and entire genomes to study the relationships between populations of organisms and to understand how these populations have changed over time. Data collection involves traditional molecular biology wet-lab bench work while the analysis is entirely computational.

Specifically, I am interested in understanding how the actions of humans have shaped the evolution of various organisms. Current projects in my lab include 1) using DNA to better understand the relationships of domestic dog breeds including estimating the timing and location of early diversification events, 2) using mitochondrial DNA to look at the population structure of dogs and cats from different geographic areas towards building a database of sequence variants (haplotypes) for forensic use, and 3) using DNA sequences to study population structure of carp at the Pymatuning spillway relative to other areas of Pymatuning Lake.

Lisa Whitenack
My general research interest is on the evolution of shape. My main focus is on functional morphology, the relationship between form and function, in extinct and extant organisms. My primary tool for this is biomechanics, the application of engineering techniques to determine how organisms perform mechanical functions, the design of morphological systems, and the relationship of these to the organism's environment. I also use shape as a diagnostic tool for species delimitation in the fossil record via geometric morphometrics, as well as determining paleoecological relationships. My research has historically concerned teeth and jaws of sharks and other fishes, the biomechanics of marine gastropods and their predators, and jumping mechanics of salamanders.

Potential comp projects in my lab could concern invertebrate or vertebrates; extinct or extant; biomechanics, morphometrics, or paleoecology. Previous comp topics in my lab include sexual dimorphism in macaque monkeys and great horned owls, northern pike bite force, bluegill feeding

kinematics, and biomechanics of various aspects of locomotion in fishes, lizards, frogs, salamanders, and humans. A complete list of comps from my lab can be found at:
https://sites.google.com/a/allegheny.edu/whitenack/student-research

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Scott Wissinger
My research interests are mainly in aquatic ecology. I am particularly interested in aquatic invertebrates, their functional roles in stream and wetland ecosystems, and their interactions with vertebrate predators such as salamander & fish. I'm also interested in using fish as indicators or stream health in NW PA. Projects often involve field studies in the fall and follow-up lab experiments and data analysis during winter. Topics that my students and I have been working on in recent years for which there are opportunities for ongoing studies by comp students include

1) using fish and invertebrate communities to assess the ecological health of stream
2) understanding the effects of beaver dams on invertebrate & fish communities.
3) processing of detritus by wetland invertebrates, especially caddisflies.
4) comparing communities in restored wetlands to those in natural wetland habitats.
5) colonizing strategies of invertebrates that inhabit temporary wetlands.

Recent senior projects conducted in my lab include:
Mark Kirk (2011) *Effects of Stream Size on Fish and Macroinvertebrate Diversity and Biomonitoring Indices in the Sugar Creek Subdrainage of French Creek*
Emily Thorton (2010) *Excreting where they're eating: An investigation of the ecological role of Limnephilus externus caddisfly larvae in subalpine ponds*
Alan Messenger ('09) *Using Biological Indicators to Determine the Ecological Status of an Urban Stream in Northwestern Pennsylvania*
Amanda Klemmer ('08) *Top-down effects of caddisfly shredders on detritus processing and nutrient flux in subalpine ponds in Colorado*

Abstracts of other senior projects that I have advised in recent years can be found at
https://sites.google.com/a/allegheny.edu/scott-wissinger/senior-projects