The Signal

Monthly newsletter of the W. M. Keck Center for Behavioral Biology
at North Carolina State University
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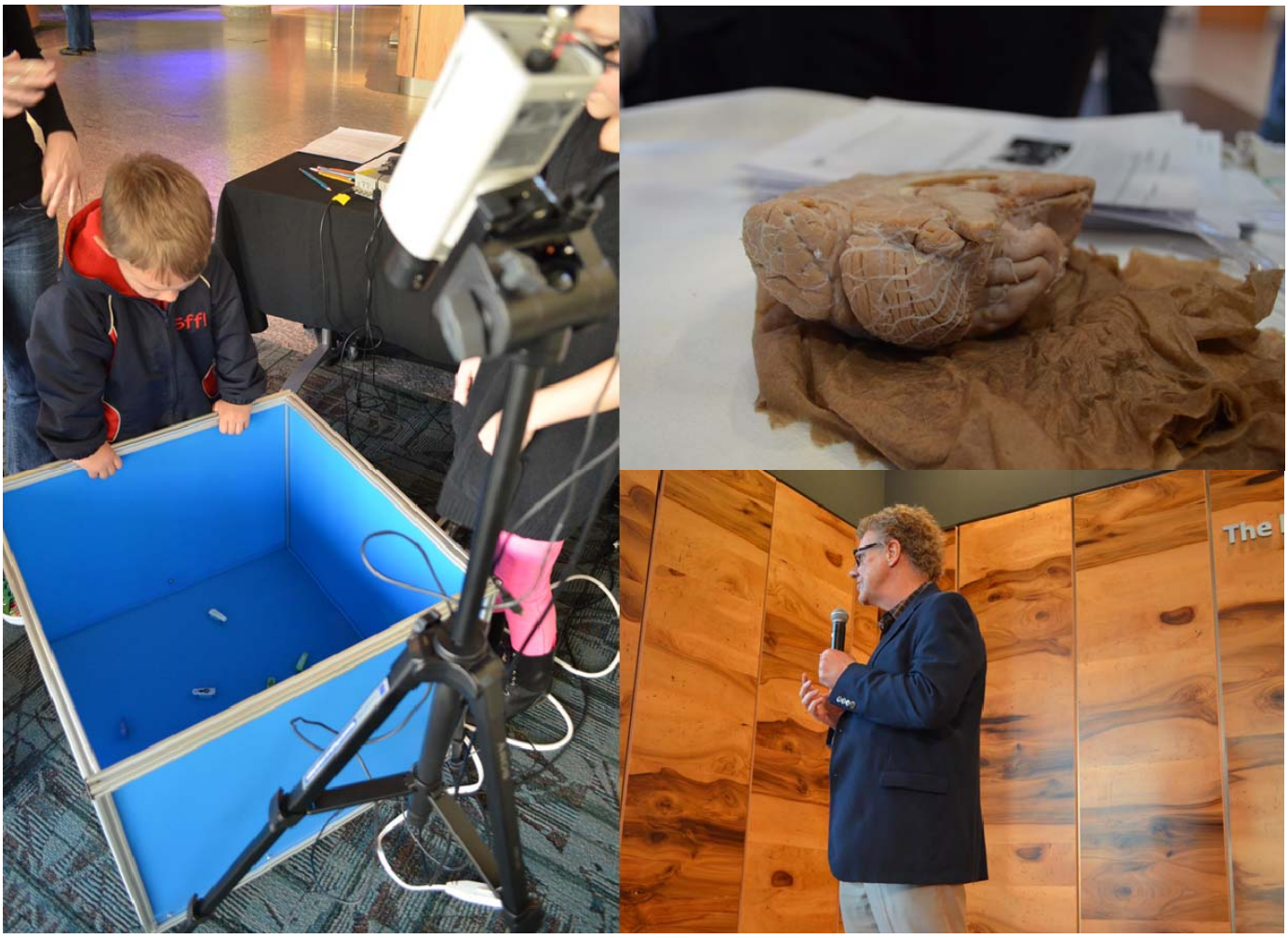
Keck Center Scientists Reach Out During Brain Awareness Week



Left: a child watches behavior tracking; top right: a human brain on display; bottom right: keynote speaker Dr. Larry Swanson discusses neuroscience with the public at the Museum's Daily Planet Café. (photos by Ariana Loghin).

The W. M. Keck Center for Behavioral Biology organized a neuroscience-filled event to celebrate Brain Awareness Week at the North Carolina Museum for Natural Sciences. Keck Center faculty and students presented demonstrations and short talks to highlight the remarkable potential of the human brain. This successful event was attended by more than 200 children and adults. Keynote speaker, Dr. Larry Swanson, lectured in the jampacked museum's Daily Planet Café on President Obama's BRAIN initiative and neuroscience research in general engaging the audience in a lively questions and answers discussion. Special thanks for making this event memorable are due to Lisa McGraw, John Godwin, Heather Patisaul, John Meitzen, Leslie Sombers, Antonio Planchart, Carolyn Mattingly, Troy Ghashghaei, Megan Serr, Alana Sullivan, Melissa Slane, and Ryan Wong. A report of the Brain Awareness Week event by Lingjiao Qi appears on page 2 of this issue.

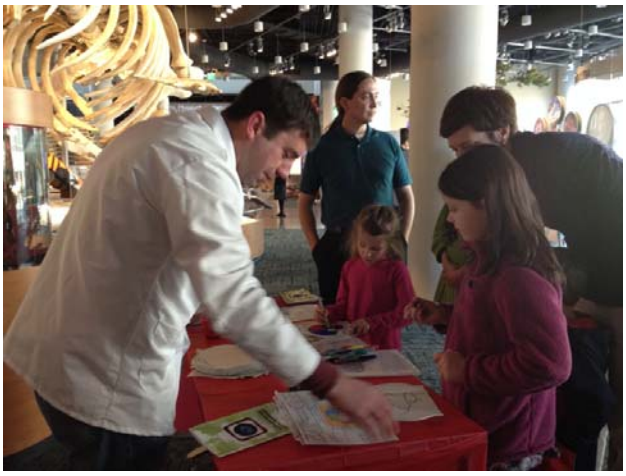
Brain Awareness Week Celebrated at the North Carolina Museum of Natural Science

by Lingjiao Qi

Brain Awareness Week is a nationwide effort to increase public awareness of the progress and benefits of brain research. March 10-16 was the Brain Awareness Week for the year 2014. On Thursday, March 13th, several neuroscience groups from the W.M. Keck Center worked together effectively and organized a successful outreach event in the North Carolina Museum of Natural Sciences in Raleigh, aiming at bringing the public's attention to ongoing brain science, helping them explore the wonders of the brain, and celebrating the brain for people of all ages.

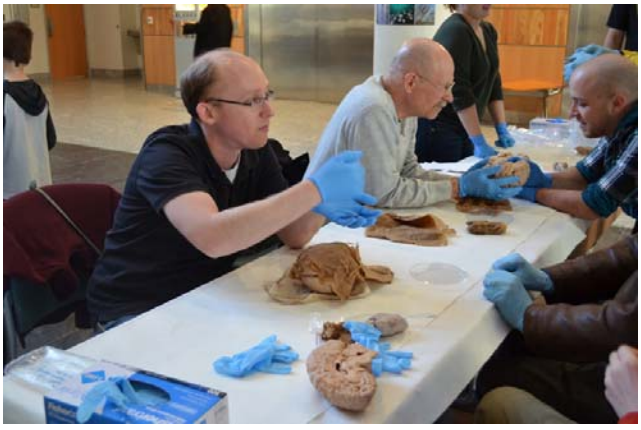
There were more than 8 neuroscience labs from different departments of North Carolina State University that participated in the museum event. The participants included faculty members, postdoctoral scholars, graduate students, and undergraduate students. The events included 7 exhibitions and more than 15 brain-related activities, which displayed the diverse aspects of brain research at NCSU, and demonstrated how the brain controls our behavior. For example, the public was given the opportunity to touch a real human brain to help better understand structure-function relationship in the nervous system.

The museum events were followed by a special lecture entitled "What is President Obama's Brain Initiative All About" by esteemed speaker, Dr. Larry W. Swanson, at the Daily Planet Café of the North Carolina Museum of Natural Sciences. Swanson is Appleman Professor of Biological Sciences at the University of Southern California in Los Angeles. His research focuses on the parts of the brain controlling motivation and emotion. Swanson first introduced President Obama's announcement of the BRAIN Initiative (Brain Research Through Advancing Innovative Neurotechnologies). He mentioned that he was invited to the White House when President Obama made this exciting announcement. During his lecture, he discussed his thoughts on this initiative and explained the urgency of this project. Swanson also talked about how our brain works, and emphasized how neuroscience research will advance medical research. "What is the best thing of the 21st century in life science? last century it was DNA, this time it is thebrain," Dr. Swanson said. Swanson also shared his personal experiences about how he became a neuroscientist, and offered career advice for young people. "Young people, you need to go to different labs, expose yourselves to different research, check if you like the type of research before you set your mind to be a neuroscientist as your career", according to Swanson.



James Robert, from Leslie Sombers lab, was explaining different regions of the brain to kids.

Overall, these outreach events for Brain Awareness Week showcased the diverse ongoing brain research conducted by neuroscientists from the Keck center at NCSU. The public had a great opportunity to learn how our brain controls our behavior, and were truly impressed by the fantastic exhibitions. Additionally, it was a great experience for the researchers to use their love and passion for neuroscience research to educate people and bring attention to neuroscience research. Given the ongoing exciting new research findings, it seems apparent why President Obama called his BRAIN initiative "the next great American project". On to the next "Brain Awareness Week" in 2015!



John Meitzen showing a real human brain

Using Brain Connectomics to Understand Behavior

by Melissa Slane

On March 13, 2014 during Brain Awareness Week, the W.M. Keck Center for Behavioral Biology had the great pleasure of hosting prominent neuroscientist Dr. Larry Swanson from the University of Southern California. Among many other distinctions, Dr. Swanson is the Milo Don and Lucille Appleman Professor of Biological Sciences, member of the National Academy of Sciences, and former president of the Society for Neuroscience. We were delighted to have Dr. Swanson back in North Carolina, his birthplace and home during his first few weeks of life. His presentation "Development and adult connectomics of cerebral cortex" highlighted projects from his truly prolific research career.

Swanson began his neuroscience career in graduate school, researching an area of the medial hypothalamus involved in feeding and drinking behaviors, later discovered to be the paraventricular nucleus (PVN). When Swanson joined the lab of L.G. Sharpe at Washington University in St. Louis, the lab was studying the effects of neurotransmitters on feeding and drinking behaviors in rats: acetylcholine injected into the PVN elicited drinking behaviors, while norepinephrine injected into the same region provoked feeding behaviors. As Swanson watched as the rats' behaviors changed after each chemical was injected, he became hooked.

Swanson started investigating the neurocircuitry involved in feeding and drinking behaviors. He used anterograde and retrograde labelling approaches, in combination with other histological techniques, to determine where PVN neurons project to and from what areas of the brain PVN neurons receive axonal projections. He was able to uncover a number of regions in the central nervous system (CNS) that communicate with the PVN to regulate feeding and drinking behaviors, including 1) the arcuate nucleus of the hypothalamus, which detects leptin levels to help control feeding, 2) the subfornical organ, which detects circulating angiotensin II levels to regulate drinking, 3) the nucleus tractus solitarius, which relays information about dryness of the throat to modulate drinking behavior, and 4) parts of the cerebral cortex that process higher level information, such as where food and water sources may be located.

These early studies examining the neurocircuitries that regulate feeding and drinking behaviors helped inspire him to develop the rat CNS connectome project. This remarkable project investigates the wiring of the entire CNS in order to better understand how neurocircuits regulate behaviors. Swanson compares

Dr. Larry Swanson

the connectome to the genome: just as a genome is necessary to understand gene function, a connectome is necessary to understand behaviors.

Swanson and his former graduate student, Mihail Bota (Associate Professor at the University of Southern California), began this project by gathering mapping data of all macroconnections (axonal connections between gray matter regions) entering and leaving the cerebral cortex in the rat brain. They separated the cerebral cortex into 73 histologically-defined gray matter regions. After extracting thousands of connection reports from roughly 375 sources, Swanson's team assembled a 73x73 matrix, with each cell in the matrix containing information about the strength of the macroconnection between two regions, the types of chemicals and receptors produced in the neurons, and the types of neurons in these regions. Thus far, they have data on 1831 macroconnections in the matrix. Each brain region, or node, on average possesses 33 connections, or edges. This cerebral cortex connectome and other connectomes of the rat brain are in progress (currently, 81% of cells in the 73x73 cerebral cortex matrix contain data), but updates are continuously added to the Brain Architecture Knowledge Management System. The website is BAMS; http://brancusi.usc.edu/bkms.

To more deeply understand these connections in the cerebral cortex, Swanson and his former post-doc, Olaf

Sporns (Provost Professor at Indiana University), took a neuroinformatics approach to analyze their connectome data. Using clustering algorithms, they found that the cerebral cortex connectome clusters into four non-redundant "modules" containing different brain regions that are highly interconnected within their own module. Each module is anatomically separate, but contiguous with the other modules. Intriguingly, at the borders of these modules lie highly interconnected regions of the brain, such as the entorhinal hippocampal area, where, as Swanson noted, Alzheimer's disease begins.

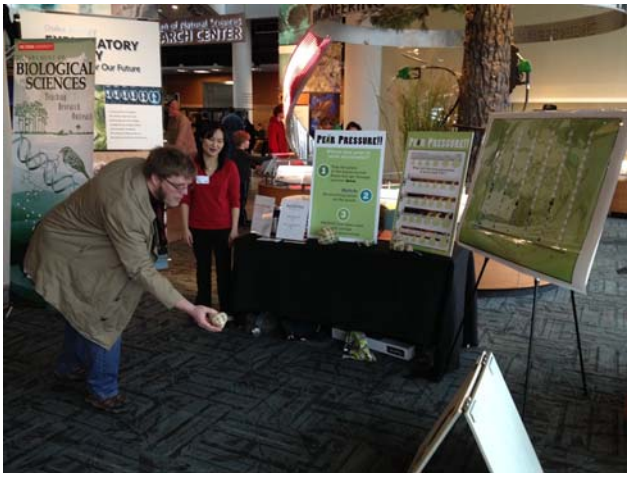
This monumental effort by Swanson and his research team to map all connections and characteristics of these connections in the rat brain will be invaluable for understanding neurobiological control of behaviors and cognitive functions. Normal or wild type connectomes could be used to investigate such important questions as how internal and external environmental factors during development affect neuronal connections and behaviors, whether faulty wiring during development causes certain disease states, how genes affect the strength and types of connections between brain regions, and whether connectomic differences among species account for behavioral differences. Last April President Obama announced the BRAIN Initiative to map neuronal connections and interactions in the human brain (http://www.whitehouse.gov/share/brain-initiative). The NIH, NSF, and DARPA have each contributed tens of millions of dollars to this project. Clearly, both the science community and general public understand the enormous value in mapping our most precious, complex organ.

Evolution in Action

by Holly Menninger

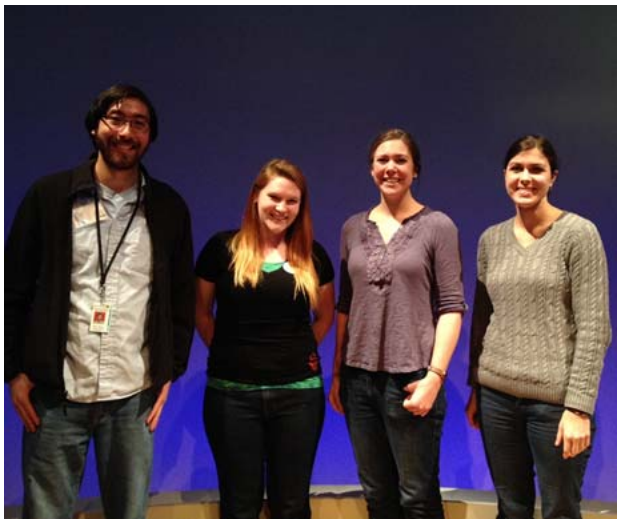
Step right up! On Saturday, February 15, a team of enthusiastic biologists from NC State encouraged visitors young and old attending Darwin Day festivities at the North Carolina Museum of Natural Sciences to participate in a beanbag toss game. But this was not your typical beanbag toss.

Rather than square shaped bags of identical sizes, visitors were given pear-shaped beanbags of 6 different sizes (ranging from the size of a lime to the size of a small cantaloupe) and were instructed to toss the "pears" through a pear-shaped hole. Players were informed that only "pears" passing through the hole would live on to contribute pears to the next generation. After each turn, players added their data, the successful pear sizes, to a real-time bar graph and were asked to make predictions about what we might expect the next generation to look like. The goal of the game, cleverly named Pear Pressure and designed by Dr. Jennifer Landin, was to demonstrate the process of natural selection, a key mechanism in evolution. "People of all ages really enjoyed playing Pear Pressure," said Landin. "And they got it. They walked away with a better idea of how evolution works."



A young Charles Darwin (played by science historian, Paul Brinkman), under watchful eye of Alice Lee, plays the Pear Pressure game.

Pear Pressure was not the only activity sponsored by the Department of Biological Sciences at the Museum's annual Darwin Day event. Four graduate students stepped into the spotlight of the Daily Planet Theatre to share their research and its connection to evolution in a series of flash talks. In their ten-minute presentations, the students – Magdalena Sorger, Emily Moore, Kate Coyle and Khai Button – covered the breadth of evolutionary research in Biological Sciences, from evolution on islands to the evolution of behaviors, from ants to fish to living dinosaurs.



Students on stage in the Daily Planet Cafe (left to right): Khai Button, Kate Coyle, Emily Moore, and Magdalena Sorger.

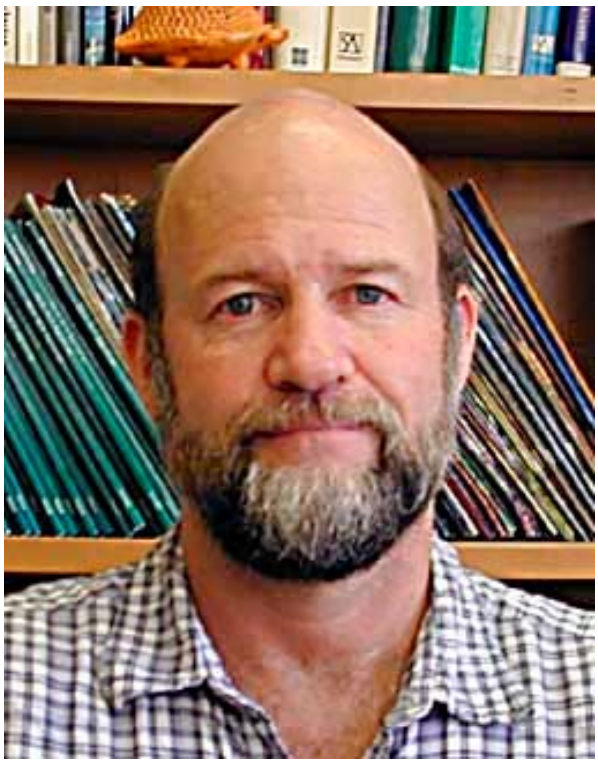
Acoustic Communication in Tungara Frogs

by Elizabeth Hassell

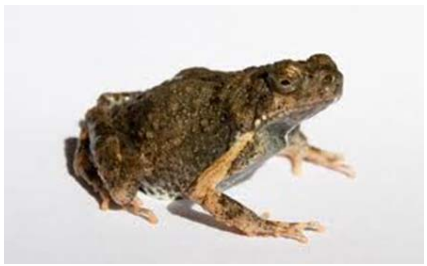
Students and faculty were privileged to listen to distinguished biologist Michael J. Ryan, professor at the University of Texas at Austin, at a seminar hosted by the W. M. Keck Center for Behavioral Biology on Thursday, March 28th. His well-attended talk described some of the major advances Ryan has made in the study of sexual selection, the product of several decades of dedicated work. In the 1980s Ryan pioneered the use of female preference tests to address hypotheses about sexual selection. Female choice as a major factor in sexual selection had long been largely dismissed, most work focusing on other mechanisms such as the role of male-male competition in driving the evolution of sexual traits. However, with a simple study design involving male frog calls played from two speakers and a female frog allowed to hop towards one or the other, Ryan showed how female choice can be easily and reliably assayed and demonstrated its importance in the Tungara frogs of Central America. Today, researchers at NC State University themselves use variants of this preference test (which has since gone far beyond frog calls).

Ryan's subsequent work on the Tungara frogs, which would soon become a model organism for acoustic communication largely thanks to his efforts, uncovered surprising evidence about frog hearing that altered scientists' understanding of animal signaling. For example, it was previously assumed that the preference for and ability to detect signals (such as mating calls, aggregation pheromones, or bright colors) evolved in females in response to the use of such signals by males. However, Ryan showed that female preference for certain variants in frog calls can exist even before the signal arises in evolutionary history. For example, a "whine and chuck" call is preferred over a straight "whine" in the Tungara frog, but females of related frogs in which the chuck never existed also prefer calls with chucks. The anatomy of the frog ear, in which two different organs function in hearing the whine and the chuck respectively, explains why females can perceive both kinds of signals, while the anatomy of the frog throat explains why only some species are capable of making a chuck sound. This discovery underscored a subtle but important difference in the way that evolution has progressed, in terms of sensory exploitation. Since Ryan's surprising findings, other systems have also been uncovered where latent female preference determines the evolution of male signaling.

Ryan regaled his listeners with stories of further developments in the Tungara frog system as he discussed one of their predators, a frog-eating bat. He started by introducing the concept of psychophysics (cognitive perception of the magnitude of physical stimulus) to his audience by polling them on their ability to distinguish between two quantities of black dots simultaneously displayed on a presentation slide. As the quantities got larger, the audience discovered they had more and more difficulty detecting which set was larger, even though the absolute difference between the two options remained constant. In like manner, Ryan explained, there is a threshold of detectability necessary for animals to make comparisons and chose one stimulus over another, such as a female preferring a larger male to a smaller one. He then illustrated his findings on how both bats and female frogs make decisions between differently sized male frogs, and showed they were surprisingly similar.



Dr. Michael Ryan



The 55th Annual *Drosophila* Research Conference

by Megan E. Garlapow

From March 26 to March 30, drosophilists from around the world converged on San Diego, California, for the Genetics Society of America's 55th Annual *Drosophila* Research Conference. From North Carolina State University, Trudy Mackay, Robert Anholt, Xiaofang He, Akihiko Yamamoto, Megan Garlapow and Victoria Pray attended.

Ruei-Jiun Hung, a graduate student from the laboratory of Jonathan Terman, received the prestigious Sandler award. She gave a plenary talk in which she presented her impressive work on the molecular basis of axon guidance. She discovered that interactions between semaphorin, which mediates axon repulsion, and its receptor activate a cytoplasmic protein, Mical, which mediates oxidation of two specific methionines at the interphase of actin subunits, which results in the collapse of actin polymers. She further discovered an additional protein, SelR, which reverses this oxidation allowing actin polymers to form.

In the first plenary session, Dr. David L. Stern (Janelia Farm Research Campus) discussed the molecular evolution of morphology and behavior, in which he described a large number of mutations of small effect in the promoter region of *shavenbaby* as being largely responsible for the trichome differences seen in larvae of *Drosophila sechellia* versus *D. melanogaster*. Dr. Stern then discussed orthologous promoter mutations in *D. virilis* as causal of convergent evolution in trichome patterning

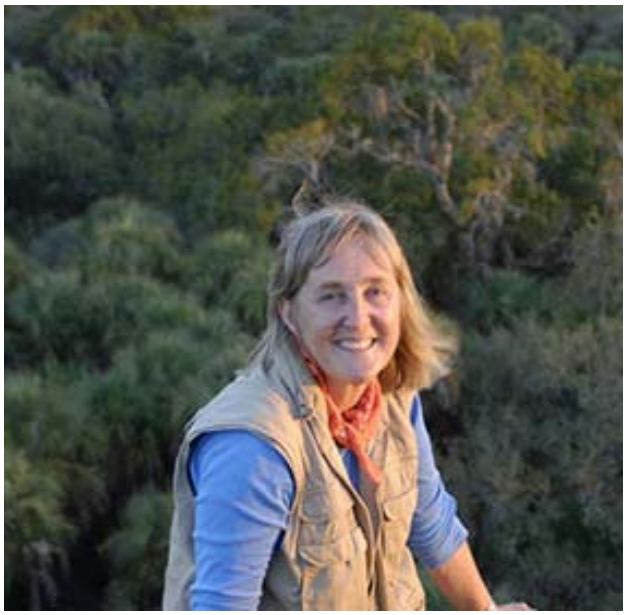
Xiaofang He presented her poster "Variation in epistatic interactions that modify olfactory behavior in the *Drosophila melanogaster* Genetic Reference Panel." She is a visiting researcher from South China Agricultural University, who has been working in the Anholt laboratory how epistasis affects olfactory behavior. Victoria Pray, an undergraduate student in the Anholt laboratory presented her poster, "Effects of ethanol exposure on developmental time and survival in *Drosophila*." Victoria works with Tatiana Morozova, a research scholar in the Anholt laboratory, raising *D. melanogaster* on ethanol-containing food and assessing the food's impact on different life history traits. Megan Garlapow, a Ph.D. student in the Mackay laboratory, presented her poster, "Quantitative genetics of food intake in *Drosophila melanogaster*." Megan's work assesses natural variation in food intake to better understand the genetic architecture of feeding behavior.

Presentations, posters, platform sessions, and workshops covered various aspects of behavior, from Drosophila models of human disease to neurophysiology and behavior and an exciting workshop on "Feeding behavior, nutrition, and metabolism" led by Dr. Tania Reis (University of Colorado School of Medicine) and William Ja (The Scripps Research Institute). Among the workshop presentations, Dr. Nilay Yapici (The Rockefeller University) described a GAL4 line, 57f03, deficient in post-fasting food intake behavior in her talk which described an internal taste circuit that promotes food intake. A neuronal dissection of the line identified a small subset of interneurons in the suboesophageal ganglion that were partially responsible for defective post-fasting feeding. The 57f03 feeding phenotype was mimicked by inhibition of synaptic vesicle release of sugar-sensitive pharyngeal taste neurons in the suboesophageal ganglion.

Josh Dubnau from the Cold Spring Harbor Laboratory gave an exciting talk that showed that during aging retroviral transposons, I n particular the *gypsy* transposon, become transcribed and may contribute liability to age-dependent neurodegenerative disorders.

Trudy Mackay gave two presentations at the meeting. In the *Drosophila* Metabolomics Workshop, she encouraged use of the *Drosophila melanogaster* Genetic Reference Panel (DGRP), a population of inbred wild derived fly lines with sequenced genomes as a resource for studies on metabolomics. Along with proposed common control lines, extensive work on the DGRP would both deepen and broaden our understanding of metabolism and its various related behaviors. Mackay's plenary presentation titled "Charting the Genotype-Phenotype Map: Lessons from *Drosophila*" was a convincing systems genetics description of not just the benefits of the DGRP but also of specific complex phenotypes whose genetic architecture has been better understood through the power of phenotype-genotype regression in the DGRP. Not even the beauty and lure of San Diego could distract the W. M. Keck Center for Behavioral Biology's representative behavioral drosophilists from the meeting activities.

Meg Lowman Receives Roy Chapman Award



Margaret D. Lowman ("Canopy Meg") has been named winner of the 2014 Roy Chapman Andrews Society Award. Nicknamed the "real-life Lorax" by National Geographic and "Einstein of the treetops" by Wall Street Journal, Meg pioneered the science of canopy ecology. Meg is currently the Chief of Science & Sustainability at the California Academy of Sciences and maintains a position as Research Professor with the College of Sciences at NCSU and affiliation with the W. M. Keck Center for Behavioral Biology.

Meg Lowman will visit Beloit on April 11th 2014 to receive the Roy Chapman Andrews Society's Distinguished Explorer Award. This presentation marks the second time the Beloit-based organization has celebrated the science canopy ecology. In 2008 the Society recognized the work of Beloit native Dr. Mark Moffett, entomologist, ecologist and photojournalist for his work in tropical forests and ecology.

Seminars

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.

Of note…

Carlos Botero worked in New Zealand on a project on the evolution of human culture funded by the Templeton Foundation.

Carlos Botero has accepted a faculty position at Washington University, St. Louis, MO.

Megan Garlapow, Victoria Pray and **Xiaofang He** presented posters at the 55th Annual Drosophila Research Conference in San Diego (CA).

Caroline Leitschuh and **Megan Serr** presented a poster entitled, "Predicting wild mouse mating behavior: towards a novel mate choice strategy" at the annual meeting of the Triangle Consortium of Reproductive Biology.

Trudy Mackay participated in a metabolomics workshop and delivered a plenary lecture at the 55th Annual Drosophila Research Conference in San Diego (CA).

Megan Serr, Alana Sullivan, Melissa Slane, and **Ryan Wong** gave presentations at the Brain Awareness Week event at the North Carolina Museum of Natural Sciences.

Gabrielle Schroeder, an undergraduate research assistant in Lisa McGraw's laboratory received a UK Fulbright Scholar Award to study neuroinformatics at Newcastle University for a year. Following her year abroad, she will head to California to join the Neurosciences PhD program at Stanford University.

John Shorter received a second place award for best poster and **Emily Moore** a third place in the Life Sciences category at the 2014 NCSU Graduate Student Research Symposium

Leslie Sombers presented lectures at the Department of Chemistry at the University of Pittsburgh as well and in the Brains and Behavior Distinguished Lecture Series at Georgia State University, titled "Disambiguating the complex chemical mechanisms underlying basic brain function using microelectrochemistry."

Lingjiao Qi, Andy Schmidt, Lars Dunaway and **Leslie Sombers** gave talks at the Pittsburgh Conference on Analytical Chemistry in Chicago (IL).

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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