

The Signal

Monthly newsletter of the W. M. Keck Center for Behavioral Biology
at North Carolina State University
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Keck Center's Trudy Mackay Receives The 2011 North Carolina Award for Science



William Neal Reynolds Distinguished University Professor Trudy F. C. Mackay is among the distinguished North Carolinians who will receive the North Carolina Award, the highest civilian honor the state bestows. Mackay is honored for redefining the boundaries of the genetics of complex traits. Other honorees are Charles E. Hamner, Jr., of Chapel Hill and H. Martin Lancaster, of Raleigh, both for Public Service; Ron Rash, of Cullowhee, for Literature; and Vollis Simpson, of Lucama, and Branford Marsalis, of Durham, both for Fine Arts. The awards will be presented on Thursday, November 10, at 8:00 pm during an awards ceremony at the North Carolina Museum of History. The awards are administered by the North Carolina Department of Cultural Resources.

"Each year, the North Carolina Awards are a chance for us to honor men and women who reflect the very best in imagination, exploration, creativity, and

humanitarian service," said Cultural Resources Secretary Linda A. Carlisle.

For Mackay, the North Carolina Award for Science follows a long string of awards and honors, including the Genetics Society of America Medal, the O. Max Gardner Award, election to the American Academy of Arts and Sciences, the Royal Society of London, the National Academy of Sciences and, most recently, appointment to the Board of Regents of the National Library of Medicine of the National Institutes of Health.

"The North Carolina Award is a well-deserved tribute that acknowledges the impact of Trudy's continuing scientific contributions and the positive impact her work has on agriculture, education and human health and welfare in North Carolina, the nation, and the world," says Keck Center Director, Robert Anholt.

Congratulations, Trudy!

This issue of *The Signal* contains the announcement of the 2011 Professional Development Workshop on "The Future of Science in the USA: A survival Guide for Young Scientists" sponsored by the W. M. Keck Center for Behavioral Biology and the NCSU Initiative for Biological Complexity on October 28 at the Sigma Xi Conference Center in Research Triangle Park.

The registration deadline is October 14.

Ant Diversity, from Local to Global Scales: Effects of Environmental Conditions, Community Structure and Biological Invasions

by Andrea Lucky and Amanda Traud

In a relatively short four-year Ph. D. study in the Department of Biology and the W. M. Keck Center for Behavioral Biology at NC State University, Benoit Guenard has managed to make a major impact on the 'Ant-scape' by fundamentally improving our understanding of the global distribution and diversity of ants. On September 19th, 2011, in his thesis defense seminar, Guenard presented his work which was done under the mentorship of Drs. Robert R. Dunn and James F. Gilliam. Guenard's seminar focused on global diversity patterns and the impacts of ants (Hymenoptera: Formicidae). Guenard presented three research topics, each corresponding to a chapter of his thesis: 1) Global generic diversity of ants; 2) Ants of China; and, 3) Ecology and behavior of the introduced Chinese Needle Ant.

To study the global diversity of ants, Guenard developed global distribution maps for each of the 300 extant ant genera. He illustrated how our current understanding of global diversity patterns is largely based on the study of vertebrates and plants, while the vast majority of described (and not yet described) species are insects. As a consequence, the effort to protect biodiversity is skewed toward a visible minority of organisms while the impacts of human activities on the majority of species are less well known. While the study of diversity of all insects at a large scale or at a global scale is at this point impossible, the study of specific groups of insects, as surrogates for most insect groups, is feasible. Guenard's results represent the first attempt to understand the global distribution of a large group of insects, ants. Ants are one of the best indicator species at local and regional scales and are ecologically relevant for the stability and composition of ecosystems. The data demonstrate that diversity hotspots in ants differ from those observed in vertebrates, and suggest that conservation plans established on the basis of the diversity of vertebrate groups might not be optimal for insects. Guenard's research also identified 'hotspots of ignorance' (where more studies are needed), which also appear to be the most threatened regions in terms of deforestation, highlighting an urgent need to both conserve and study these regions before species in these areas disappear. Guenard also focused on the ants of China. His inventory of ants of China, the third largest country in the world, represents an important contribution to our knowledge of ant distribution. This study compiled



Benoit S. Guenard

literature to assess the Chinese ant fauna, which is composed of almost 900 species from both the Palearctic and Oriental regions. Analyses suggest the presence of a distinct regional fauna on the Tibetan plateau. This updated review of ants of China is likely still incomplete.

Of special interest is the Chinese needle ant. Among the native species found in Asia, *Pachycondyla chinensis* (the Chinese needle ant) represents an interesting example of a successful invasive species in North America. This species was introduced in the United States in the 1930s and is now one of the most widespread invasive species in eastern North America. Results from Guenard's studies show that this species can reach very high population density and directly impact the community composition of native species. During the study of *P. chinensis*, a novel foraging behavior was described: tandem carrying. This behavior represents a new recruitment technique previously unknown for ants. To recruit nest mates, a successful scout grabs a worker with its mandibles and carries it directly to the food resource intended for exploitation.

The successful completion of Benoit Guenard's thesis offered a chance to learn about the incredible work that he has contributed to fields spanning global biodiversity, diversity and distributions, animal behavior, and invasive species. He will be missed when he leaves Raleigh for a postdoctoral position in Japan!

All the best to you, Dr. Guenard!

Getting the Better of Mosquitoes

by Jessica Nye

Dr. Anandasankar (Anand) Ray from the University of California at Riverside visited us on September 12th to deliver the Keck Center's distinguished lecture entitled "Targeting olfaction in *Drosophila* and mosquitoes." Ray's talk included an account of his exciting work which was recently featured on the cover of *Nature* with the epithet "Fatal Attraction."

The Ray lab focuses on the carbon dioxide response in insects and strives to develop safe, pleasant smelling, and inexpensive odorants to repel mosquitoes. In *Drosophila*, carbon dioxide can signal food, but also provides an alarm signal, released by flies that are subjected to mechanical stress. Mosquitoes sense and are attracted to carbon dioxide and navigate carbon dioxide plumes to track human hosts for blood feeding. Once carbon dioxide plumes are sensed, mosquitoes fly upwind and become more sensitive to human skin odors. Using electrophysiological methods in *Drosophila*, Ray discovered odorants that block the carbon dioxide response both in *Drosophila* and mosquitoes, such as the malaria harboring mosquito, *Anopheles gambiae*.

In wind tunnel experiments both *Drosophila* and mosquitoes fly straight upwind toward a carbon dioxide emitting bait. However, when they are pre-exposed to the chemical butanone, found in both butter and beer, insects are unable to detect the bait, and at high doses do not even expend the energy to leave the wind tunnel release cage. Butanone effectively blocks the carbon dioxide response after a one-second puff. Electrophysiological studies showed that pre-exposure to this odorant causes persistent activation of carbon dioxide sensing neurons, thus disabling the mosquito's ability to track changes in carbon dioxide concentration. The result is that the human host becomes essentially undetectable.

After these encouraging results, members from the Ray lab traveled to Kenya to test whether or not blocking carbon dioxide responses of mosquitoes in the field yields the same results. Kenya is a country that is heavily affected by diseases passed to humans through mosquito bites such as dengue fever and malaria. Traditional methods of repelling mosquitoes are too expensive for the average Kenyan, so it is important to develop new affordable methods for repelling these disease spreading pests. In semi-field conditions, with natural vegetation and typical huts, mosquitoes were collected overnight into huts that did not release a CO₂ blocking chemical and huts releasing butanone. They found that huts with the butanone had far fewer mosquitoes entering than those without. The buttery smell of butanone, however, is not pleasant and to identify a compound that is an effective CO₂ blocker



Anand Ray

with a pleasant odor quality, Ray hunted for alternatives.

This inspired the development of Olfactory Labs, Inc. (OLI), a company that researches and produces new odorant technology. A mathematical algorithm that takes into account a chemical's size, shape, and other properties was developed to predict which other chemicals are likely to induce a similar response. Such candidates are tested electrophysiologically in the *Drosophila* model to assess their effects on carbon dioxide-responsive olfactory sensory neurons. After searching chemical space for compounds similar to butanone, 600,000 chemicals were predicted. These chemicals can be cross referenced to a list of approved fragrances, reducing the number of compounds to be tested. Candidate chemicals can then be tested in OLI's semi-field test huts to develop safe, inexpensive, and pleasant smelling mosquito agonists. The Ray lab also uses this technology in *Drosophila* for reverse chemical ecology in which computational approaches can be used to help in better characterizing the response profiles of olfactory receptors. Clearly, Ray's work is seminal and pioneering and holds great promise for advancing our basic understanding of insect olfaction, while at the same time enabling more effective disease vector control.

Memory and the Brain: Lessons from Neurosurgical Patients

by Alana Sullivan

On September 29th, the W.M. Keck Center for Behavioral Biology hosted Dr. Brenda Milner, a veritable icon of neuroscience, who shared with us her life history lessons of the brain and memory in a talk entitled “Brain and Memory: Lessons from Neurosurgical Patients.” Dr. Milner mentioned that she owned much of her acclaim to luck. No matter how humble, she is beyond doubt a great pioneer and inspiration for neuroscientists today. She is a Fellow of the Royal Society of Canada, the Royal Society of London and a Foreign Associate of the National Academy of Sciences and has received numerous prestigious awards.

Dr. Brenda Milner was born in 1918, a time when women in the U.S. still were not able to vote. Despite the social expectations of that era, she knew even as a child that she wanted to have a career and she was driven to become a pioneer in the field of neuropsychology. In 1950, while working with Dr. Donald Hebb, first at Cambridge University in the UK and later at the Department of Psychology at McGill University, she was asked to go to the Montreal Neurological Institute to study Dr. Wilder Penfield’s patients. It was through that work that she earned her Ph. D. and notoriety in the field.

Penfield was treating epilepsy patients by surgically removing portions of the brain thought to cause epilepsy. Temporal lobe epilepsy was common at that time and often patients did not respond to medications and therefore were desperate for relief, prompting these surgeries. Penfield was only removing tissue from one side of the brain, limited to the anterior temporal neocortex. This surgery did not always control the epilepsy and patients returned, in which case Penfield removed more tissue, making this now a bilateral excision, including medial portions of the brain. Some of those patients returned later with a memory impairment, causing concern with this procedure. After presenting the theory that this memory impairment was a consequence of the removal of medial structures, such as the amygdala and hippocampus, Penfield was contacted by Dr. William Scoville who was performing bilateral medial excisions in Hartford, Connecticut. Milner found that his patients too were suffering a memory loss post-surgery and she specifically began to work with one patient, Henry Molaison, referred to as HM.

HM had a normal IQ, but suffered from severe epilepsy. The seizures were detrimental to his quality of life and he consulted Dr. Scoville regularly to try to control his condition. Eventually, Scoville performed the bilateral temporal lobe surgery and although it



Brenda Milner

relieved HM of his severe epileptic episodes, it also resulted in memory loss. In 1954, Scoville published a three-page paper in the *Journal of Neurosurgery*, “The Limbic Lobe in Man” based on HM. Through work with HM, Milner found evidence for multiple memory systems. For instance, HM could learn certain motor skills, even though his “immediate memory” was lost. He could remember a series of simple numbers as long as he could ruminate over them and repeat them to himself, but when momentarily distracted he would not remember that he had been asked to memorize numbers at all. When presented with different shapes, for example an ellipse, which could not be verbalized, he was unable after a brief delay period to correctly identify the shape he had seen only moments earlier.

To explore HM’s limitations and abilities, Milner picked up a few testing kits from the psychology lab that she could transport to Hartford where she was testing HM. One test was a mirror-drawing task, where the subject was required to use a mirror to trace a line between two solid lines in the shape of a five-pointed star. HM improved with practice over multiple trials, even though he did not remember performing the task previously. This improvement led Milner to believe that this must be motor learning and is carried out in another system of the brain, independent of the formation of episodic memory, which requires the hippocampus. This was an exciting moment for Brenda Milner and was considered a tremendous breakthrough. Milner and others continued to study patients with brain lesions to improve our understanding of brain function, and, as the title of her talk indicates, they have proven to be invaluable lessons.

The European Society for Evolutionary Biology Meeting in Germany

by Justa Heinen

I had the great pleasure of participating in the 13th annual meeting of the European Society of Evolutionary Biology (ESEB). This year's meeting was hosted in the charming college town of Tübingen in southern Germany in late August. Situated on top of a hill overlooking the city, the congress was organized into symposia with associated oral presentations and poster sessions. The meeting was focused largely around plenary speakers, and many of the symposia talks were invited speakers who gave 40 minute presentations. There were regular sized posters that had accompanying sessions, and there were also smaller Essence posters displayed throughout the central building in the coffee break area with high visibility that provided a snapshot of results.

Scientists from forty different countries came to present exciting new research and ideas. Symposia were diverse, and spanned many different topics from fossils to climate change, from humans and disease to chirality, and from speciation to family interactions, among others. Brian Charlesworth gave the Presidential address on the future of population genetics. Johannes Krause, a plenary speaker from Germany, unveiled exciting new developments on the evolution of modern humans, including the identification of specific genes associated with the split from Neanderthals. Interestingly, these genes are associated with big issues modern humans face, including type-two diabetes, autism, schizophrenia, and Downs syndrome.

I presented results that male guppies with a shorter intromittent organ (gonopodium) are more likely to reproduce (i.e., sire at least one offspring that survives until adulthood) in a natural stream in Trinidad. These results from nature are quite interesting, as female guppies, as well as other closely related species, have demonstrated a preference for males with longer gonopodia. This indicates that guppies may be faced with important reproductive trade-offs in nature. Participating in this large, international conference was a great learning experience, particularly as an early Ph. D. student. I was able to have helpful meetings with collaborators on this project, as well as establish new connections with researchers from other universities that I would not normally have the opportunity to interact with.

ESEB 2011 was a unique meeting in several ways. The conference was carbon-neutral and the organizing committee made efforts to be environmentally progressive. ESEB invested in carbon offsetting projects to neutralize the conference's emissions from



travel, electricity, food, etc. Like German buses and trains, the meeting was highly organized and ran on time. No talk went over the time limit due to an automated voice that boomed, "One minute!" and, "Discussion!" at the designated times, and upbeat music played loudly at the end. Perhaps an approach to consider for future Keck Center symposia? A unique aspect of the poster sessions, which may be particularly appreciated by Keck Center members, was that each presenter was given a bottle of wine to fill the glasses of people who came to discuss their research. Needless to say, the poster sessions were very well attended.

In 2012, there will be a joint conference with ESEB, the American Society of Naturalists, the Society for the Study of Evolution, the Society of Systematic Biologists, and the Canadian Society for Ecology and Evolution held in Ottawa, Canada. This large joint meeting will certainly be worth attending.

Announcement

The 37th annual SouthEastern Population Ecology and Evolutionary Genetics (SEPEEG 2011) meeting will take place on October 21-23, 2011 and is hosted by The University of North Carolina, Chapel Hill. The meeting will be at the Besty-Jeff Penn 4H center in Reidsville, NC (about 40 minutes north of Greensboro, NC). For information, see <http://sepeg.bio.unc.edu>. The conference registration fee will cover on-site housing, meals, and entertainment. Participants may register to give an oral presentation and/or poster. A poster session will be held during the social event after dinner Saturday. A keynote address will be given on Saturday afternoon by Dr. Haven Wiley from the University of North Carolina at Chapel Hill. Questions can be emailed to SEPEEG@bio.unc.edu.

The W. M. Keck Center for Behavioral Biology and the
North Carolina State University Initiative for Biological Complexity
announce the 2011 Professional Development Workshop

***The Future of Science in the USA:
A Survival Guide for Young Scientists***

Friday, October 28, 2011

Sigma Xi Conference Center, Research Triangle Park

Program

- 8:15 Continental breakfast
- 8:45 Welcome remarks
- 9:00 Alan Leshner
CEO, American Association for the Advancement of Science
- 9:45 Kei Koizumi
Assistant Director, White House Office of Science and Technology Policy
- 10:30 Coffee break
- 11:00 David Price
Congressman (D-NC)
- 12:00 Lunch
- 1:00 Vernon Anderson
Program Officer, National Institute for General Medical Sciences
- 1:45 General Discussion
- 3:00 Adjourn

Directions: From Raleigh-Durham airport: Follow directions from the airport to Interstate 40 West. Travel westbound on Interstate 40 for approximately four miles to Davis Drive exit (Exit 280.) Turn left on Davis Drive. At second intersection, turn right on NC Highway 54 (west). Proceed approximately seven-tenths of a mile. The Sigma Xi Center is located on the left at 3106 East NC Highway 54.
If driving eastbound on Interstate 40: Take Davis Drive exit (Exit 280) and turn left on Davis Drive. At next intersection, turn right on NC Highway 54 (west). Proceed approximately seven-tenths of a mile. The Center is located on the left at 3106 East NC Highway 54.

The registration fee is \$30 and includes breakfast and lunch. Make checks payable to "North Carolina State University" and indicate on your check "Keck Ctr/IBC." Send your check to: Dr. Robert R. H. Anholt, W. M. Keck Center for Behavioral Biology, Campus Box 7617, North Carolina State University, Raleigh, NC 27695-7617.
The deadline for registration is October 14. For information, e-mail anholt@ncsu.edu.

Seminars

On Thursday, **October 20**, at 3:30 pm, Dr. Nirao M. Shah from the Department of Anatomy at the University of California at San Francisco will present a seminar, titled “Sex, Genes, and Videotape: Representation of Gender in the Brain.”

The seminar will be in 101 David Clark Laboratories.

On Monday, **November 7**, at 11:15 am, Dr. Consuelo M. De Moraes from the Department of Entomology at Pennsylvania State University will present a seminar, titled “Chemical Communication among Plants and Insects.”

The seminar will be in the Stanley Stephens Room, 3503 Thomas Hall.

March of the Penguins



The next **Keck Center popcorn movie** will be on Friday, **October 7**, 2011, at 4:00 pm in the Stanley Stephens Room, 3503 Thomas Hall, and will feature the classic 2005 movie “March of the Penguins.” Popcorn and soft drinks will be provided.

Each winter, in the ice deserts of Antarctica, a remarkable journey takes place as it has done for millennia. Emperor penguins in their thousands abandon their ocean home and clamber onto the frozen ice to begin their long journey into a region so bleak it supports no other wildlife at this time of year. In single file, the penguins march blinded by blizzards, buffeted by gale force winds. Guided by instinct, they head unerringly for their traditional breeding ground where, after a ritual courtship of intricate dances and delicate maneuvering, accompanied by a cacophony of song, they will form monogamous couples and mate.

Tax deductible gifts to the Keck Center can be donated via our secure website. Support the Center and invest in the future!

<https://harvest.cals.ncsu.edu/giving/index.cfm?AllocationCodeList=011355>

Publications

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

Richard, F.-J., Schal, C., Tarpy, D. R. and Grozinger, C. M. (2011) Effects of insemination quantity on Dufour’s gland chemical profiles and vitellogenin expression in honey bee queens (*Apis mellifera*). *J. Chem. Ecol.* **37**: 1027-1036.

Roberts, J. G., Hamilton, K. L. and Sombers, L. A. (2011) Comparison of electrode materials for the detection of rapid hydrogen peroxide fluctuations using background subtracted fast scan cyclic voltammetry. *Analyst* **136**: 3550-3556.

Tarpy, D. R., Keller, J. J., Caren, J. R. and Delaney, D. A. (2011). Experimentally induced variation in the physical reproductive potential and mating success in honey bee queens. *Insectes Sociaux* **58**: 569-574.

Of note

Robert Anholt delivered a plenary lecture at the European Chemoreception Research Organization conference in Manchester, UK. He also presented a seminar in the Department of Cellular and Molecular Physiology at Yale University on the genetic architecture of behavior in *Drosophila*.

Jim Hunt has begun a nine-and-a-half month stay as a Fellow of the Wissenschaftskolleg zu Berlin, where he will be working on a book “Origin and Adaptation of Insect Societies.”

Leyda Lugo-Morales received a GAANN Nanoscale Electronic and Energy Materials (NEEM) Fellowship.

Trudy Mackay presented a seminar at the University of California at San Diego. She has also been appointed by the Secretary of Health and Human Affairs to the Board of Regents of the National Library of Medicine of the National Institutes of Health.

James Roberts has been selected as a recipient of a BASF scholarship. The award comes with \$5,000 academic support.

Leslie Sombers gave a seminar at Wayne State University on real-time electroanalysis of rapidly fluctuating small molecules in neuronal systems.

David Tarpy gave a seminar to the North Carolina State University College of Veterinary Medicine on honey bee health and colony collapse disorder.

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