The Signal

Monthly newsletter of the W. M. Keck Center for Behavioral Biology
at North Carolina State University
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Ants in Space!!!!

Keck Center scientist Rob Dunn's "anthusiasm" for little creatures has no limits. Dunn has studied ants all over the world. No, make that all over the universe. Clint Penick, a postdoc in Dunn's lab together with Eleanor Spicer Rice have worked with Stefanie Countryman and BioServe Space Technologies to send ants to the International Space Station. They collected pavement ants (*Tetramorium spE)* and sent about 800 of them to the space station. The ants made their space voyage in a small container, in which they float around up at the space station. The purpose of studying this colony of ants in space is to assess the effects of absence of gravity on these little animals. The ants appear to be doing remarkably well. Clearly, there will be two types of animals that will persist after global climate change or nuclear war brings about the apocalypse: ants, and….., of course, there will always be cockroaches….

The deadline for submission of abstracts for the Fifteenth Annual Student/Postdoc Symposium of the W. M. Keck Center for Behavioral Biology on February 21, 2014, is February 7.

Chemoreception in the Fruit Fly: "What Makes a Fruit Fly Taste Bitter?"

by Lauren M. Dembeck

As children, many of us learn that different regions of the tongue enable us to detect different tastes. For example, the taste buds near the front of the tongue are the taste buds that detect sweetness. Alas, taste perception is more complex than this. On January 13th, the W.M. Keck Center hosted Dr. John Carlson from Yale University to share his research on taste perception in the fruit fly.

Carlson's study of taste receptors began with an algorithm searching for chemoreceptor genes. The algorithm identified 60 seven-transmembrane-domain genes, putative gustatory receptors (*Gr*). One of these, *Gr5a*, was located in a genomic region previously shown to have an effect on a fly's response to trehalose. To confirm that the trehalose response locus and *Gr5a* are the same gene, the Carlson lab took advantage of RNA interference and heterologous expression analysis. In a two-choice behavioral assay where flies were offered both trehalose and sucrose, the *Gr5a* knockdown flies showed a reduced preference for trehalose. Furthermore, unlike olfaction in which each olfactory neuron expresses one odorant receptor, subsequent work showed that in taste sensilla sugar neurons tend to express multiple sugar receptors.

Next, the Carlson lab sought to decipher how fruit flies taste bitter compounds. Bitter compounds are often toxins and thus serve as an avoidance cue. Many researchers hypothesized that neurons responding to bitter compounds would be broadly tuned. This hypothesis creates an all or nothing scenario where the fruit fly would treat all detectable bitter compounds with avoidance. Dr. Carlson asked if fruit flies have the ability to discriminate among bitter compounds, which would allow them to assess the level and type of toxins in potential food and oviposition locations.

To answer this question, the Carlson lab offered fruit flies a panel of bitter tastants including compounds such as caffeine and denatonium, the most bitter compound known to man and flies. This work showed that flies can discriminate among bitter compounds and different concentrations of those compounds. Next, they created promotor-GAL4 lines for nearly all *Gr* genes. This allowed them to systematically map the location of the bitter taste receptors using GFP creating a receptor-to-neuron map. Future use of these lines for other taste receptors will allow further dissection of the genetic and neuronal circuitry of taste perception which ultimately drives behavior.

Dr. John Carlson

In addition to the olfactory and gustatory receptors identified by Carlson's algorithm were a group of ionotropic receptors (Irs). The functions of many of these Irs is still being investigated. However, a graduate student in the Carlson lab found that some Irs are present on the dorsal surface of the fly's forelegs. One in particular, Ir52c, is present specifically on the forelegs of young male flies. This is odd, because this portion of the leg does not come in contact with food. Unraveling the mystery, the student was able to capture a photograph of a male fly touching this region of his foreleg to the female abdomen during courtship. Mutant analysis demonstrated that males lacking functional Ir52c delay courtship of females. The finding suggests that Ir52c may represent a new class of pheromone receptors.

Carlson has conducted elegant and meticulous work to elucidate the genetic and cellular mechanisms underlying chemoreception and behavior. Not only have his discoveries been important for our basic understanding of sensory systems, but can also inform applied research efforts such as creating novel odorants to prevent the detection of human sweat components by disease vectors.

Phenotypic Plasticity and Genetic Assimilation

by Beth Dumont

Dr. Russell Lande

On January 30, the Keck Center hosted Dr. Russell Lande, Royal Society Research Professor at the Imperial College of London. Lande is an international leader in the field of evolutionary biology and his seminal work has laid the theoretical foundation for the field of evolutionary population genetics. The extensive scope of his research program has touched upon virtually every topic in the field of evolutionary biology, including sexual selection, speciation, evolution of life history traits, species conservation, and population dynamics. His many key contributions to the field have earned him numerous honors and career awards, including the Sewall Wright Award, a MacArthur Fellowship, and induction into the Royal Society.

His well-attended seminar, entitled "Adaptation to an extraordinary environment by evolution of phenotypic plasticity and genetic assimilation" addressed an intriguing question from a theoretical perspective: how do organisms adapt to rapid changes in their environment?

Throughout his talk, Lande's scholarly dedication to the history of evolutionary biology was obvious. He referenced the classical works of C. H. Waddington, Karl Pearson, and R. A. Fisher, describing how his own research builds on the foundational knowledge they established.

Lande explained that organisms can adapt to changes in their environment by two mechanisms: plasticity and/or classic Darwinian evolution. Unlike Darwinian evolution, which relies on the gradual accumulation of rare, beneficial mutations in a population, plasticity can lead to adaption in a single generation. Plasticity can, therefore, increase the probability of population persistence in a changing environment. Interestingly, plasticity itself is a genetically variable - and therefore, heritable - trait that can evolve within and between populations. Lande gave the example of how species invading novel or extreme environments often have increased plasticity relative to populations that remain in their native range.

Results from Lande's theoretical models show that, following a sudden change in environment, phenotypic adaption occurs in two time-scale dependent phases. In the short-term phase, the mean phenotype of the population rapidly approaches the new phenotypic optimum determined by the conditions of the new environment. This rapid phenotypic evolution is achieved through the evolution of increased phenotypic plasticity. In the long-term phase, the population slowly reaches the phenotypic optimum through genetic changes (*i.e*. Darwinian evolution and genetic assimilation). At this point, high plasticity may carry a fitness cost, as it will cause phenotypic values to deviate from their new optimum. This so-called "cost of plasticity" will eventually cause plasticity to decrease.

Although his own research is strictly theoretical in scope, Lande did suggest several empirical tests of his model's predictions. He briefly described how artificial selection experiments and comparative tests between invasive and non-invasive populations could be used to directly test the predicted short-term increase in plasticity. Testing the long-term predictions of the model, which would likely require many thousands of generations of evolution, poses a more difficult challenge. Analyses that combine fossil data with the natural environmental history logs stored in tree rings or ice cores may be fruitful.

Lande's focus on the question of organismal adaption in the face of environmental change is particularly timely, as strong human-mediated effects on global climate patterns and deliberate habitat destruction are triggering rapid, extreme, and often unpredictable changes in species' environments. These changes are perturbing the dynamics of many populations and ecosystems, and fast action is needed to ensure the preservation of current species diversity. Lande's theoretical models indicate that organisms with low plasticity for ecologically relevant traits and low genetic variance for plasticity are likely in need of greatest attention for conservation.

Seminars

On **February 21**, the W. M. Keck Center for Behavioral Biology will host its 15th annual student/postdoc symposium from 9:00 am to 5:00 pm in 3503 Thomas Hall.

Publications

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

Swarup, S., Morozova, T. V., Sridhar, S., Nokes, M. and Anholt, R. R. H (2014) Modulation of feeding behavior by odorant-binding proteins in *Drosophila melanogaster*. *Chemical Senses* **39:** 125-132.

Robinson, M., Stone, E. A. and Singh, N. D. (2014) Population genetic analysis reveals no evidence for GC-biased gene conversion in *Drosophila melanogaster*. *Mol. Biol. Evol.* **31:** 425-433.

Hunt, J. H. (2013) Ten Years in the Rearview Mirror. *Wissenschaftskolleg zu Berlin Fellows' Club Newsletter* **No. 1.**

Robert, M. A., Okamoto, K., Lloyd, A. L. and Gould, F. (2013) Reduce and replace strategy for suppressing vector-borne diseases: Insights from a deterministic model. *PLoS One* **8:** e73233.

Huang, Y., Wan, P., Zhang, H. N., Huang, M., S., Li, Z. H. and Gould, F. (2013) Diminishing returns from increased percent Bt cotton: The case of pink bollworm. *PLoS One* **8:** e68573.

Legros, M., Xu, C., Morrison, A., Scott, T. W., Lloyd, A. L. and Gould, F. (2013) Modeling the dynamics of a non-limited and a self-limited gene drive system in structured *Aedes aegypti* populations. *PLoS One* **8:** e83354.

Okamoto K. W., Robert, M. A., Lloyd, A. L. and Gould, F. (2013) A reduce and replace strategy for suppressing vector-borne diseases: Insights from a stochastic, spatial model. *PLoS One* **8:** e81860.

Of note…

Trudy Mackay was a plenary speaker at the Plant and Animal Genome Conference in San Diego (CA).

John Meitzen presented a seminar entitled "Using whole-cell patch clamp and an ex vivo brain slice preparation to study neural sex differences" to the Complex Matter and Biophysics group at the Department of Physics at North Carolina State University. He also presented a talk in a symposium on "Slices, cells, circuits, and steroids: Insights on estrogen action in the brain using ex vivo techniques." at the 47th Winter Conference on Brain Research in Steamboat Springs (CO). As part of the outreach program of the conference he led 43 5th graders with sheep brain dissections at Soda Creek Elementary School.

Heather Patisaul gave a talk entitled "Disrupted development: impacts of endocrine disruptors on adolescent behavior and related neuroendocrine pathways" for the Laboratory of Neurobiology seminar series, at the National Institute for Environmental Health Sciences, Research Triangle Park (NC).

Leslie Sombers presented a talk in a symposium on "Methods to explore the brain: Peptides, light and toxins" at the 47th Winter Conference on Brain Research in Steamboat Springs (CO). At the conference, she won first place in the women's snow board division with an average time of 26.33 seconds!

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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