The Signal

Monthly newsletter of the W. M. Keck Center for Behavioral Biology
at North Carolina State University
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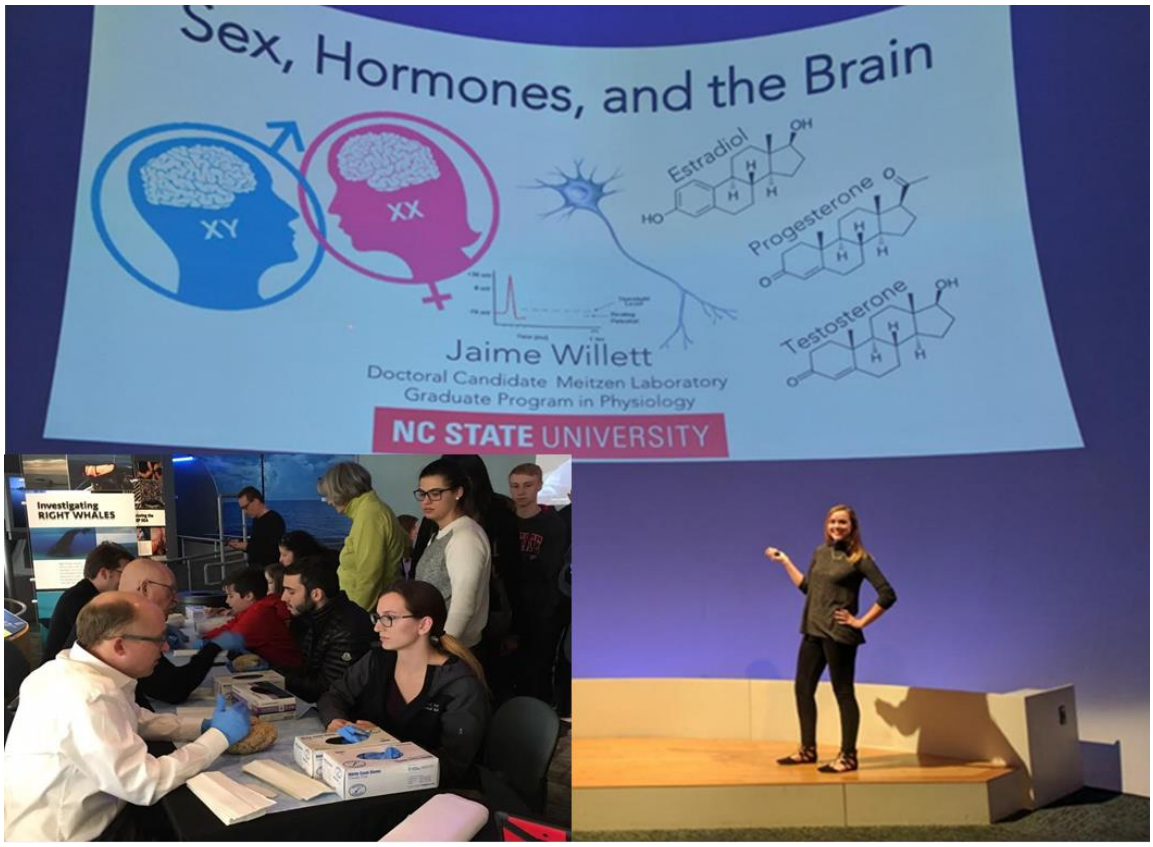
Brains Rock!

by John Meitzen



Jaime Willett gives a talk in the Daily Planet Theatre, while John Meitzen demonstrates a human brain

Brain & Behavior night 2017 was a complete success! On Thursday, March 16, 18 different organizations sponsored interactive exhibits, along with 4 student and post-doctoral scholar talks, and a special Science Café presentation by Dr. Jon Kaas from Vanderbilt University at the North Carolina Museum for Natural Sciences. Keck Center scientists were heavily involved in this event, showing the public everything from bed bug mating, to neuroanatomy, to action potential recording, the brain on love and fish dancing. One Keck Center laboratory even demonstrated electrical recordings from a potato! Attendance for this year was 349 people, up 5% from last year and the new record for all four years of the event. To put this into perspective, the typical attendance range for a Thursday night Science Café event at the Museum is between 70-150 people. So the extra effort matters. We are also very pleased that the event continues to appeal to a wide range of age groups and demographics, bringing together grandkids, millennials, boomers, and grandparents. Thanks to every single person who made this event possible, with extra kudos to this year's organizing committee, Drs. Scott Belcher, Lisa McGraw and John Meitzen, our coordinator, Megan Serr, our speakers, Dr. Hongmei Li-Byarlay, Dilara Sen, Caroline Johnson and Jaime Willett, and the Keck Center for sponsoring Dr. Jon Kaas.

Cue the Crickets: The Novel Trait of Silence

by Caroline Leitschuh

March 9th, 2017 might have been a normal day for those of us used to the 'winters' in North Carolina, but it certainly was out of the ordinary for Dr. Marlene Zuk! A professor in the Department of Ecology, Evolution, and Behavior at the University of Minnesota, she very much appreciated the balmy winter weather for her first visit to NCSU. She was also excited to put some faces to names – after all, her post-doc is one of our very own Keck Center alumni, Dr. Justa Heinen-Kay!

Zuk gave a seminar titled "Rapid Evolution in Silence: Adaptive Signal Loss in the Pacific Field Cricket." The room was full, and for good reason – her talk was excellent! She spoke about her research in sexual signaling, specifically auditory signals. Her study system involves two non-native species in Hawai'i – the Pacific field cricket *Teleogryllus oceanicus* and a parasitic fly, *Ormia ochracea. O. ochracea* depends on crickets for reproduction. Female flies listen for male crickets calling and use the calls to locate a male. Once the fly locates a cricket, she deposits a mobile, free-living larva onto the cricket, which burrows inside the host to develop. Seven to ten days later, the maggot emerges, killing the adult in the process.

Zuk has been studying this system since 1991, and has made some fascinating discoveries about co-evolution. These particular species of fly and cricket only co-occur on 3 islands in Hawai'i. One of the first things she did was to compare the song patterns between parasitized and unparasitized populations of crickets. She found that parasitized populations of crickets have song features that are unique from unparasitized populations of crickets, primarily that unparasitized populations have longer 'chirps', a trait that is preferred by female crickets. But female flies are also attracted to this characteristic, and male crickets from parasitized populations have modified songs to attempt to avoid being parasitized.

This research went on for years. Then something weird happened. The cricket population on one of the islands started declining, and in 2003, Zuk only heard a single male calling and could hardly find females. She thought that maybe the parasitism had finally taken its toll on the population. But when she returned in 2003, she saw tons of crickets! Except that they were silent. They were all over the sides of the road, but without a flashlight she would not have known they were there. What was going on?

It turns out that the males had acquired a mutation in their wings. Though they still made the wing movements required to create a song, their stridulatory apparatus, the part that makes the noise, had gone flat. They were morphologically unable to call, which means they cannot be targeted by the parasitic flies. So how do the females find a mate? It turns out that there are still some callers remaining. Through some field testing, Zuk found that both the silent males as well as females tend to gravitate towards callers, greatly increasing the crickets' chances of running into a member of the opposite sex. Crickets in these populations are also much less picky about their mates than crickets in unparasitized populations. Testing the behavioral changes in these populations is still ongoing. These discoveries provide a striking example of the interplay between natural and sexual selection.

Dr. Marlene Zuk

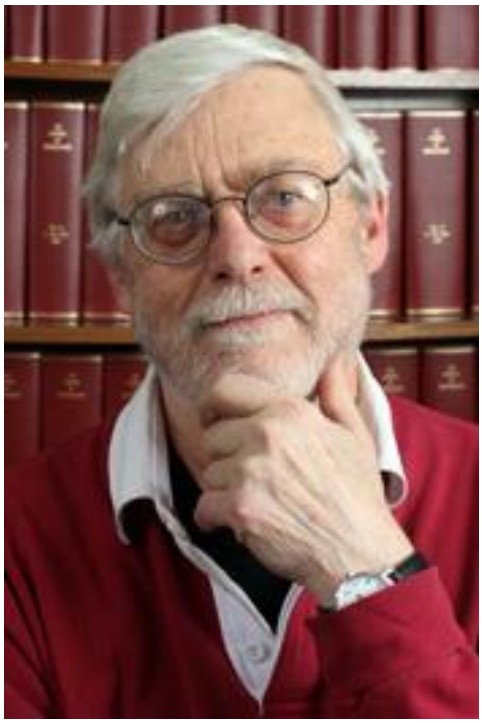
The flat-wing mutation has since appeared on a second island. Interestingly, genetic analysis shows that the flat-wing mutation in the two cricket populations arose independently. How do these novel traits get established, and how do they persist? The work of Zuk and her collaborators suggest that behavior is just as important as a genetic basis for the development of new traits. We are all looking forward to see what her research in the coming years will reveal!

The Evolution of Parietal-Frontal Networks for Specific Actions in Primates

by Shanshan Zhou

On March 16th, it was our great pleasure to have Dr. Jon Kaas from Vanderbilt University visiting the Keck Center and give a seminar on evolution of neuronal networks for movement in primates. Kaas is a pioneer in brain anatomy and neuroplasticity. His experiments of manipulating cortical representations by removing mouse whiskers, has been used as a classic example of neuroplasticity in neuroscience text books.

In 1917, Leyton and Sherrington published the first primate brain map showing that cortex areas form a strip that corresponds with movements of certain parts of the body. It was thought that production of movements is like playing a piano, where sequences of activation in different motor cortex areas that systematically represent the body can produce certain movements. However, throughout the years, scientists including Kaas himself, found more and more cortex regions involved with movement control. Current movement maps reveal a very complex pattern with many regions associated with the same movement scattered and intermixed with regions corresponding with different movements, forming a somatosensory mosaic mixture. So, why would the same movement need to be represented in multiple corresponding cortex areas? Are there any underlying rules for this seemingly random cortical organization?



Dr. Jon Kaas

Kaas and his colleagues started to tackle these questions by generating a "complete movement" map. Complete movement in contrast to initial movement, can be evoked by a long electrical stimulation that lasts for half second to give the experimental animal enough time to complete a complex movement. For example, stimulation of one region can evoke hand-to-mouth movement that involves closure of a hand into a grip, turning the hand toward the mouth, moving the hand to the mouth, opening the mouth and turning the head to align the mouth with the hand.

Kaas and his colleagues found that electrical stimulation of regions in posterior parietal cortex between visual cortex and somatosensory cortex reliably evoked defensive movements in monkeys, even in anesthetized animals. From there, they injected dye in each region and traced its neuronal connections with other parts of cortex. They found connections with small regions in motor cortex and premotor cortex. Stimulation of these regions will evoke the same defensive movement as stimulating the connecting module in the posterior parietal cortex. Using a cooling chip, they were able to knock down neuronal activity of a specific cortical region. Knocking out motor cortex modules eliminated defensive movements being evoked; however, knocking out posterior parietal cortex did not affect defensive movements being evoked form motor cortex. This suggests that motor cortex modules are required for animals to carry out the movement.

Why are modules that are associated with the same movement repeated three times, in premotor cortex, motor cortex and posterior parietal cortex? What is the function of the posterior parietal cortex? Kaas proposes that these three modules have different functions, and that together they integrate information from sensory cortex and other domains at different processing stages to make decisions for a particular action. For example, a monkey sees a threat that stimulates a forelimb reaching module in the posterior parietal cortex and which in turn stimulates both premotor and motor cortex; however, at the same time, the stimulation can be repressed by input from other movement domains, which themselves could be stimulated by different visual cues. So the random arrangement is not random after all. The three repeats form an information chain that allows animals to integrate sensory inputs to make decisions for action and multiple chains will then weave into an interacting network to modify and feedback on each other to direct complex sequential movements.

Finding Your Place: The Genetics of Habitat Use

by Erin Peterson

On March 17th, Emily Moore gave the defense talk for her dissertation, marking both a great personal occasion and a milestone for the Roberts lab, as she is the first student to complete her graduate degree work in this group. Her talk, entitled "Behavioral adaptation is associated with microhabitat divergence in Malawi cichlids," focused on the behavioral aspects of speciation in the evolutionary model, the African cichlid fish.

Moore began by explaining how different organisms have adapted both physically and behaviorally to their environments, and while large differences may stand out between more distantly related organisms, differences can also be found in those more closely related. Species can diverge due to physical barriers, known as allopatry, or in the same geographic area, sympatry, as is exemplified in the African cichlid fish system. These fishes inhabit the Great Lakes of Africa, Victoria, Tanganyika, and Malawi and the Lake Malawi cichlids have been of particular interest in many evolutionary and genetic studies, including study of vision, microbiome, sex determination, and behavior. They have particular power as the many different species allow for not only broad evolutionary studies across genera, but also detailed functional validations within single species.

This work was focused on how species-specific behaviors relate to habitat use and how this can drive speciation, with particular interest in the fine partitioning of habitat use. This can be seen in comparisons between fish that utilize the rocky habitats compared to those utilizing the more open, sandy regions alongside "interface" species, living in the intermediate zone between these discrete habitats. To begin dissecting species-specific behaviors, both aggression and exploratory behaviors were examined with a battery of tests and analyses of behavior, such as speed in an open field test and latency to approach novel objects. Moore showed association of behavior with specific genera. Upon further inspection, she also found behavioral association with habitat use in the lake.

Next, Moore explained the dissection of the genetic architecture of these traits through QTL mapping and comparative mapping efforts. Utilizing hybrid fish from two species that have different behavior and habitat use for QTL mapping, several preliminary loci were shown to be associated with open field behavior. Moore also made use of a previously published genome scan of many different species and showed associations of specific SNPs with microhabitat use that also segregated with the behavioral patterns she had previously characterized. One SNP with high association lies within a locus near three

Reade Roberts (left) and Emily Moore (right)

genes that are known to be expressed in the nervous system. While this SNP is not in a coding region, it is likely regulatory as it lies in a conserved element across many fish species and has sequence similarity to known transcription factor binding sites. Of particular interest, many of the predicted downstream targets have known neural functions. The different versions of the SNP also show putative expression differences with the nearby neuronal genes, CHL1, CNTN3, and CNTN4. These genes have known roles in neuronal patterning and axon guidance.

Further evidence linking this SNP to behavior was found in the literature, with a study in mice showing differences in behavior in an open field test when one of these genes, CHL1, was knocked out. This suggests that differential expression of this gene, regulated by the SNP Moore identified, has a definitive effect on behavior that is evolutionarily and ecologically relevant. With the use of a natural population, Moore was able to dissect the fine genetic architecture of behavior with potential for implication in speciation and her findings lay the groundwork for further studies of the genetic underpinnings of behavior and the role of behavior in speciation.

Seminars

On **April 21**, 8:30 am-5:00 pm, the W. M. Keck Center for Behavioral Biology hosts its annual graduate student/postdoc symposium. The symposium will be in 3503 Thomas Hall.

On **April 24**, 1:30 pm, Dr. Craig Montell from the Department of Molecular, Cellular and Developmental Biology at the University of California at Santa Barbara, will present a seminar, titled "Decoding the receptors controlling animal behavior in Drosophila." The seminar will be in 3503 Thomas Hall.

Publications

Moore, E. C. and Roberts, R. B. (2017) Genital morphology and allometry differ by species and sex in Malawi cichlid fishes. *Hydrobiologia* **791:**127-143.

Liu, H., Todd, E. V., Lokman, P. M., Lamm, M. S., Godwin, J. R. and Gemmell, N. J. (2017) Sexual plasticity: A fishy tale. *Mol. Reprod. Dev.* **84:**171-194.

Ren, Y., Ao, Y., O'Shea, T. M., Burda, J. E., Bernstein, A. M., Brumm, A. J., Muthusamy, N., Ghashghaei, H. T., Carmichael, S. T., Cheng, L. and Sofroniew, M. V. (2017) Ependymal cell contribution to scar formation after spinal cord injury is minimal, local and dependent on direct ependymal injury. *Sci. Rep.* **7:** 41122.

The W. M. Keck Center for Behavioral Biology gratefully acknowledges generous support from our corporate sponsors.

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Of note…

Catie Mason won the James Manner Award given by the Society for Analytical Chemists of Pittsburgh! This prestigious award was given at the undergraduate poster sessions at the PittCon Conference. Catie presented a poster on "Real-Time Measurement of Oxidative Stress and Dopamine in the Dyskinetic Rat During Chronic L-DOPA Treatment for Parkinson's Disease".

Carl Meunier received the Caitlin, Erin, and Jocelyn Muddiman Outstanding and Creative Research Award at the NCSU 18th Annual Chemistry Poster Session!

Erin Peterson received an Honorable Mention for her National Science Foundation Graduate Research Fellowship Proposal.

Reade Roberts presented a seminar on "Evolution across trophic levels: The gut, host-microbiota interactions, and beyond" at Texas A&M University. He also gave a talk at Universität Basel, Switzerland, on "Dietary adaptation and sex determination: Rapid evolution of fundamental traits in East African cichlids.

The **Roberts lab** participated in two outreach events at the North Carolina Museum of Natural Sciences, Darwin day with an exhibit titled "Fish Face Frenzy" and Brain Awareness Night with an exhibit titled "Dances with Fishes."

To contribute to The Signal, to be placed on our mailing list or for information about the W. M. Keck Center for Behavioral Biology, contact Dr. Robert Anholt, Department of Biological Sciences, Box 7614, North Carolina State University, Raleigh, NC 27695-7614, tel. (919) 515-1173, anholt@ncsu.edu.

Visit our website: http://keck.sciences.ncsu.edu

Symposium 2017

Announcement and Call for Abstracts

The Eighteenth Annual Student/Postdoc Symposium of the W. M. Keck Center for Behavioral Biology will be held on Friday, April 21, 2017, in the Stanley G. Stephens room, 3503 Thomas Hall, at North Carolina State University. Participation is open to all students, postdoctoral fellows and faculty, and is mandatory for students enrolled in the Concentration for Behavioral Biology.

Preliminary Program

8:30	Breakfast
9:15	Welcome by Dr. Robert Anholt, Center Director
9:30	Symposium
10:45	Coffee break and group photograph
11:15	Symposium
12:30	Lunch
1:30	Symposium
3:00	Break
3:30	Symposium
5:00	Reception

Presentations will be 12 minutes with 3 minutes for discussion. Participants should submit an abstract by e-mail to Andrea Vogel (arvogel@ncsu.edu) or Samantha Smith (sksmith4@ncsu.edu) no later than **April 7.** The abstract should contain no more than 300 words without figures or tables. It must provide a title and the name of the presenting author (without co-authors or affiliation).

Undergraduate students are invited to submit abstracts for poster presentations.

Trainees within their first year may present their future research objectives. Advanced trainees will present progress of their research. Computer-assisted projection and a PC-type laptop will be available for PowerPoint presentations. All presentations must be rehearsed with the mentor.

Breakfast, lunch and a reception with hors d'oeuvres will be provided.