

The Signal

Monthly newsletter of the W. M. Keck Center for Behavioral Biology
at North Carolina State University
March, 2014, vol. 15, no. 7.

Students and Postdocs Shine at the 15th Annual Keck Center Symposium



Participants in the 15th Annual Student-Postdoc Symposium of the W. M. Keck Center for Behavioral Biology.

First row (from left to right): Elizabeth Russell, Alex Weitzel, Emily Moore, Sarah Keesom, Megan Garlapow, Andrea Vogel, Megan Thoemmes, Terry Campbell. Second row (from left to right): Sean Giery, Jeremy Heath, Lingjiao Qi, Beth Dumont, Katherine Myers-Knudsen, Rachel Hanauer, Christopher Anderson, Crystal Tabor. Third row (from left to right): Colin Funaro, Michael Simone-Finstrom, Thoams Jackson, John Shorter, Xiaohu "Tiger" Xie, Megan Serr, Melissa Slane, Jaqueline Fitzgerald, Allison Nolker, Gabriel Zilnik. Not pictured: Alex Ko and Kirsty Ward.

Photo by Shanshan Zhou.

The 15th Annual Student and Postdoc Symposium of the W. M. Keck Center for Behavioral Biology displayed an impressive diversity of research activities encompassing a wide range of model organisms and ranging from cellular to population levels with perspectives spanning and integrating genetics, ecology and neurobiology. This year's symposium featured 19 oral presentations from students and postdocs of the Keck Center, two talks from students from the Center for Integrative Study of Animal Behavior at Indiana University in Bloomington, our longstanding student exchange partner, and five poster presentations by undergraduate students. All presentations were of high

quality, both in terms of scientific content and delivery, making the assignments of awards especially difficult. Katherine Myers-Knudsen received an honorary mention as runner-up for the best talk award, John Shorter won the award for best oral presentation and Kirsty Ward received the prize for best poster. Congratulations to everyone for yet another excellent event. Gabriel Zilnik and Allison Nolker deserve special recognition for preparing and designing the symposium program. A detailed account of the symposium by Jennifer Baltzegar and Kate Coyle is on page 2 and 3 of this issue of *The Signal*.

Vignets from the 15th Annual Student Postdoc Symposium

by Jennifer Baltzegar and Kate Coyle

The 15th Annual Student and Postdoctoral Symposium presented by the W.M. Keck Center for Behavioral Biology was held on February 21, 2014. This year offered an incredibly diverse range of topics from mites that live on people's faces to the ethics of using recombinant DNA technology to the role that the kisspeptin2 system plays in sex change of coral reef fish. The symposium was opened by Dr. Robert Anholt who encouraged students to apply for available grants offered by the Keck Center. Then the talks began.

Emily Moore presented first by showing her most recent data on the behavioral diversity in African cichlid fishes. She is currently perfecting behavioral assays used in these fishes to measure open field behavior and exploratory behavior of novel objects and expanding the phenotypes she will use for a genetic mapping project to assess the genetic basis of anxiety and boldness.

Lingjiao Qi followed Emily's talk with a fascinating use of fast scan cyclic voltammetry using carbon-fiber microelectrodes to assess the effects of l-DOPA in a Parkinson's disease rat model. She found that the rat model shows an impaired motivation for natural rewards, which may lead to advances in Parkinson's Disease research.

Next, Jeremy Heath discussed the dual role of male moth courtship pheromones. He illustrated the conflict between sexual selection and natural selection. He also told us about the evidence he has gathered to support the hypothesis that pheromone production of *Heliothis virescens* is under de-stabilizing selection.

Melissa Slane followed with her talk on the role that the hypothalamic kisspeptin2 system plays in socially induced sex change in coral reef fish. Kisspeptin2 and gonadotropin-releasing hormone interact and are hypothesized to be involved in the socially induced sex changing behavior observed in the bluehead wrasse.

Colin Funaro spoke in depth about queen recognition in termites. He showed a video of stereotypical shaking behavior that termites exhibit around reproductively active individuals in the colony. In addition to this interesting behavior, Funaro also updated us on his work involving cuticular compounds associated with queen recognition.

Sarah Keesom from Indiana University gave the first talk of the second session. Using carbon fiber voltammetry techniques she presented data on how serotonin levels change in the auditory midbrain region of socially naïve male mice when paired with females.

Andrea Vogel followed with a presentation on the variation observed in pair-bond formation in the prairie

vole. She showed videos of stereotypical prairie vole behavior collected during alloparental care and resident intruder behavioral assays. Then she showed data, which illustrate the amount of behavioral variation seen in the species, and discussed the potential for investigating the genetic architecture that underlies pair bonding.

The next speaker was Megan Serr who presented an overview of her plan of work to study the invasive mouse crisis in the Farallon Islands. She plans to examine mate choice among several different mouse strains, including wild-caught mice from the Farallon Islands in an effort to determine the feasibility of using transgenic mouse lines as an eradication tool for pest mice.

Christopher Anderson described the research he has been conducting on the Bahamas mosquitofish. Female genital morphology of the Bahamas mosquitofish is divergent across predation regimes with more closely related species diverging more quickly than distantly related species. In addition, he presented evidence that male and female genital morphology are coevolving.

Rachel Hanauer, who was visiting from Indiana University, gave the last talk before lunch. She spoke about the effects of disturbances on corticosterone production and infection rates in urban and sub-urban populations of the songbird, dark-eyed junco. Hanauer found that there are no differences between corticosterone hormone levels in frequently disturbed juncos versus the control group, but that there were other physiological differences, such as mass loss in the experimental group.

After lunch, the afternoon talks started with Katherine Myers presenting a new genetic tool for agricultural pest management. She described the economic problem posed by the invasion of the spotted wing *Drosophila*, *D. suzukii*, which has unique serrated ovipositors, allowing the species to feed on fresh fruit and causing considerable economic damage. She is working to develop a tetracycline-dependent female lethal system in order to develop a line of male-only flies that can penetrate the wild population and control or eradicate it.

Next, John Shorter talked about his studies on pathways and mechanisms involved in aggression, which are conserved across species and are important for maintaining social structure. He phenotyped the aggressive actions of starved male flies and used the *Drosophila melanogaster* Genetic Reference Panel, a collection of 205 inbred wild-derived fly lines with sequenced genomes, to perform a genome-wide

association study in search of genes associated with aggression. He presented evidence for epistatic interactions between candidate genes, and he plans to continue work to functionally validate these candidates.

Beth Dumont spoke about an unanswered fundamental question in the mechanism of recombination: What is the meiotic requirement for recombination? In order to answer this question, she has begun to analyze previously published recombination maps as well as to employ cytogenetic methods for *in situ* imaging of crossover events. Thus far, her work appears to support two prevailing opinions in the field, one that assumes that some taxa require one crossover per chromosome and another advocating one crossover per chromosome arm.

Sean Giery gave a talk describing his work to disentangle the complex social behavior of the Bahamas mosquitofish, *Gambusia hubbsi*. He used natural populations that differed in level of predation to study the effects of ecological costs on communication system evolution. In populations with high predation, fin coloration strongly predicted body condition, but this link did not exist in populations without predators.

Michael Simone-Finstrom spoke about social and individual immune defense mechanisms in honey bees. He was interested in determining how colonies invested in different defenses. He found a positive correlation between colony-level hygienic behavior and larval immune response.

After the coffee break, Gabe Zilnik presented an interesting ethical framework with which to make decisions in science, centered around principles of Stewardship, Justice, Animal Welfare, and Precaution. He then applied this framework to the question of whether genetically modified mosquitos should be used to control the spread of dengue fever. Ultimately, the answer depends upon what control strategy is used and further testing may be required to first ensure the safety of use.

Xiaohu “Tiger” Xie described the neural mechanisms of visual stimulus-conditioned behavior. After training Sprague Dawley rats to press a lever and receive a visual stimulus, he proceeded to test the effects of microinjections of various receptor agonists on this behavior. His results suggest that particular receptors play a synergistic role in modulation of a cell signaling pathway that is likely critical for motivation for a visual stimulus.

Megan Garlapow presented her research on the quantitative genetics of food intake. She performed a genome-wide association study, using the *Drosophila melanogaster* Genetic Reference Panel in order to identify factors associated with variation in food intake across different lines of *D. melanogaster*. She also looked at the coefficient of environmental variation to find factors associated with variation within individual

lines. In the future, she will work to functionally validate candidate genes identified in this study.

Megan Thoemmes gave a talk about her work investigating *Demodex* mites, which live on most, if not all, mammalian species, including humans. She presented her work thus far in elucidating the genetic diversity and evolutionary history of two species of mite known to live on humans. Her results suggest that the amount of genetic diversity observed may warrant recognition of a third, previously undescribed *Demodex* species. Allison Nolker talked about the response of mockingbird (*Mimus polyglottos*) vocalizations to anthropogenic change. She has been comparing recordings of mockingbird songs recorded in the early 1980s in Greensboro, NC, to recordings taken in the same locations in 2013. She hypothesized that as the city of Greensboro grew, the mockingbirds needed to adapt to sing at higher frequencies in order to compensate for the increased city noise. Her preliminary data are consistent with her hypothesis.

Lastly, Alex Ko presented his research on optimizing bait to attract German cockroaches. He tested baits of different nutritional qualities on cockroaches that had been feeding on different diets. He found that in particular, high-protein diets seemed to nutritionally stress the roaches, resulting in increased bait performance.

This year’s Keck Center symposium showcased the enormous breadth of research activities conducted by students and postdocs of the Keck Center. On to the next symposium in 2015!

Announcing the Vandenberg Travel Awards

A generous donation by John and Barbara Vandenberg has established the Vandenberg Travel Awards. These awards are intended to help enable students or postdocs to attend specialized summer courses or workshops. Students and postdocs from Keck Center affiliated laboratories may apply.

To apply for a Vandenberg Travel Award, submit a request with the location, dates and title of the course/workshop, a one paragraph description of current research activities, and a one paragraph statement of how participation in the course/workshop will enhance the research program or contribute to career advancement. A separate statement of the mentor should be provided that indicates the availability of additional funds to enable attendance of the course or workshop and explains how participation would benefit career development of the trainee.

Applications should be sent by e-mail Dr. Robert Anholt (anholt@ncsu.edu) and will be evaluated by the Executive Committee of the Keck Center.

Alcohol and the Nervous System Gordon Research Conference

by Tatiana Morozova



The Hotel Galvez, Galveston, Texas

The 1st Alcohol and the Nervous System Gordon Research Conference was held in the Hotel Galvez. It is a historic hotel located in Galveston, Texas, that opened in 1911. American Presidents Franklin D. Roosevelt, Dwight D. Eisenhower, and Lyndon B. Johnson stayed at the Galvez, as did other notable names including Jimmy Stewart, Frank Sinatra, and Howard Hughes.

The conference was very well attended with more than 170 participants with half of them being young investigators including graduate students. The idea of all Gordon conferences is to bring together young scientist with more senior and well established ones, to discuss their current research and build informal networks and future collaborations.

The program started with a keynote lecture by Dr. George Koob who was recently selected as Director of the National Institute on Alcohol Abuse and Alcoholism (NIAAA). He gave us an overview of the neurobiology of alcoholism and addiction, emphasizing



Tatiana Morozova

that an understanding of addiction will lead to understanding recovery mechanisms. He finished with the question that each of us should ask while planning and performing experiments: “What do you know, now that you know that?”

With this question in our minds we had four days filled with a broad range of alcohol-related studies at the genetic, molecular, cellular, circuit/systems and

behavioral levels with an emphasis on presentation of unpublished data that ensured the newest and most exciting developments in the field were discussed. There were a lot of presentations covering different aspects of neuropharmacology, neurophysiology, optogenetics, behavioral pharmacology, clinical studies and human neuroimaging. Varieties of model organisms for alcohol research were presented, including yeast, nematode, fruit flies, mice, rodents and primates, with rodent model being among the most popular. There was ample of time built in for formal and informal discussions after each plenary session, with students and young investigators having priority for asking questions. Poster presentations took place on each day of the conference allowing for more interactions. In addition we had an opportunity to interact and exchange ideas during informal breakfasts, lunches and dinners.

There were two plenary sections of particular interest to me: “The genetic basis of alcohol’s neural actions” and “Translational/human studies”. Igor Ponomarev from the University of Texas at Austin told us about signatures of excessive alcohol consumption. His research is focusing on examining gene expression profiles in human brain and animal models using microarrays and next generation sequencing, building computationally-predicted networks of candidate genes and validating the most promising targets using combinations of approaches. He introduced to us the INIA Texas gene expression database (IT-GED) that was created to identify specific clusters of genes whose expression is regulated by alcohol. The database is still under construction and consists of only few gene expression studies on mice, rats and humans. Researchers intend to expand it further and add additional datasets. This database has a lot of potential since it contains a “plug and play” search engine with which one can perform multiple gene analysis, look for most-connected genes or do reverse network analysis by entering one’s favorite gene to find all genes that were significantly co-expressed with this gene.

David Goldman from NIAAA in Bethesda, MD, presented his study on exon-focused sequencing on fourteen genes involved in dopamine or serotonin function of impulsive individuals from a Finnish population. A stop codon in the *serotonin receptor 2B* (*HTR2B*) gene was identified that is exclusive to the Finnish population and blocks expression of the 5-HT_{2B} receptor protein. In addition, severe developmental problems were observed in *Htr2b* knockout mice, including increased impulsivity and responsiveness in an open field novelty test. The study by Goldman and colleagues shows the potential for identifying effects of rare alleles on complex behavioral phenotypes, and availability of model systems offer an opportunity to validate orthologous alleles in controlled genetic and environmental

backgrounds. Furthermore, in a separate study, Goldman and colleagues, by combining genomic sequencing, linkage analysis and functional validation, were able to identify genetic variation of the *Grm2* gene, which encodes the metabotropic glutamate receptor 2 (mGluR2) and is associated with increased alcohol consumption and preference in animal models. They speculated that the mGluR2 receptor can be a potential drug target for pharmacotherapies of excessive alcohol use.

Kathleen Grant from Oregon Health and Science University shared with us here success in creating a primate animal model for alcohol dependence. She and her colleague’s use the self-administration procedure of alcohol as a model of human alcohol drinking, trying to understand factors that allow some individuals to drink to the point of alcohol dependence. They allow each monkey to establish its own pattern of alcohol consumption, or water and food. Patterns of drinking displayed by the monkeys reveal aspects of human alcohol consumption ranging from low volume avoiding intoxication, or high volumes resulted in rapid intoxication. They also see occasional three- or four-day sprees of very heavy drinking, voluntary periods of abstinence, morning tremors, and relapses to heavy drinking after imposed periods of abstinence. The self-administration procedure allows for analysis of time course and *in vivo* imaging of brain adaptations to chronic alcohol consumption. Grant and colleagues established that age at onset of access to alcohol, but not initial intake, was associated with future escalation of ethanol self-administration. In addition, escalation of intake was observed in nearly all monkeys that began drinking during late adolescence, but not in a few monkeys that began drinking as young or middle-aged adults, suggesting a critical period for escalation of ethanol intake.

Rajita Sinha from Yale University presented her research on stress and addiction. She showed that stress increases drug craving in addicted individuals relative to controls. Stress was the trigger for heavy drinking. The shift from moderate consumption to drug craving with increased levels of drug use was also associated with changes in brain regions, including prefrontal cortex and ventral striatum. Changes in ventromedial prefrontal cortex/anterior cingulate cortex predicted alcohol craving, time to relapse and relapse severity, suggesting that this region may be further developed as a neural marker for alcohol relapse risk.

Overall, I was impressed with the diversity of the talks and variety of cutting-edge techniques primarily used on rodent models, and the unique networking opportunity that quite often is missing at large conferences. I also had a chance to see dolphins, enjoy bicycle rides along the beach, and feel the spirit of the approaching Mardi Gras festival in Galveston. I look forward to the next Gordon Conference in 2016!

Seminars

On **March 13**, 3:30 pm, Dr. Larry W. Swanson from the Department of Biological Sciences and Sections of Neurology and Psychology at the University of Southern California will present a seminar, titled “Development and adult connectomics of cerebral cortex.”

The seminar will be in 101 David Clark Laboratories.

On the occasion of Brain Awareness Week, Dr. Swanson will also deliver a Science Cafe presentation for the public titled “What is President Obama’s BRAIN Initiative all about?”

This event will be held on **March 13** at 7:00 pm in the North Carolina Museum of Natural Sciences Daily Planet Café.

On **March 27**, 3:30 pm, Dr. Michael J. Ryan from the Department of Integrative Biology at the University of Texas at Austin will present a seminar, titled “Sexual selection and the brain: cognitive aspects of mate choice in tungara frogs.”

The seminar will be in 101 David Clark Laboratories.

On **April 14**, 4:30 pm, Dr. Iain D. Couzin from the Department of Ecology and Evolutionary Biology at Princeton University will deliver the Kwangil Koh Lecture on Mathematics in Our Time, titled “From democratic consensus to cannibalistic hordes: the principles of collective behavior.”

The lecture is co-sponsored by the Keck Center and will be preceded by a reception from 4:00-4:30 pm in the SAS Hall second floor lobby.

The seminar will be held in SAS Hall 2203.

On **April 15**, 1:30 pm, Dr. Iain D. Couzin from the Department of Ecology and Evolutionary Biology at Princeton University will present a seminar, titled “Will it spread or not? Predicting behavioral contagion on real-world complex networks.”

The seminar will be held in 3503 Thomas Hall.

Publications

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

Hunt, J. H. (2014) The Spirit of the Hive by Robert E Page Jr. *Reports of the National Center for Science Education* **34**: 1.

Roberts, J. G., Toups, J. V., Eyualem, E., McCarty, G. S. and Sombers, L. A. (2013) *In situ* electrode calibration strategy for voltammetric measurements *in vivo*. *Anal. Chem.* **85**:11568-11575.

Phillippi, J., Xie, Y., Miller, D. R., Bell, T. A., Zhang, Z., Lenarcic, A. B., Aylor, D. L., Krovi, S. H., Threadgill, D. W., Pardo-Manuel de Villena, F., Wang, W., Valdar, W. and Frelinger, J. A. (2014) Using the emerging Collaborative Cross to probe the immune system. *Genes and Immunity* **15**: 38-46.

Mackay, T. F. C. (2014) Epistasis and quantitative traits: using model organisms to study gene-gene interactions. *Nat. Rev. Genet.* **5**: 22-33.

Romero, A. and Schal, C. (2014) Blood constituents as phagostimulants for the bed bug *Cimex lectularius* *L. J. Exp. Biol.* **217**: 552-557.

Groot, A. T., Schöfl, G., Inglis, O., Donnerhacke, S., Classen, A., Schmalz, A., Santangelo, R. G., Emerson, J., Gould, F., Schal, C. and Heckel, D. G. (2014) Within-population variability in a moth sex pheromone blend: genetic basis and behavioural consequences. *Proc. Biol. Sci.* **281**: 20133054.

Of note...

Robert Anholt and **Trudy Mackay** participated in the Epistasis Detection in Genetics and Epidemiology (EDGE) workshop in Key West, FL. Trudy Mackay delivered a plenary talk at the conference.

Kate Coyle and **Emily Moore** gave outreach talks to the public for Darwin Day at the North Carolina Museum of Natural History Nature Research Center. Kate presented “got milk?” using the story of lactase persistence in humans to explain dietary adaptation and human evolution. Emily presented “Studying the Evolution of Behaviors”, describing how genetic mapping can be used to understand behavioral differences between species.

Fred Gould works on two National Research Council committees, the Board on Agriculture and Natural Resources and Public Interfaces in the Life Sciences which deals with science communication at varying levels. He also participated in a Gates Foundation funded workshop on New Vector Control Tools for Dengue Prevention.

Lisa McGraw participated in the Genes and Behavior Gordon Research Conference in Galveston, TX. She also gave a seminar in the Department of Neuroscience at Carleton University in Ottawa, ON (Canada).

John Meitzen presented a seminar entitled “Sex differences in striatal neurons” to the Behavioral Neuroscience Program in the Department of Psychology at the University of North Carolina at Chapel Hill. He also gave a talk at the 47th Winter Conference on Brain Research, Steamboat Springs, CO.

Tatiana Morozova presented a poster at the Gordon Research Conference on Alcohol and the Nervous System in Galveston, TX.

James Roberts, Andy Schmidt, Edwin Mitchell and **Lingjiao Qi** participated in the College of Sciences access day.

Heather Patisaul and **Leslie Sombers** served on the Chancellor's Discussion Panel on Interdisciplinary Research.

Leslie Sombers and colleagues gave a presentation at the 47th Winter Conference on Brain Research, Steamboat Springs, CO, on "Monitoring real-time enkephalin dynamics and modulatory effects in brain tissue." She also gave lectures at the State University of New York at Buffalo, at Florida State University and at the University of Pittsburgh.

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 7617, North Carolina State University, Raleigh, NC 27695-7617, tel. (919) 515-1173, anholt@ncsu.edu.

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

