Keck Center’s 2016 Student/Postdoc Symposium: A Great Success!

The seventeenth annual student/postdoc symposium of the W. M. Keck Center for Behavioral Biology drew record participation with 24 platform presentations and nine posters. The presentations showcased the breadth of the Center with talks ranging across neuroscience, ecology and genetics, across multiple levels of organization, from cellular to organismal and population levels and encompassing a wide range of invertebrate and vertebrate systems. Grace Parker received the award for best poster presentation and Ayako Wada-Katsumata and Magadalena Sorger received awards for best oral presentations. Congratulations to Lauren Dembeck, who was awarded The Robert and Margaret Grossfeld Award for her groundbreaking work on the genetic architecture of natural variation in cuticular hydrocarbon composition in Drosophila melanogaster. See the article by Hongmei Li-Byarlay on page 3 for further details.

The Signal will not be published during the summer recess. Volume 18 of The Signal will appear in September.
The Illumina MiniSeq System, unveiled earlier this year, is the company’s smallest and simplest next-generation sequencing (NGS) system to date. The Go Mini Scientific Challenge Program was launched to highlight the range of applications that can be performed using Illumina’s most affordable sequencer. After receiving more than 1,100 grant submissions from around the world, the winners were announced at a reception at the American Association for Cancer Research (AACR) annual meeting in New Orleans, Louisiana. Hongmei Li-Byarlay, Ph.D., a postdoctoral fellow of National Research Council based at North Carolina State University, will receive a MiniSeq and reagents needed for three sequencing runs. She plans to sequence the honeybee genome and further research into the immune systems in insects by investigating the underlying genetic and epigenetic components of the immune systems of honeybees. She believes the MiniSeq is the ideal platform for this study because targeted RNA sequencing and whole transcriptome sequencing will allow for better understanding of antiviral immune response pathways and insights into gene regulation and epigenetic changes after viral infection.

“Many people don’t realize the importance of honeybees to our economy or our food supply. A majority (87 percent) of flowering crops require help from pollinators such as bees. These crops and plants correspond to 33 percent of human food consumption. Pollination from honeybees supports about $15 billion worth of agricultural production, including many fruits and vegetables (such as blueberries, avocados, watermelons, and pumpkins) in the U.S. economy,” said Dr. Li-Byarlay. “I hope my research can help prevent the 30-40 percent annual loss in the population we observe due to natural pathogens and parasites.”
Flies, ants, cockroaches, moths, bed bugs, fishes, rodents, moles, iguanas, and humans, oh my! What event can possibly bring all these animals together? The W.M Keck Center for Behavioral Biology did it! On April 29th of 2016 with beautiful spring flowers, the 17th annual student and postdoc symposium of the W. M. Keck Center for Behavioral Biology was successfully organized and well attended.

In total, twenty-four outstanding scientific talks and nine posters were presented with topics covered in animal behavior related to sex differences and sex pheromones, neuroscience, chemosensation, oxidative stress, aging, social environment, genetic engineering in pest management. However, due to the large number of presentations this year, I only highlight a few selected talks here.

The symposium started with interesting behavioral questions on the topic of sex differences in responding to social environments in vertebrates. To investigate whether kisspeptin signaling plays an important role in socially-induced sex change, Mellissa Lamm identified different gene expression patterns of kiss1 and kiss 2 in different sexes of the bluehead wrasse fish, and also discovered similar patterns over their breeding periods compared to the Japanese medaka. However, there was no evidence of colocalization of kisspeptin receptors with gonadotropin-releasing hormone in the hypothalamus.

Antennal grooming behavior is a key component of insect behavior and important to enable chemosensation and social interactions. Sex pheromone is needed for insect aggregations as well. Ayako Wada-Katsumata performed a fascinating experiment to test the role of male antennal grooming behavior and how that is enhancing courtship performance and prevents mating disruption in the German cockroach. After preventing the grooming by gluing their mouthparts, male cockroach antennae accumulated more cuticular lipids in the dark phase than the light phase of the daily cycle, and their courtship responses decreased significantly. This study addressed the importance of grooming behavior in brain habituation, sensory adaptation, and sexual identity and recognition in aggregations.

The exciting Grossfeld Award is given to the student or postdoc who published the most creative and influential peer reviewed article during the preceding year. This year’s recipient was Lauren M. Dembeck for her work on the genetic architecture of natural variation in cuticular hydrocarbon composition in *Drosophila melanogaster*. Lauren’s doctoral dissertation was under the guidance of Dr. Trudy Mackay. Her study revealed new functions of 24 candidate genes affecting cuticular hydrocarbon composition in at least one sex. More interestingly, these genes are related to fatty acid metabolism and provided mechanistic targets for individual variation in cuticular hydrocarbon composition.

Environmental contamination of bisphenol A (BPA) may disrupt the development of children’s brains. Sheryl Arambula’s study tested whether BPA exposure gives rise to sex-specific changes in neonatal rat hippocampus and hypothalamus by measuring gene expression profiles. Expression of 32 genes was differentially changed in males exposed to a high dose of BPA. Expression changes of estrogen receptors alpha and beta, oxytocin, and GABA vesicular transporter were identified in hypothalamus.

Oxidative stress was also a hot topic in our symposium. Xiaohu Xie’s study revealed a potential new link between hydrogen peroxide and dopamine release during cocaine-induced locomotor activity in mice. The cocaine-induced generation of H2O2 regulated dopamine levels in the nucleus accumbens with a negative correlation. Another study from Leslie Wilson reported the role of H2O2 and the dynamics of dopamine in Parkinson’s disease by monitoring brain tissues after chronic L-DOPA administration in rodents. Correlation was detected between the chemical fluctuations and behavioral abnormalities such as rotating behavior.

Desireé Unselt presented her study on the genetic components affection variation in *Drosophila* lifespan using natural populations. A genome-wide association study identified 28 genes closely associated with lifespan. RNA interference tests verified their effects on lifespan.

In order to gain better knowledge of chemosensation, especially the functions of odorant binding proteins (Obps), Joel Johnstun performed novel experiments using the CRISPR-Cas9 system to test subfunctionalization or neofunctionalization of paralogs of the *Obp56a-d* gene cluster, and the *Obp56h* gene. Both knockout
lines appear to affect early development and development time. These Obps also appeared to be implicated in different aspects of mating behavior. This is the first functional study of Obps using genomic editing approaches.

A special thank you to the graduate student coordinators, Jamie Mankiewicz and Desireé Unsell, who did a great job of helping organize this year’s symposium.

Lauren Dembeck receives the Robert and Margaret Grossfeld Award; left, Dr. John Godwin, Chair of the selection committee; center, Dr. Robert Grossfeld; right, Center Director, Dr. Robert Anholt.

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Thermal and Chemical Detection in Drosophila

by Zachary DeVries

On April 11, 2016 the W.M. Keck Center for Behavioral Biology had the pleasure of hosting Dr. Paul Garrity, professor at Brandeis University, who presented research on thermal and chemical detection in Drosophila.

Garrity began his talk by explaining the importance of the thermosensory system, primarily the transient receptor potential (TRP) channels. He explained that these systems serve several functions in insects, namely avoidance of dangerous conditions, optimizing body temperature, and prey seeking. Garrity explained that in Drosophila, TRPA1 is responsible for heat avoidance. He showed this through bioassays in which larvae with functioning TRPA1 channels selectively avoided hot areas; however, when the TRPA1 channel was knocked out, Drosophila larvae could not detect heat zones, remained in hot areas, and thus did not thermoregulate.

Next, he discussed the history of TRPA1 channels in mammals where they have been shown to respond to chemicals. In mammals, Garrity said TRPA1 channels work by responding to electrophiles (or noxious chemicals) and alert the organism to potential damage that these reactive chemicals may cause. The key question Garrity posed from this information was how do invertebrates sense and detect electrophiles? To answer this question, Garrity used hungry flies and offered them glucose (phagostimulant), along with other noxious compounds of interest (electrophiles). When wild type flies were tested, they refused to feed when noxious compounds were present with the glucose (e.g. wasabi); however, when TRPA1 channels were knocked out, flies readily fed on diets containing electrophiles, such as wasabi. Similarly, electroantennograms (EAGs) revealed TRPA1 knockdown mutants did not respond to electrophile stimuli, but wild type flies did.

Garrity further evaluated the evolution of electrophile detection. Interestingly, he found that some of the key elements in human pain sensation are shared with invertebrates and have changed very little over 500 million years. He further explained the challenge of chemical sensation: animals must be able to discriminate yet still have an ability to detect a wide range of compounds.

Next, Garrity discussed the multimodal functionality of TRP channels. He explained how there are two TRPA1 isoforms in Drosophila, A and B. The A isoform is found in the proboscis and responds to electrophiles only, while the B isoform is found in the head and responds to both electrophiles and warmth. To further test this system, Garrity proceeded to create a Drosophila line where the TRPA1 isoforms were reversed (A in the head and B in the proboscis). When this new line was tested by stimulating the proboscis with heat, the flies responded by regurgitating, as if they had ingested a noxious substance. This system shows how flies have repressed thermal reception in the proboscis.

Up to this point, Garrity had only discussed responses to electrophiles and subtle temperature gradients. Next, he discussed how flies (both controls and TRPA1 knockdown mutants) could still respond to steep temperature gradients. Garrity explained how Gr28b, a gustatory receptor, is responsible for rapid warmth avoidance. Thus, flies have two independent systems for thermal sensing: dTRPA1 (slow changes) and Gr28b (rapid changes).

Next, Garrity shifted from thermal sensing to cold sensing. He explained that IR25a and IR93a are what drive fly responses to cold temperature and showed when knocked down, flies could no longer respond to cold temperatures. He also suggested that IRs may be responsible for humidity detection, but further work is needed.

Garrity concluded his seminar with this thought: multimodal reception appears to be the rule, rather than the exception.
The Association for Chemoreception Sciences (AChemS) held their annual meeting in sunny Florida at the Hyatt Regency Coconut Point, Bonita Springs from April 21-24, 2016. The four-day meeting got off to a good start with a welcome banquet and awards ceremony for accomplishments in taste and smell research.

The symposia encompassed a wide range of topics, from the effect of traumatic brain injury on olfaction and anosmia to structural insights into chemosensory receptors. Most of the talks were on work done in mice and humans with few presentations focusing on insects.

During the session on olfactory dysfunction in traumatic brain injury, James Schwob (Tufts University) talked about how to fix a broken nose using stem cell therapy. Two posters by graduate students from Stefan Liebau’s lab also focused on stem cells. Their lab has successfully generated olfactory sensory neurons in culture from induced pluripotent cells. Akiva Cohen (University of Pennsylvania), on the other hand, talked about taking a much simpler route to treat olfactory dysfunction by modifying amino acid composition in diet to balance synaptic transmission.

The clinical symposium shed light on olfactory decline through a different lens. Clinicians shared case studies of patients with partial and complete anosmia resulting from different causes and also on translational research focusing on gene therapy strategies to tackle congenital anosmias.

Several talks focused on the role of the microbiome in chemosensation. Although the idea that microbes in our gastrointestinal tract affect smell and taste perception seems a bit far fetched, work by Ann Griffen, Johanna Reichert and Lynette McCluskey indicates its importance. The hypothesis proposed by Ann Griffen, a pediatric dentist who researches the oral microbiome, is that our gut and oral bacteria need sugar for their survival, so they make our brain think that we want to eat sugary food, resulting in the cravings for chocolate nearly everyone is familiar with.

The symposium on structural insights into chemosensory receptors had talks by researchers from the Monell Chemical Senses Center and Senomyx. They study the properties of the sweet taste receptor and how different allosteric modulators (including artificial sweeteners such as sucralose and aspartame) can affect sweet taste perception. Craig Montell talked about taste in Drosophila, explaining how flies detect salty tastes and different textures.

The presidential symposium was the highlight of the meeting, with talks by recipients of the AChemS Merit Awards. John Hayes (Pennsylvania State University) received the Barry Jacobs Memorial Award for research in the psychophysics of human taste and smell. He uses data from the 1000 genomes project to understand individual variation in taste perception and preference. John McGann (Rutgers University), the recipient of the AChemS Young Investigator Award for research in olfaction gave an enlightening talk titled “What is the olfactory bulb for?” His lab uses calcium imaging in mice to understand the effect of the ROB (Rest of Brain) on the olfactory circuit. He hypothesized, and supported with recent data, that when the amygdala is suppressed, it leads to changes in circuitry in the olfactory sensory neurons and the olfactory bulb, indicating that the olfactory circuit does not follow a unidirectional flow of information, but instead involves complex feedback from various brain regions, previously unknown to play a role in olfaction. Stephen Wooding (UC Merced) received the AChemS Young Investigator Award for research in gustation. He spoke about the genetics of bitter taste perception, and how it evolved as a mechanism to avoid ingesting toxins. John Cave outlined the work of Harriet Baker (Burke Medical Research Institute) over the past 30 years on the function of tyrosine hydroxylase on olfaction. Her work included showing that olfactory sensory neuron innervation was necessary to maintain tyrosine hydroxylase expression in the olfactory bulb dopaminergic neurons. Interestingly, this was one of the first studies to demonstrate that gene expression could be regulated by olfaction.

There were several other enlightening talks during the meeting. Erin Maher (University of Virginia) talked about taste in tree shrews, which seem to have an olfactory system different from and yet similar to both primates and rodents. Huey Hing (SUNY Brockport), in one of the few insect talks, talked about the role of the Wnt signaling pathway in axonal guidance in the Drosophila antennal lobe. The Wnt pathway was also shown to play a role in taste (specifically, in taste bud homeostasis and maintenance of behavioral taste perception) in adult mice by Linda Barlow (University of Colorado).
I was invited to participate in a workshop on genetic and neurobiological basis for the evolution of behavior, which was held at the Janelia Research Campus in Virginia, April 3-6, 2016. The core strategy of the Howard Hughes Medical Institute has been to find and generously support innovative scientists, allowing them to focus on their research, gain access to tools, space, and staff, and accelerate discovery. The Janelia Research Campus opened in 2006 to implement this strategy, and it systematically removes the obstacles that normally slow scientists down and adds elements that boost productivity or even alter the kinds of research possible. Over 50 research groups (each with one group leader and several postdocs) are specialized in specific areas of neuroscience, chemical and molecular tool development, and evolution and genetics using model systems such as mice, rat and Drosophila.

The workshop was organized by Jessica Cande, Yun Ding, and Troy Shirangi in David Stern’s lab and Josh Lillvis in Barry Dickson’s lab. Twenty-nine participants (14 graduate students and 15 postdocs) were invited from applicants all over the world. All participants presented both a poster and a 25-minute oral presentation. Before the opening remarks on the first day, we had a “welcome reception and science speed dating”, where we were paired for 5 minutes with sequential partners and introduced ourselves. The workshop included six sessions and each session was followed by a discussion that recapped the main points. At the end of each day, participants were separated into small working groups and assigned one question per group. The questions ranged from “How to develop a strategy to write a grant proposal for research on evolution?” to “What are the technical challenges to using model/non-model systems?” After dinner, we all discussed each group’s summary.

The one great thing about participating in a small workshop is that well trained scientists can discuss and develop ideas with a focus on similar interests, using different backgrounds including different research skills and animal models. Evolution has been defined as a change in the heritable traits of biological populations over successive generations. To understand the evolutionary processes which give rise to diversity at every level of biological organization (species, individuals, neural/molecular system), participants have been working on cues that guide behaviors (e.g. sex pheromones, courtship song), sensory systems (e.g. olfaction, gustation, electoreception), brain structures (e.g. cerebral cortex, hippocampus), motor systems (e.g.
courtship song, escaping) and genes which drive social traits such as monogamy, tameness and aggression in vertebrates and invertebrates.

For example, Lucia Prieto Godino from the University of Lausanne (Postdoc, Richard Benton lab) presented on the evolution of acid-sensing olfactory circuits in drosophilids. To understand the genetic and cellular basis of nervous system evolution, she compared the olfactory circuits of the specialist *Drosophila sechellia*, a specialist on *Morinda citrifolia* fruit, with its generalist cousins, *D. melanogaster* and *D. simulans*. She found that *D. sechellia* exhibits novel odor-evoked attraction and physiological sensitivity to the abundant *Morinda* volatile hexanoic acid, and she characterized how the responsible sensory receptor (a variant ionotropic glutamate receptor IR75b) and attraction mediating circuit have evolved.

Wen Xu from the Georgia Institute of Technology (Grad Student, Patrick McGrath lab) presented her excellent work showing that selection on a subunit of the NURF chromatin remodeler modifies life history traits in *C. elegans*. Evolutionary life history theory seeks to explain how reproductive and survival traits are shaped by selection through allocations of an individual’s resources to balancing life functions. While life-history traits evolve very rapidly, little is known about the mechanisms that control these tradeoffs. She used two strains of *C. elegans* (grown in the laboratory for >500 generations) that exhibit 14 diverse life history traits including reproductive timing, growth rate and lifespan, and mapped these traits to a region containing five mutations by Quantitative Trait Locus (QTL) analysis. Using CRISPR/Cas9-induced genome editing, she demonstrated that the QTL is due in part to a 60 bp deletion in the 3’ end of the nurf-1 gene, which is orthologous to the human gene encoding the BPTF component of the NURF chromatin remodeling complex.

Yuxiang Liu from the University of North Carolina at Chapel Hill (Grad Student, Sabrina Burmeister lab) presented on the parallel evolution of gene molecular mechanisms underlying evolution of hippocampal function. The vertebrate hippocampus is closely associated with flexible cognition, including spatial memory and behavioral flexibility. Animals that have adapted to complex social and/or physical environments often have advanced hippocampal cognition. His model system, poison frogs which show parental care, have greater behavioral flexibility than the sympatric túngara frog, which shows no parental care. He used RNA-seq on hippocampal transcriptomes from two types of frogs to identify gene molecular mechanisms underlying the species differences in hippocampal function, and found that gene modules related to neurogenesis rate are expressed at higher levels in parental care poison frogs. Advanced hippocampal cognition, such as in poison frogs, has evolved multiple times in each major vertebrate clade. He hypothesized that the evolution of hippocampal function within each clade represents parallel evolution of the same molecular mechanism. To test the hypothesis, he gathered hippocampal transcriptome data from public databases for species pairs with differences in hippocampal function, with one species showing relatively inferior hippocampal function compared to the other species within the clade. In Initial analyses of three major clades, which contain four species pairs (túngara frog vs. poison frog, chicken vs. chickadee, mouse vs. rat, chimpanzee vs. human), he found that expression of genes related to neurogenesis, synaptic plasticity, learning and memory, and neural apoptosis are clustered in the species with relatively superior hippocampal function, while control gene modules related to cellular respiration, glucose metabolic processes, and cell metabolism show no clustering with hippocampal function. This result is consistent with his hypothesis. He is currently expanding the analysis to include fish and lizards. This large-scale analysis of hippocampal gene expression has the potential to find common molecular mechanisms that underlie the evolution of hippocampal function across vertebrates.

The workshop also featured three plenary speakers: The telencephalon and other key innovations in vertebrate brain evolution by Georg Striedter (University of California, Irvine), lineages and the evolution of nervous system diversity by James W. Truman (Janelia Research Campus), and David Stern concluded the workshop with a talk about challenges for future work on evolution of behavior. The Stern lab uses Drosophila as a model for studies of motor neurons that drive courtship song and olfactory neurons that guide food choices.

It was a great opportunity to participate in the workshop. The discussions were engaging and stimulating, and in my case stimulated me to reorganize and re-focus my research strategy on the evolution of behavior in cockroaches. Of course, this workshop also stimulated participants to “think outside the box”, adopt new technical approaches, network with other scientists, and consider career opportunities at the Janelia Research Campus.
The 2nd Annual Spring Neuroscience Conference of the NC Triangle Chapter of the Society for Neuroscience

by Gunjan Arya, Lavanya Turlapati, and Sneha Mokashi

The 2nd Annual Triangle SfN Spring Neuroscience Conference was held on April 7th 2016 at the NC Biotechnology Center. Distinguished scientists from universities in the Triangle presented their work. It was intriguing to see the advancements made in the field of neuroscience.

The NC Triangle Chapter of the Society for Neuroscience promotes and fosters collaborations between neuroscientists, the public and our legislators and is intended to be a great outreach for the students and diverse audience.

This year, they had four distinguished scientists to speak at the conference, including three from the Triangle- Dr. Eroglu of Duke University, Dr. Garret Stuber of UNC-Chapel Hill, Dr. Wayne Silver of Wake Forest University. The keynote talk was addressed by Professor Emeritus of Immunophysiology, University of Illinois, Dr. Keith Kelley.

Eroglu was the first speaker of the day. Her lab is interested in understanding how central nervous system (CNS) synapses are formed and the role of astrocytes in the development, remodeling and function of synaptic circuits. She spoke on the role of Hevin (an astrocyte secreted protein), in cortical synapse formation. Hevin is a synaptogenic protein that shares structural homology at its N-terminal with an anti-synaptogenic protein called SPARC. Both Hevin and SPARC are important in controlling synapse formation. Cultures of retinal ganglion cells (RGCs) from rodent retina are used to understand the role of astrocytes and screen their secreted proteins involved in synapse formation. Dr. Eroglu summarized on how synaptogenesis has important health implications for understanding the pathophysiology of diseases such as Alzheimer's disease, epilepsy, and drug addiction.

Stuber talked about neural circuits that mediate motivated behavior. His lab uses a head-mounted mini-epifluoroscope to access deep tissue for calcium imaging.

Silver gave a historical overview about chemesthesis in Drosophila. Chemesthesis is the “other chemical sense” which often tends to be ignored. It is the stinging and burning sensation that wasabi elicits and is mediated through the Trp channels projecting to the trigeminal nerve.

What really caught our attention was the keynote talk delivered by Dr. Keith W. Kelley, Professor Emeritus of Immunophysiology, University of Illinois and Editor-in-Chief of Brain, Behavior and Immunity. He went down memory lane and talked about how his outlook towards medicine has changed in his four decades in academia. In the present day and age of amalgamation, globalization, systems biology, it is only right to consider a holistic approach to treating ailments instead of looking at a single disease picture. Kelley, although a trained immunologist, always believed that every ailment is in some way psychosomatic. He introduced us to the world of PsychoNeuroImmunology (PNI).

The posters presented by students and postdocs from universities all over North Carolina were both intriguing and thought provoking. Overall, this was a great meeting to attend. We got to learn a lot and also meet new colleagues and make new connections.

Publications

The following publications from the W. M. Keck Center for Behavioral Biology has appeared in print:


Riedl, C. A., Oster, S., Busto, M., Mackay, T. F. C. and Sokolowski, M. B. (2016) Natural variability in

**Of note…**

**Zach DeVries** was awarded the 2016 National Conference on Urban Entomology Ph.D. Scholarship ($1,500). He will present his research at the plenary session in Albuquerque (NM) in May. He also received first prize in the student competition of the Southeastern Branch meeting of the Entomological Society of America.

**Alex Ko** successfully defended his Ph.D. dissertation on nutritional ecology and insecticide resistance in the German cockroach.

**John Meitzen** presented a seminar at the Neuroscience and Behavior graduate program at the University of Massachusetts at Amherst.

**Sneha Mokashi** has been accepted in the Cold Spring Harbor Laboratory summer course on Drosophila Neurobiology: Genes, Circuits & Behavior.

**Grace Parker** received the best poster award at the W. M. Keck Center for Behavioral Biology 17th annual student/postdoc symposium.

**Stephanie Proano** has been accepted into SPINES, the Summer Program in Neuroscience, Ethics and Survival at the Molecular Biology Laboratory in Woods Hole (MA).

**Coby Schal** received NCSU’s College of Agriculture and Life Sciences Outstanding Adviser Award.

**Angela Sierras** and **Michael Fisher** were each awarded a $2,000 scholarship by Pi Chi Omega, the national fraternity of pest management professionals formed in 1950.

**Ayako Wada-Katsumata** and **Magdalena Sorger** received best presentation awards at the W. M. Keck Center for Behavioral Biology 17th annual student/postdoc symposium.

**The W. M. Keck Center for Behavioral Biology gratefully acknowledges generous sponsorship from BASF, Inc.**

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