Anastasia Linger

The Affect of Various Genes on the Development and Emergence of Lateral Roots in *Arabidopsis thaliana*.

In plants, lateral roots form by budding off the side of a main root. Before a lateral root fully emerges, it begins as a bundle of cells known as a lateral root primordium. Lateral roots tend to form on the outside of a curve on the main root, but the longitudinal location in which they form is otherwise variable. I am examining the effects of mutations in several genes including one associated with energy supply from the cotyledon (SPD1) on the emergence and spacing of lateral root primordia in the model plant *Arabidopsis thaliana*. To do this, I will be crossing the various mutant plants with a line of plants in which expression of a marker is driven by the promoter of a gene that is activated and expressed in lateral root primordia. Upon exposure to GUS, the lateral root primordia of any plants into which I have bred this reporter system will stain blue. I will be examining the distance between lateral roots, their general frequency, and their tendencies towards forming on the outside versus the inside of a curve on the main root to see if mutations to the aforementioned genes change these patterns. I find it fascinating and rewarding to do research on plants because of the great deal of freedom we have in manipulating their genomes.

Research Advisor: Marta Laskowski
The research I am participating in this academic year is trying to understand the mechanisms involved with the emergence and spacing of lateral roots in plants. Lateral roots are important for anchoring plants in soil and for gathering nutrients that a plant needs to grow and survive. Root development in plants is still relatively unknown in comparison to development of other major plant organs. My project is dedicated to understanding the mechanisms behind initiation and spacing of lateral roots. The plant hormone auxin has been found to help promote lateral roots in plants. My project is specifically looking at whether auxin transport affects lateral root spacing. I will grow plants with loss-of-function auxin transporters and cross them to plants that carry markers that identify early stage lateral root primorida. Once I have obtained plants that are homozygous for these features, I will compare the distance between lateral roots in these and wildtype plants. If I find a mutant that does affect lateral root spacing, I will determine the locations where the gene product is expressed. Because most of the auxin transporters are expressed in multiple locations throughout the plant, I will then take the first steps toward determining which locations are most important for the effect.

Honors Advisor: Marta Laskowski
Ben Garfinkel

Gregarine Parasites of the Damselfy Ischnura verticalis: Relationships to Fecundity

Damselflies (Order: Odonata) are winged insects found on the edges of ponds and streams. Found in every county in the state, Ischnura verticalis is the most common damselfly in the State of Ohio. As an adult, I. verticalis attracts both endo- and ectoparasites from its habitat. These parasites include protozoan gregarines, water mites (sub-genera Arrenurus and Limnochares), and trematodes (Haematoloechus spp.). Prior research has documented parasite intensity affecting egg load, fat reserves, lifespan, and fluctuating asymmetry (the deviation in symmetry of normally symmetrical traits) in other species of odonates; however, results vary widely between different species. The primary interests of my project are (1) to explore the diversity and intraspecific distribution of parasites within I. verticalis populations, and (2) to document potential fitness costs of parasitism in I. verticalis through fitness proxies such as female egg load and fluctuating asymmetry. As egg load and fluctuating asymmetry are indicators of fitness, this project has implications for how odonates may mitigate fitness costs of parasitic organisms. Furthermore, learning about these types of interspecific relationships may inform study of fitness costs of parasite-mediated selection across other organisms.

Honors Advisor: Chris Anderson
For my project I will be working with the Alaska Department of Fish and Game (ADFG) to assess the temporal and spatial abundance of select flatfish species in the Northern Gulf of Alaska (GOA). In the United States more than half of the population lives in coastal areas. These coastal areas produce 60% of the gross national product each year, heavily supporting our nation’s economy as well as supporting the lives of people who depend on coastal and pelagic resources. The GOA is a highly productive ecosystem supporting an enormous commercial and recreational fishing industry as well as supporting subsistence fishing. The importance of the coastal resources in this area to local communities and to the United States cannot be overstated. From my project I hope to provide the ADFG with information that can be used in future management decisions, further promoting sustainable fisheries.

Research Advisor: Angie Roles
Dominic D'Andrea

Carotenoids and Oxidative Stress in Female American Goldfinches

The American Goldfinch (Spinus tristis) is a small, socially monogamous songbird in which female bill color serves as a signal of competitive status. We are studying social relationships between female goldfinches to look at the impacts of bill and feather coloration on a bird's place in the dominance hierarchy. The color in their bills and yellow neck feathers is provided by carotenoid pigments, and seems to function as an honest signal of health to other goldfinches. Circulating carotenoids appear to aid in prevention and repair of oxidative damage to cells, but it's unclear whether high bill and feather color intensity are linked to oxidative health. Thus, my project this semester is to measure oxidative damage, antioxidant potential, and circulating carotenoids in wild-caught female goldfinches following staged competitive interactions, and evaluate whether these parameters are related to dominance status or changes in bill color that result from competitive interactions.

Research Advisor: Keith Tarvin
This year I am assisting with two research projects studying mutation in plants (*Arabidopsis thaliana*). Broadly, these projects aim to quantify the rate, distribution of effects, and environmental dependence of mutations affecting fitness. The first experiment is a mutation accumulation project, studying the effects of spontaneous mutations on plant fitness, estimated by fruit production. We will grow many generations of several plant lineages, allowing multiple mutations to accumulate by using only one seed from each lineage to produce the next generation, neutralizing natural selection acting against harmful mutations. After many generations, we will measure any changes in the distribution of fruit production among these lineages. In the second experiment, a somatic mutation project, we are studying the effects of selection during vegetative growth on the distribution of mutations that we observe in offspring. We will mutagenize young *Arabidopsis* seedlings with UVB light, before any germ line cells have been produced, causing mutations in the population of stem cells. As the plants grow and produce an inflorescence and fruits, we expect more mutations acting in the first fruits produced than in the last fruits produced, as selection has been able to act on somatic cells between the production of these fruits.

*Research Advisor: Angela Roles*
There are numerous proteins that make up the sarcomere, or the contractile unit responsible for muscle movement. While there is a significant base of knowledge about their individual properties and mutations, there is a large gap of information regarding their interactions. It is difficult to determine this information biochemically, so in this lab, we are testing the mechanism genetically with the organism *C. elegans*. We are producing organisms which have two different mutations in an effort to determine how the mutations interact and affect body movement amongst the worms. Our research focuses primarily on the interactions between the proteins myosin, troponin, and twitchin. By engineering double mutants, we can investigate if certain mutations conspire to make the situation worse, or compensate for each other. In this way, double mutants reveal information about suppression mutations and provide a roadmap of interactions within this ensemble of proteins.

*Research Advisor: Taylor Allen*
Garbiel Moore

Acetylcholine Sensitivity in Caenorhabditis elegans Defecation Mutants

The body wall muscles of Caenorhabditis elegans (C. elegans) are utilized for multiple behaviors including locomotion and defecation. Neurotransmitters, or small signaling molecules, are used by neurons to initiate contraction or relaxation of these muscles. However, because different signaling pathways are involved for both of these processes, inhibition of muscle function for one process via mutation of an “upstream” event is not thought to necessitate loss of muscle function for another. For locomotion, the excitatory neurotransmitter that initiates muscle contraction is acetylcholine. For the defecation motor program, signaling from the intestine and neurons induces muscle contractions. Yet preliminary data suggests that mutants with defecation signaling deficits also appear to affect neurotransmission. In this study, acetylcholine responsiveness in mutant strains of C. elegans with mutant defects were tested in two chemical assays which affect muscle contraction signaling: aldicarb and levamisole. Aldicarb is an inhibitor which blocks the enzyme acetylcholinesterase, a major component needed to allow for muscle relaxation. In the absence of this enzyme, body wall muscles are exposed to excess acetylcholine, and are thus unable to relax. This leads to paralysis via hypercontraction within the worms. Similarly, levamisole has the ability to permanently bind and open the muscular acetylcholine receptors, causing hypercontraction and paralysis. Resistance to this compound indicates muscle response problems. Wild and mutant strains were induced with these chemicals in separate assays and scored for paralysis to determine sensitivity to acetylcholine, allowing us to observe where the defects in muscle function originate. Using both of these assays in tandem, our study suggests a complex connection between defecation-related signaling and nervous system function.

Research Advisor: Maureen Peters
Through genetic methods and physiological analysis, we have constructed strains of worm (C. elegans) that have interacting mutations in proteins involved in muscle contraction. Previously, troponin and myosin were thought to be involved in discrete stages of contraction, and twitchin (a titin homolog) was thought to simply modulate the actomyosin complex. However, by combining mutations in these proteins and showing subsequent phenotypic rescue (or lack thereof), we can illuminate previously unknown interactions.

Advisor: Taylor Allen
Pregnancy in marsupial mammals is brief, with the fetuses being born within days or a mere few weeks of conception. Moreover, these fetuses do not attach to the uterus, existing mainly suspended in the uterine cavity. For these reasons, maternal recognition of pregnancy was for a long time considered to be absent in these unusual mammals. However, work in our lab has shown that early pregnancy factor (EPF) and progesterone both fluctuate during pregnancy in the opossum, *M. domestica*, evidence that maternal recognition of pregnancy does occur in marsupials.

I will examine especially prepared and stained thin slices of uteri from pregnant and non-pregnant opossums to determine if the known changes in serum progesterone and EPF in these animals correspond to visible changes in uterine tissues and cells.

*Research Advisor: Yolanda P. Cruz*
I am interested in how kin selection dynamics influence decisions made by birds at the earliest stages of their lives. Birds typically have more than one offspring per reproductive event. This creates a nest dynamic where nestlings within a brood can vary in their degree of development, leading to a situation where some nestlings may be ready to fledge before their nest mates. In passerines, parental care is vital to nestling survival and most species are not independent when they fledge. This means that once birds leave the nest the parents will follow them in order to provide parental care such as feeding and protection. If one nestling leaves the nest before the others are ready, the nestling that has fledged will draw parental care away from the remaining nestlings, thus hurting these more immature nestlings. This creates a trade-off that older nestlings must face in leaving the nest in order to protect themselves from predation risks while risking their nestmate’s fitness, or staying in the nest and delaying their own development but helping their siblings. I am investigating how the degree of relatedness between nestmates influences the decisions made about the fledging trade-off. Using data gathered from published sources, I hope to gain a better understand of what influences the nesting's fledging decisions.

Research Advisor: Keith Tarvin
Sickle Cell Disease (SCD) is a genetic disease that is far more prevalent in African American populations. 1 in 8 African Americans carry the gene for SCD and 1 in 400 African Americans have the disease. There is a significant disparity between funding, research and awareness of Sickle Cell Disease in comparison to other equivalent diseases. In order to better understand the debilitating pain experienced by those with the disease, patients from Akron Children’s Hospital were asked a series of open-ended questions about their pain such as how the pain feels, their goals for managing pain and how the pain effects school, work, and relationships with friends and family. These pain diaries are then read and coded using conventional content analysis. As one might search a literary text for themes, this method of analysis allows researchers to find commonalities in data, and then group the qualitative data based on these commonalities. With these groupings, qualitative data can be made quantitative by calculating the percentage of data that fits into each specific category. Coding pain diaries with such a method is clinically useful for realizing goals of pain management, and then tailoring pain treatment methods to work toward fulfillment of goals.

*Research Advisor: Taylor Allen*
The defecation cycle in the nematode, *Caenorhabditis elegans*, occurs at approximately 50 second intervals and consists of three contractions. The first contraction occurs in the posterior body wall muscle and is followed by a contraction of the anterior body wall muscle. Finally, waste is expelled via contraction of the intestinal muscles. The second and third contractions are initiated by the release of neuropeptides from the intestine. These neuropeptides activate neurons which synapse with the intestinal and body-wall muscle. A genome-wide RNA interference (RNAi) screen identified *EPS-15 homologous sequence 1* (ehs-1) as a gene involved in defecation. RNAi uses double-stranded RNA to decrease, or knock down, expression of a specific gene. Detailed analysis of each contraction revealed that when *ehs-1* is knocked down, the frequency of the expulsion step is 89% lower than in wild-type worms. *Ehs-1* has previously been implicated in synaptic vesicle recycling in neurons, suggesting that the expulsion defect is due to defective neurotransmission (Salcini 2001). However, intestine-specific knockdown of *ehs-1* produces a 92% reduction in expulsion frequency, matching the results of the systemic RNAi experiment. These findings suggest that intestinal expression of *ehs-1* is required for expulsion. Therefore, we hypothesize that *ehs-1* is needed for vesicle recycling in both neurons and intestine.
Nicole Le and Lisa-Qiao MacDonald

“Investigating the expression of transposon sequences and conserved genes in the opossum genome”

We use qPCR to determine whether a known filovirus transposon known to be present in the opossum genome is actually being transcribed into mRNA. If so, this suggests the possibility of these genes being utilized by various tissues (liver, kidney, spleen, etc.) in normal cellular function. Detecting functional transposon mRNA in these cells could lead to exciting future therapeutic strategies using transposon genes to confer desired transcribable elements across genomes.

Research Advisor: Yolanda P. Cruz
Pearl Rivers

Can adult Eastern gray squirrels (*Sciurus carolinensis*) learn to respond to a novel heterospecific alarm call?

Eastern gray squirrels (*Sciurus carolinensis*) are known to increase their alertness in response to the alarm calls of sympatric bird species that share common predators. By eavesdropping on local birds squirrels can gain valuable information about predators in the area. Because the presence of bird species in a particular habitat varies with the season or even year, gray squirrels likely do not innately respond to heterospecific alarm calls and it is therefore expected that adults have the ability to learn new alarm calls. Through training trials pairing the playback of a novel alarm call with the presentation of a flying hawk model, individual squirrels will be trained to respond to a previously neutral sound as a heterospecific alarm call. If focal squirrels quickly learn to respond to the novel alarm call it will show that gray squirrels do not rely on innate knowledge of particular acoustic features in the calls of sympatric species to recognize heterospecific alarm calls. If adult squirrels have the ability to learn to respond to any novel call as an alarm call, it allows for greater adaptation to changes in community structure and the acoustic environment.

*Honors Advisor:* Keith Tarvin
Phoebe Hammer

"Intestinal gap-junction protein is needed for normal acetylcholine response in Caenorhabditis elegans"

The comparatively simple Caenorhabditis elegans (C. elegans) nervous system is understood in fine detail at the level of connectivity and neurotransmitter localization, yet it is not possible to accurately predict the behavior it controls. This may be due to the effects of neuromodulators, molecules that can dynamically regulate synaptic function. A neuropeptide is a type of neuromodulator that is released from cells when internal calcium levels rise. In the C. elegans intestine a periodic calcium wave occurs that regulates the release of signaling molecules, including peptides, to trigger muscle contractions associated with defection. The intestinal calcium waves require intercellular connections between the intestinal cells via gap junctions. Our protein of interest, innexin-16 (INX-16), is a gap junction subunit that is essential for normally timed and patterned intestinal calcium waves (Figure 1). The defecation-associated contraction that is signaled via peptide release from the intestine is largely missing in these mutants. These data suggest that the abnormal calcium waves in the inx-16 mutant cannot induce release of at least one peptide. Preliminary observations indicate that the inx-16 mutants also exhibit abnormal movement, another process that can be regulated by neuromodulation of locomotory circuits. We hypothesize that calcium triggered peptide release from the intestine is used to regulate locomotory circuits in C. elegans. The goal of this project is to determine the relationship between an intestinal calcium wave and locomotion signaling by quantifying neurotransmission rates in the intestinal calcium wave mutant, inx-16. Acetylcholine (Ach) responsiveness in mutant inx-16 worms were tested in two chemical assays which affect muscle contraction signaling: aldicarb and levamisole. The results of these two assays allow us to define whether there is a defect in acetylcholine signaling and whether it is due to problems originating in the neurons or the muscles. Our study suggests a connection between defection-related signaling and nervous system function.

Research Advisor: Maureen Peters
The defecation motor program of the nematode *Caenorhabditis elegans* (C. elegans) consists of sequential posterior, anterior, and enteric muscle contractions. A posterior to anterior calcium wave with 45-55 second periodicity initiates the motor program. Functional propagation of the calcium wave requires the gene *inx-16*, which encodes a gap junction subunit that connects intestinal cells. In *inx-16* mutant worms, calcium waves occur, although they often initiate ectopically, propagate slowly, or fail. While the defective calcium wave is capable of initiating the posterior body contraction, the expulsion contraction is absent in a majority of defecation cycles. Expulsion contractions occur when the enteric muscles are stimulated by the dorsal ventral neuron B (DVB). DVB is activated neuropeptide-like protein 40 (NLP-40), which is released from the cells of the intestine. I am using optogenetics and fluorescence microscopy to characterize which of these steps in the expulsion contraction-signaling pathway are affected by *inx-16* mutation.